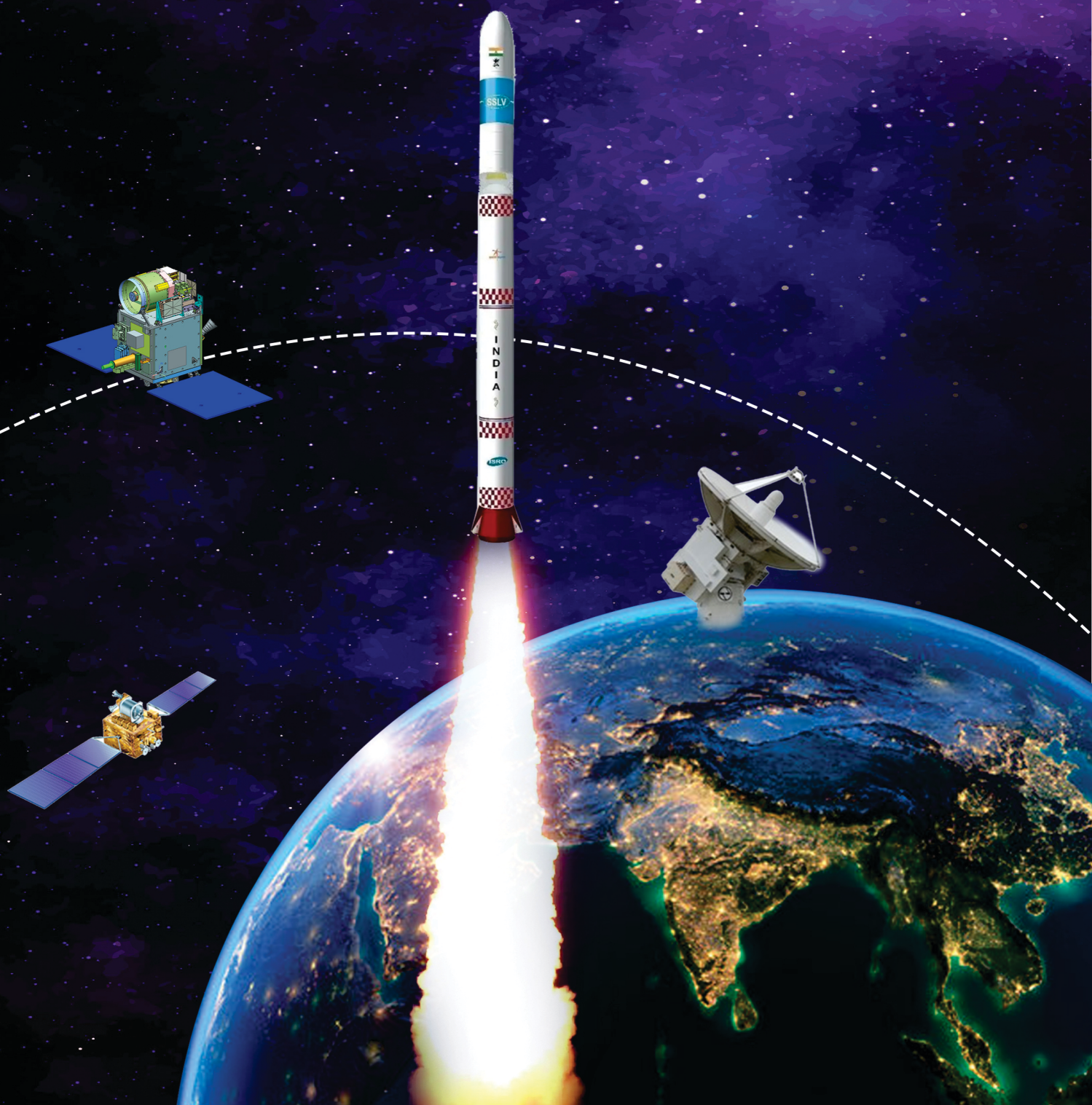


TECHNOLOGY TRANSFER



Contents

1	Indian Mini Satellite-1 (IMS-1) Bus.....	7
2	Ceramic Servo Accelerometer (CSA)	8
3	ISRO Laser Gyro (ILG)	9
4	Lithium-Ion Cells	11
5	C/Ku Ortho Mode transducer for Combined C/Ku Receive Feed Systems	12
6	Dual Feed Square Patch Antenna for Reporting Terminal.....	14
7	Dual Feed Square Patch Antenna for Broadcast Receiver	15
8	Multilayer Printed Antenna Technology	16
9	Design of Ku/C/I and S Band Cassegrain Feed	18
10	Patch Array Antenna for Portable Multimedia Terminal	20
11	Xband Wide Scan Active Phased Array Antenna.....	21
12	Rapidly Deployable Multi-band VSAT Terminal for Disaster Management	23
13	Compact L5 Band Ceramic Antenna	25
14	Distress Alert Transmitter (DAT-SG)	26
15	Personnel Tracker.....	28
16	Two Way MSS Terminal For Vessel Tracking	30
17	Mobile Satellite Services Terminal (Broadcast receiver)	32
18	Mobile Satellite Services Terminal (Portable Multimedia Terminal)	33
19	Mobile Satellite Services Terminal (Reporting Terminal)	34
20	Mobile Satellite Services Terminal (Satellite Mobile Radio)	36
21	Two-Channel Digital Monopulse Tracking Receiver for Earth Station	37
22	NAVIC Messaging and Positioning Receiver.....	39
23	Radiosonde.....	41
24	Satellite Gateway Unit (SGU)	44
25	Low Cost Multi Standard Satellite Receiver (Data DTH) Technology	46
26	Pseudolite Based Navigation System.....	48
27	Ferrite Based Wave Guide Circulators and Isolators	50
28	High Power Circulator-Switch Assembly	52
29	Mini SAR: X Band Airborne SAR	54
30	SCPC Modem IP Core	56
31	V Band Low Noise Amplifier	58
32	21 NA Pressure Transducer	59
33	Differential Pressure Transducer (DPT)	61
34	HLP-85 Temperature Sensor	63
35	IDLV Pressure Transducer.....	65

36	MEMS based Pressure Transducer	67
37	PtS-84 temperature Sensor.....	69
38	TCP-84 temperature Sensor	71
39	Ultrasonic Liquid Level Sensor (USLS)	73
40	Burst Demodulator IP Core	75
41	Solid State Recorder (SSR).....	77
42	Transmit-Receive Module	78
43	Power Conditioning and Processing Unit	79
44	L-Band True Time Delay Phase Shifter	80
45	Ka Band 5W Solid State Power amplifier.....	82
46	15W C Band Solid State Power amplifier	83
47	C Band Active Radar Calibrator	85
48	Miniaturised High Frequency DC-DC Converter.....	86
49	Supercapacitors	88
50	Ultrasonic Burning Rate Measurement System (UBRMS)	90
51	MEMS Acoustic Sensor	91
52	Thermal Sensors.....	92
53	TRISP (Triple Input Smart Power Supply)	93
54	Dual Polarized, S&X Band Mono Pulse Feed for Tracking LEO Satellites	95
55	Integrated Tracking System for Satellite Auto Track	97
56	Programmable IF Matrix.....	99
57	Design & Development of FPGA Based Digital Demodulator	101
58	Low Noise Amplifiers (LNAS) And RF Amplifiers for GNSS & VHF Bands	103
59	E-Plane Filter	105
60	Evanescent Mode Filters	106
61	Battery Charge Regulator (BCR)	108
62	Battery Discharge Regulator	110
63	Eddy Current Damper	112
64	Foil Heaters using Pyralux® Adhesive	113
65	Fine Line PCB Technology for Fine-Pitch Surface Mount Devices	115
66	Rigid-Flex Multilayer PCB Technology	117
67	HMC DC-DC Converters (30W)	119
68	Advanced High Data Rate Modulator.....	121
69	Miniaturized Methane Sensor Based on Grin Lens.....	122
70	Active 3D Imaging Lidar Camera	124
71	Highly Accelerated Thermal Shock (Hats) System for Assessment of PCB Via Reliability	126

72	Electronic Safety Handheld Ohmmeter (ESHO 4.5).....	128
73	Piezo-Electric Vibration Sensor (PEVS).....	129
74	Ribbon Stack Heat Flux Sensor	130
75	Precise Timescale	131
76	Cal-Val Systems for Spaceborne Ocean Colour Sensors.....	133
77	Photosynthesis Irradiance Incubator	134
78	Ground Penetrating Radar (GPR)	136
79	Detection of Landslides from High Resolution Optical Satellite Data	138
80	e-smart.....	140
81	Methods and System to Control the Data Processing Workflows in Distributed Environment with Asynchronous Message Driven Mechanism	142
82	Microwave Data Analysis Software (MIDAS).....	143
83	Lithography and Patterning on Thin Film for Hi-Rel MIC	145
84	Low Temperature Co-Fired Ceramics (LTCC)	147
85	Black Anodizing on Aluminium 6061t6 & Chromatin Technology	149
86	Smart Fire-Retardant Coating	151
87	Gold Plating on Aluminum 6061 T6 and Kovar.....	153
88	Cr-Cu-Au Metallisation for Hi-Rel MIC Fabrication.....	155
89	Silver Plated Waveguides Technology.....	157
90	Thermal Control Coating Technology	158
91	Flameproofing Coating-Caspol	159
92	Corrosion Resistant Coating NRCM-204.....	162
93	Silicone Polymer based Thermal Protection System: PC-10 TPS (Red) and (White)	163
94	High Emissive Silicone Coating, HESC/CSNM-29	165
95	FB-CVI for Realisation of C-C Composite.....	166
96	Pulse Hard Anodization Process	167
97	Anodising on Titanium Alloys	169
98	Pulse Hard Anodising.....	170
99	Nanoparticle (Silver & Gold) coating on Aluminum.....	171
100	Nano-Structured Metal Deposition by Electroplating Method for PCB required for Space application	173
101	Electroless Nickel Electroless Palladium Immersion Gold (ENEPIG) Process for Printed Circuit Boards.....	175
102	Gold Plated PTH / non PTH PCBS	177
103	Precision Tapping Attachment.....	178
104	Vibration Management Solutions.....	179
105	Fabrication of Waveguide Runs.....	181

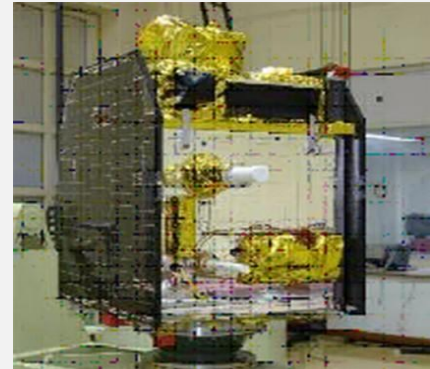
106 Sit on Umbilicals for Remote Fluid Servicing of Launch	183
107 Tool for Connector Pin & Teflon Trimming.....	185
108 SAC Video Imaging System (SVIS).....	186
109 Optical Imaging System.....	188
110 Film Adhesives EFA 1753 and EFA-1752.....	190
111 EPG 2601 [M].....	191
112 Rocasin.....	192
113 5-Aminotetrazole Nitrate.....	193
114 BMT- Ceramics.....	194
115 DK 18- Ceramics.....	196
116 High-Permittivity Ceramic (DK36) For R F Applications.....	197
117 Cryo Adhesive EPIFIL-9661	198
118 Matrix resin for composite application EPY PEEKTOH.....	200
119 Guanidinium Azotetrazolate (GZT).....	201
120 Polydimethylsilane (PDMS).....	202
121 Phenolic Resin (PF-106).....	203
122 Phenolic Matrix Resin (PF-108).....	205
123 RTV Silicone Single Part Adhesive, Silcem R9.....	207
124 Silica Fibres.....	209
125 Silica Granules.....	210
126 Silica Aerogel by Ambient Pressure Drying Method.....	211
127 Silica Aerogel Based Composite Sheet.....	213
128 Waterproofing Compound RWPC-03.....	215
129 Sealant EPY 2121N.....	216
130 Adbond EPP-3521.....	217
131 Umbilical Pads.....	218
132 Low Density Epdm Based Thermal Insulation.....	219
133 Coating Compound EPY 1061.....	220
134 Benzoxazine Polymer.....	221
135 Compensated Alumina (Comal) For Electronic Applications.....	222
136 Silicone Polymer Based Low Density Syntactic Foam TPS, SSF P-70.....	224
137 DK65 Ceramic for Microwave Applications.....	226
138 Low Modulus Flex Seal Compound.....	227
139 NITI Based Shape Memory Alloys.....	229
140 Ceramic Foam (HTFOAM-1500) by Direct Foaming Technique.....	231
141 SiC Foam Tile SICTILE-1650 by Replica Technique.....	232

142 Strontium Perchlorate.....	233
143 High Density Sintered Silicon Carbide	234
144 D-Type Connector Demating Tool.....	235
145 Hot-pressed Boron Nitride/silica composites	236
146 Hot-pressed Boron Nitride sintered parts	237
147 SCA 9-1-1	238
148 SUPERCAPATTERY	239
149 Mineral Algorithm	241
150 Portable Bathymetry Profiler System	243
151 Small size and Low power NavIC Receiver for Radio Sonde Application	246
152 Hard Black Non-Reflective Anodising at Room Temperature	248
153 CV-CC Solar Array Simulator	249
154 Chemical Formulation of Stable, Low build Electroless Copper Concentrate for High Reliability Plated through Hole Interconnections	250
155 Paraffin actuator-based Hold Down and Release Unit.....	252
156 Special Purpose Fixture (SPF) for Assembly and Integration of Spacecraft.....	254
157 Monolithic Composite Cylindrical Sandwich Shells Process.....	256
158 Heat pipe Embedded Honeycomb Sandwich Panels – Special Tooling and Process	257
159 CFRP Honeycomb Core.....	259
160 Semi Physical Crop Yield Model	261
161 Highly Accelerated Thermal Shock (HATS) Test System.....	263
162 Irrigation Advisory Model	265
163 NON-CONTACT HERMETIC SEALING OF MICROELECTRONIC PACKAGES USING PULSED LASER	267
164 Geospatial Pest Forewarning System.....	269
165 Satcom Digital Modem (SDM).....	271
166 Geospatial Management System for Sugar Mills	273
167 10W X-Band LTCC based TR Module	275
168 PMC 30 Silicone coating system.....	277
169 Coating Compound SESCO 125	278
170 Triband (S, X, Ka) Antenna dual circularly polarized Monopulse feed for LEO satellite Auto tracking and Data reception.....	279
171 S, X Dual band Antenna Feed for LEO satellite Auto tracking and payload data reception.	282
172 Two/Tri-axis Antenna Control Servo System (ACSS)	284
173 LOW TEMPERATURE CO-FIRED CERAMIC (LTCC) MULTI-CHIP MODULE TECHNOLOGY	288
174 DK45 CERAMICS FOR RF & MICROWAVE APPLICATIONS	290

175 Anodization of 3D printed Al-10Si-Mg alloy	291
176 IMS -2 Bus (Indian Mini Satellite – 2 Bus).....	292
177 Ku Band Flat Panel Patch Array Antenna	294
178 Ka-band Flat Panel Meta-Surface Antenna	295
179 NavIC based Environmental Monitoring (NEMo) Drifter	297
180 Low Power NavIC / GNSS Baseband ASIC Receiver	299
299	
181 Octal Solid State Switch HMC	301
182 VHF-UHF TRANSCEIVER	303
183 Space Grade Traveling Wave Tube.....	305
184 Copper Plating Procedure on Tungsten-Rhenium helix for TWTA	307
185 Algorithm for Sugarcane Crop Production Estimation	308
186 Ceramic Adhesive (BMV-BOND)	310
187 CERACURE 10A	311
188 C/SiC Fasteners for High Temperature Applications.....	312
189 DK-30 Ceramic.....	313
190 HEMSICOT.....	315
191 Methylvinylborosiloxane (BMV)	316
192 Ku Band ALC Channel Amplifier	317
General Technology Transfer Process.....	319

1 Indian Mini Satellite-1 (IMS-1) Bus

UR Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed small satellite platform which would enable low-cost access to space by providing dedicated platform for payloads for earth imaging, ocean and atmospheric studies, microwave remote sensing and space science missions with quick turn-around-time.



1.1 Bus Specifications

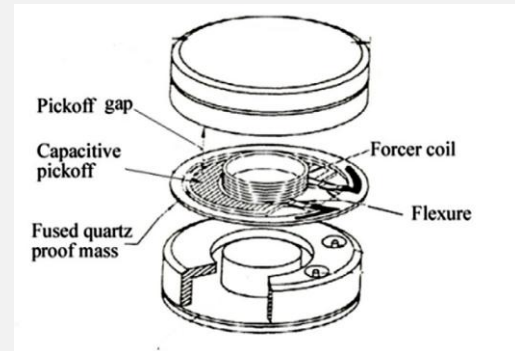
Parameters	Specifications
Stability	3-axes stabilized small satellite (Bus + P/L) of 100 kg Class
Structure	Size 600 (Y) x 552 (R) x 600 (P) mm ³
Pointing Accuracy	±0.1° (3σ) about all axes
Drift Rate	±7.5 x 10 ⁻⁰⁴ °/s (3σ) about all axes
Nominal Mission Life	2 years
Payload Mass	30 Kg
BDH	32 Mbps
Interfaces	LVDS, 1553, Standard TM/TC Interface
Solar Panel	Solar Array consists of two wings, each having one panel of size 0.915 x 0.83 m ²
Power	330 W (EOL with one string failure)
Battery	Lithium-ion battery of 27.2 Ah capacity
Attitude Sensors	Magnetometer -1 No., 4 PI Sensors, micro-Star Sensors, micro-IRU
Reaction Control System	Magnetic Torquers (2nos. of 20 A-m ²) Reaction Wheels (4 Nos. of 1 Nm-s @ 8000 RPM & 0.02 Nm) Thruster of 1N-1No. Tank- 7.5-litre Volume
SSR	32 Gb
Thermal	Thermistors - 48, FTS- 16, PRTs – 10, Thermocouples – 2, On-board heaters-28

1.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

2 Ceramic Servo Accelerometer (CSA)

IISU designed, developed quartz-based servo accelerometer called Ceramic Servo Accelerometer (CSA) for launch vehicle and spacecraft applications. CSA is a pendulous, forced rebalanced, analog, servo accelerometer with built in electronics. The core technology element of CSA is a monolithic flexure pendulum made of fused quartz, with special pick off coating and is indigenously developed at IISU.



2.1 Major Specifications

SL. No	Parameters	Specification
1	Range	±25 g
2	Scale Factor (SF)	-1.25 mA / g ± 15%
3	Bias	<±30 mg
4	Input Axis Misalignment	<±600 arcsec
5	Scale Factor Short-term stability	±50 ppm
6	Bias Short-term stability	±50 µg
7	Misalignment Short-term stability	<10 arc sec
8	Bias Warm-up to Warm-up Stability	<500 µg
9	SF Warm-up to Warm-up stability	<225 ppm
10	Misalignment Warm-up to Warm-up Stability	<36 arcsec
11	Non-Linearity	<±30 µg / g ²
12	Scale Factor Temperature Coefficient	<±150 ppm/oC
13	Bias Temperature Coefficient	<±150 µg/oC
14	Band width (-3dB)	> 300 Hz
15	Mass	60 grams
16	Power	0.6W (In +/- 1g Range)
17	Size	38mm dia. x 21mm height

2.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

3 ISRO Laser Gyro (ILG)

ISRO Inertial Systems Unit (IISU) indigenously designed, developed, qualified ring laser gyroscopes, called ISRO Laser GYRO (ILG), for the launch vehicle and spacecraft applications and inducted the same in ISRO's programs. The core technology of ILG is a RF excited, prism based square optical cavity resonator of 22 cm path length.

3.1 Features:

1. ILG is DC in - Angle out, miniature Ring Laser Gyro with 22cm path length.
2. It is a Total Internal Reflection Prisms based, square cavity, active ring laser gyro.

3.2 Major Performance Specification

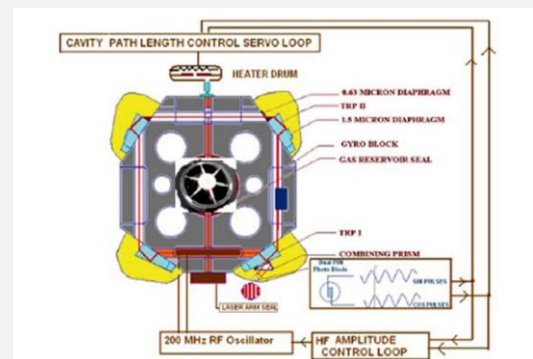
1. Maximum rate : +400 deg/sec
2. Scale factor : 0.77 arc sec/pulse + 1%
3. Absolute Bias : < + 1 deg / Hr.
4. Input axis misalignment : < 800 arc.sec
5. Scale factor Nonlinearity : <50ppm
6. Scale factor Asymmetry : <50ppm
7. Angle random walk : 0.02 deg/ \sqrt{hr} .
8. Bandwidth : 17.2 + 1Hz (Software trimmable)
9. Magnetic sensitivity : 0.1 deg/hr/gauss
10. Temperature sensitivity of bias : <0.02deg/hr/ oC

3.3 Performance Stability

1. Bias stability (1σ): 0.1deg/hr
2. Scale factor stability(1σ): <100ppm
3. Misalignment stability(1σ): <10 arc.sec

3.4 Physical Parameters

1. Size: 136 mm dia. X 100 mm height
2. Weight: 1.46 \pm 1 kg
3. Power (Nominal): 7 W



3.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

4 Lithium-Ion Cells

Lithium-ion cells are a cost-effective battery technology. It is a green alternative to fossil fuels. The technology is available for 1.5Ah, 50 Ah and 100 Ah cells.

4.1 Salient Features

Capacity	50 Ah	100 Ah	1.5 Ah
Nominal Voltage	3.6 V		
Positive Electrode	Lithium Nickel Cobalt Aluminum Oxide		
Negative Electrode	Graphite		
Cell Case and Lid	Aluminum alloy		MS/SS
Terminal Seal	Ceramic to Metal		Plastic Compression
Separator	Polymeric Separator		
Electrolyte	Lithium salt dissolved in organic solvents		
Cell Dimensions in mm	130 x 123 x 50 (W x H x T) approx.	130 x 208 x 50 (W x H x T) approx.	18650 types
Cell Mass	~ 1.5 kg	~2.7 kg	40 g
Energy Density	≥140 Wh/kg		
Operating Temperature	10°C to 30°C		
Cycle life	>1500 cycles at 80% DOD		
Calendar life	>15 years		
Vibration	25 'g' in sine mode, 17.25 'grms' in random mode and Transportation 8 'g'		10 'g' in Sine mode, 13.5 grms in Random
Leak rate	Less than 10-8 mbar L/s		Less than 10-5 mbar L/s
Safety features	Rupture disc and Shutdown separator		Shutdown separator, PTC, CID

4.2 Applications

Lithium-ion cells find large societal applications in Electric Vehicle transport and communication areas.

4.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs/industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

5 C/Ku Ortho Mode transducer for Combined C/Ku Receive Feed Systems

Space Applications Centre has developed a C/Ku Ortho Mode Transducer for combined C/Ku receive feed systems. Such an Ortho Mode Transducer permits combination of separate C and Ku terminals into a single system thereby effecting infrastructure and cost savings.

5.1 Technical Description

The polarization and frequency diplexing for combined C/Ku Feed system is carried out by two distinct OMTs on each for the respective bands. The Ortho Mode Transducers serves to separate the incoming signals depending on the polarization and the frequency and make them available at distinct ports for further processing. The configuration for OMTs in the respective bands differs as considerations for realizing requisite in band performance are different. The OMTS are connected by appropriate waveguide transitions.



5.2 C Band OMT

The C band OMT configuration comprises of a common circular waveguide with different diameters at both ends which communicates both C and Ku band signals. The signals of vertical and horizontal polarization are coupled through a pair of axial slots placed around

5.3 Isolation

1. C -Band Lin-V to Lin- H: 35 dB min
2. C -Band to Ku-Band: 70 dB min
3. Ku -Band Lin-V to Lin- H: 35 dB
4. Ku-Band to C-Band: 70 dB

The periphery of the common circular waveguide at an angular interval of 90° between the slots. The slots are uniquely profiled for effecting coupling of the C band signals and not degrading the Ku band signals. The symmetrical configuration and unique profile of the slot ensures that no higher order modes are generated at such discontinuities which may degrade the Ku band signals. The branching waveguide network then communicate the coupled signals from each pair of slots to suitable power combining components such as Magic T, one each for the

respective polarization.

5.4 Applications

VSAT Network

ISRO offers to transfer technology of combined C/Ku Receive feed system to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities.

5.5 Ku Band OMT

The Ku band OMT consist of a central circular waveguide closed at one end with four branching rectangular waveguides symmetrically arranged around it. A pair of such collinear rectangular waveguides communicates signals of the same polarization to the power combining network. The central circular waveguide consists of a unique matching element. The matching element serves to affect a good match for the incoming signals. The symmetrical configuration chosen is to circumvent that no higher order modes are generated at the common junctions. The power combining network can either be affected with Magic T or simple E plane bifurcated waveguide power combiners.

5.6 Specifications

1. Frequency Bands
C - Band: 3.7 GHz - 4.2 GHz
Ku - Band: 10.95 GHz - 12.75 GHz
2. Polarization
Dual - Linear [Lin- V/ Lin- H]
3. VSWR
C -Band : 1.65 @3.7 GHz - 4.2 GHz
Ku- Band : 1.4 @10.95 GHz - 12.75 GHz
4. Insertion Loss
C -Band : 0.5 dB [Typ] @3.7 GHz - 4.2 GHz
Ku- Band : 0.7 dB [Type] @10.95 GHz - 12.75 GHz

5.7 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs/ industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

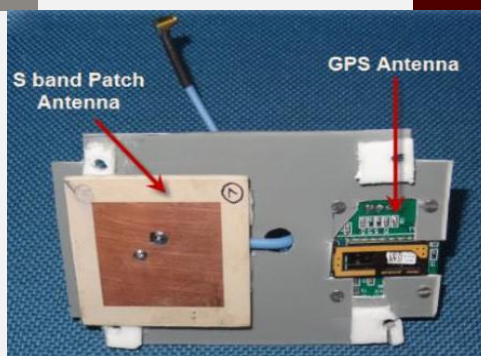
6 Dual Feed Square Patch Antenna for Reporting Terminal

6.1 Introduction

Designed and developed light weight compact volume profile Dual Feed Square Patch antenna for Reporting Terminal. Antenna is optimized with ABS radome & tested. Measured return loss is better than 17 dB over Transmit band. Measured gain and axial ratio is better than 2.5 dB and less than 3 dB up to theta $\pm 45^\circ$ in all phi planes. Antenna with radome is tested in terminal from GSAT-6 Satellite.

S. no.	Parameters	Specifications
1.	Frequency band	2.67-2.69 GHz
2.	Return loss	Better than 17 dB
3.	Gain	2.5 dB at theta $\pm 45^\circ$ in all phi planes
4.	Axial ratio	Less than 3 dB at theta $\pm 45^\circ$ in all phi planes
5.	Size	44x44x3 mm ³
6.	Weight	12 gm

6.2 Developed Hardware:



6.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

7 Dual Feed Square Patch Antenna for Broadcast Receiver

7.1 Introduction:

Designed and developed light weight compact volume profile Dual Feed Square Patch antenna for Broadcast receiver. Antenna is optimized with ABS radome & tested. Measured return loss is better than 17 dB over receive S band. Measured gain and axial ratio is better than 2.5 dB and less than 3 dB up to theta $\pm 45^{\circ}$ in all phi planes. Antenna with radome is tested in terminal from GSAT-6 Satellite.

S. no.	Parameters	Specifications
1.	Frequency band	2.56-2.59 GHz
2.	Return loss	Better than 17 dB
3.	Gain	2.5dB at theta $\pm 45^{\circ}$ in all phi planes
4.	Axial ratio	Less than 3dB at theta $\pm 45^{\circ}$ in all phi planes
5.	Size	70x70x5 mm ³
6.	Weight	30 gm

7.2 Developed Hardware:



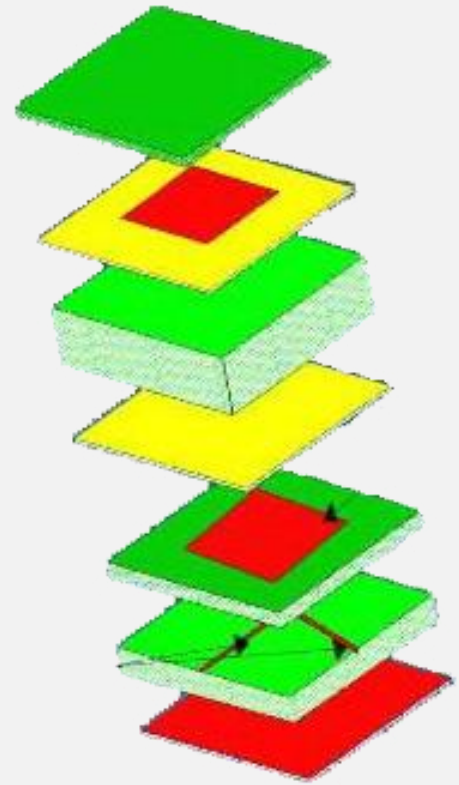
7.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

8 Multilayer Printed Antenna Technology

Space Applications Centre of ISRO has developed multilayer printed antenna array technology. Salient features of the technology include light weight structure, can be made conformal to the surface, computer controlled automated fixture for aligning layers, inspection of layers and bonding of layers. There is an ever-increasing demand of multilayer printed antenna from mobile communication to very sophisticated space qualified active phased array antenna systems.

The design includes the usage of new light weight & low dielectric constant material for high radiation efficiency, low surface wave propagation and low cross polar suppression. Development includes fixture capable of performing surface roughness using laser, inspection of PCB, high speed drilling, vacuum bagging for bonding all the antenna layers and vacuum gripping for pick and place.



8.1 Terminal Specifications

Antenna Type	: Planar
Cross Polarization	: Better than -30 dB
Beam width and Gain	: As per specifications (Efficiency better than 60%)
Bandwidth	: Up to 40% (2.1 VSWR)
Polarization	: Vertical/ Horizontal/ Circular
Size	: Up to 1.2 M x 1.2 M
Alignment	: 20 microns
Inspection	: 10 microns
Repeatability	: 5micron
Curing Chamber	: 1.3 M x 1.3 M
Magnification	: 50 x / 100 x





Clean Room : Class 1 lac

Drilling Speed : 40,000 rpm

8.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

9 Design of Ku/C/L and S Band Cassegrain Feed

Space Applications Centre of ISRO has designed Ku/C/ L/S band Cassegrain feed for its own payload missions. These feeds are used in earth station antenna.

Earth station antenna is used to provide communication and/or tracking, telemetry and tele-command to various in-orbit satellites. Earth station antenna for communication and/or tracking for geostationary orbit satellites typically consist of Main reflector, sub-reflector, feed system, LNA, power amplifiers, control units, network control management and its associated circuitry.

One of the most important elements in earth station antenna is feed system. Feed system is used to transmit/ receive power from amplifier to sub/main reflector. It also serves to provide the desired radiation patterns to reflectors to achieve the specified gain. Feed system combines / separates different polarizations and/ or transmit/ receive/ tracking frequency bands. It is the feed system's insertion-loss, return-loss, tracking performance, radiation patterns, polarization and transmit/receive isolation, power handling capability - which determines the overall earth station antenna performance, governs EIRP and G/T.

So, ISRO offers to transfer technology of different feeds to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities

9.1 Specifications

S. no.	Item description		Specifications
1.	Operating Frequency	Transmit	10.70 GHz to 12.00GHz
	Receive		12.75 GHz to 14.00GHz
2.	Feed Type		4 port LP rotatable frequency re-use feed. 2 ports for Tx and 2 ports for Rx.
3.	Feed Insertion Loss Receive	Transmit	< 0.6dB
			< 0.5dB
4.	Feed VSWR at feed flange		1.3:1 Typical
5.	Power Rating		2.4 KW CW Per Port
6.	Waveguide Interface	Receive	CPR 75 (square flange, four hole) CPR
		Transmit	75 (square flange, four hole)
7.	Isolation		> 35dB
		Tx-Tx Rx-	> 35dB
		Rx Tx-Rx	> 85dB
		XPD	> 30dB

Note- Above is the specs of feed system which will be compliant to 7.2m Cassegrain antenna.

9.2 C band LP/CP Cassegrain feed for 7.2m and 11m antenna

S. no.	Item description		Specifications
1.	Operating Frequency	Receive	3.625-4.200 GHz
		Transmit	5.850-6.425 GHz

2.	Feed Type		4 port selectable LP/CP frequency re-use feed. 2 ports for Tx and 2 ports for Rx.
3.	Feed Insertion Loss	Receive Transmit	< 0.9 dB < 0.8 dB
4.	Feed VSWR at feed flange		1.3:1 Typical
5.	Power Rating		2.0 KW CW Per Port
6.	Waveguide Interface	Receive Transmit	WR 137 (for 6 GHz band) WR 229 (for 4 GHz band)
7.	Isolation	Tx-Tx Rx-Rx Tx-Rx XPD	> 35 dB > 35 dB > 85 dB > 30 dB

Note- Above is the specifications of feed system which will be compliant to 7.2m and 11m Cassegrain antenna.

9.3 L and S band Cassegrain feed for 11m antenna

S. no.	Item description	Specifications
1.	Antenna Size and Type	11-meter Cassegrain Antenna
2.	Feed type	4 port circularly polarized L & S Band receive only feed system
3.	Operating Frequency L Band S Band	1150 to 1650 MHz 2475 to 2540 MHz
4.	Gain at Feed Output	39.4 + 20 log (F/1.15) dBi (L Band Rx) 45.4 + 20 log (F/2.475) dBi (S Band Rx)
5.	G/ T at 5 deg. Elevation	17.9 dB/ deg K + 20 log (F/1.15) (L Band) 23.4 dB/ deg K + 20 log (F/2.475) (S- Band)
6.	Polarization (Rx)	Dual Circular (RHCP/LHCP) in both the bands
7.	VSWR	1.5: 1 Typical in both Receive Bands
8.	Axial Ratio within 1 dB BW	1.5 dB in both Receive Bands
9.	Feed Insertion Loss	<0.9 dB
10.	Rx to Rx port isolation in both bands	20 dB min.
11.	Rx Pattern	Shall conform to ITU-RS 580-5. Typical first side lobe level shall be better than 14 dB.

Note- Above is the specifications of feed system which will be compliant to 7.2m and 11m Cassegrain antenna.

10 Patch Array Antenna for Portable Multimedia Terminal

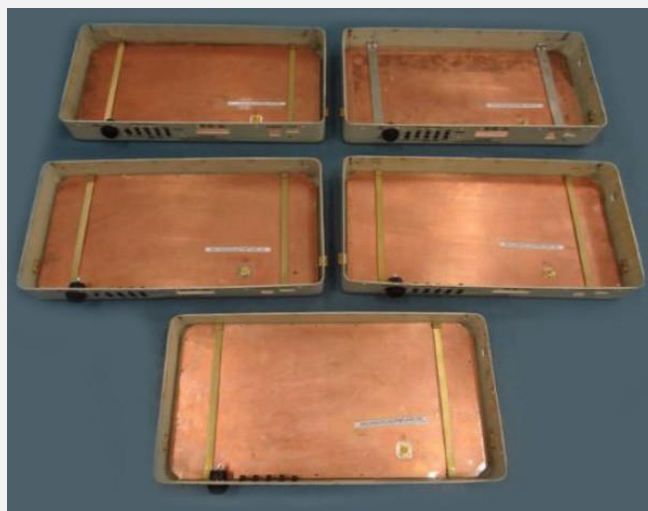
10.1 Introduction:

Designed and developed light weight Electromagnetically coupled Stacked Patch array antenna. 8-element Dual Feed Square Patch array is used for required gain. Antenna is optimized with ABS radome & tested. Measured return loss is better than 17 dB over Transmit/Receive band. Measured gain and axial ratio is better than 15.5 dB and less than 1 dB. Antenna with radome is tested in terminal from GSAT-6 Satellite.

10.2 Features:

S. no.	Parameters	Specifications
1.	Frequency band	Rx: 2.56-2.59 GHz Tx: 2.67-2.69 GHz
2.	Return loss	Better than 17 dB
3.	Gain	15.5 dB
4.	Axial ratio	Less than 3 dB
5.	Size	385x195x12 mm ³
6.	Weight	280 gm

10.3 Developed Hardware:



10.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

11 X band Wide Scan Active Phased Array Antenna

11.1 Design Features

1. Multilayer Microstrip antenna
2. Suitable for wide scanning up to 60 degrees
3. Wide Bandwidth as compared to contemporary
4. system
5. Available simulation tools and customized code 12 for planar antenna



Planar Array Antenna Facility

11.2 Major Specifications

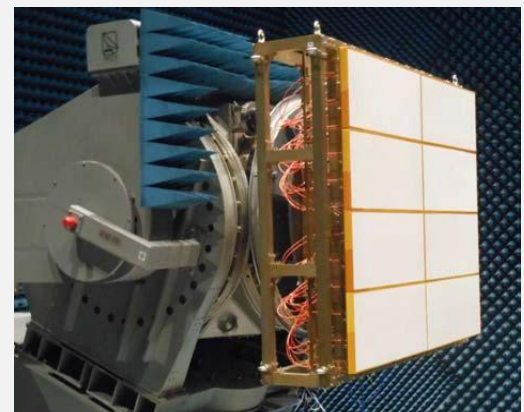
- Frequency: L band to X Band
- VSWR: 1.5:1
- Gain: better than 20 dB
- Bandwidth: 5-10 %
- Polarization: Vertical, Horizontal & Dual
- Peak Power: up to 15% Duty Cycle
- Scanning Capability: Azimuth $\pm 60^\circ$, Elevation $\pm 60^\circ$
- Measurement of Active Antenna Element Pattern



CATF Facility

11.3 Capabilities

1. Multilayer Antenna development facility at SAC
2. Qualified Materials for sustaining extreme
3. Temperature range
4. Compact Antenna Test Facility for Accurate Pattern
5. Measurement
6. Developed & characterized wide scan active



7. phased array antenna
8. Developed 8X8 X band planar array antenna

11.4 Applications

Wide scanning antenna

Tracking radar

Phased array antenna

11.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

12 Rapidly Deployable Multi-band VSAT Terminal for Disaster Management

A m-VSAT antenna terminal is designed specifically for any application requiring a compact, rugged, multi-band antenna which is rapidly deployable with no or minimal tools. It includes a multi-segmented glass fiber high density foam reflector, ensuring a very cost effective, light weight and excellent strength with very less deformation, even after being re-assembled hundreds of times. The m-VSAT terminal has a unique multi-band ring focus feed assembly allowing a change of frequency band in a matter of minutes simply by swapping out a quick release feed latch.

It is fully motorized and it can automatically acquire and track, even on inclined orbit satellites. Features such as fully adjustable wide spreading legs for high stability on any terrain.

For transportation it packs into its own mount which splits into two conveniently sized flight cases and one feed carrying case for transportation.



12.1 Applications area

Highly useful in Disaster situations which quickly deployable, requiring minimal tools, light weight, easy to transport VSAT system. This system is compliant for ISRO satellite/commercial band.

12.2 Specifications:

S. no.	Key Specifications	
1.	Antenna Type	Circular, Axially Symmetric with Ring Focus with Central Hub plus 6 Petals
2.	Diameter	1.8 m
3.	Configuration	Gregorian Ring Focus
4.	Polarization	Linear, orthogonal transmit & receive
5.	Power Requirement	250 V AC Power Supply
6.	Temperature	-20 to +70° C- Transport & Storage -10 to +60° C- Operational
7.	Wind Rating	Operational- 60 km/h with gusts to 72 km/h Survival- 120 km/h

8.	Altitude	4500 m
9.	Humidity	100%
10.	Elevation Adjustment	0 to 90°
11.	Azimuth Adjustment	+/- 170°
12.	Polarization Adjustment	+/- 95°
13.	Packed Size	Box-1: 1 m x 1 m x 1.2 m Box-2: 1 m x 1 m x 0.5 m Box-3: 0.85 m x 0.43 m x 0.83 m
14.	Weight	Box-1: 90 kg Box-2: 30 kg Box-3: 30 kg

12.3 Technology Transfer from ISRO

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13 Compact L5 Band Ceramic Antenna

Compact L5 band ceramic antenna is a compact RCP Microstrip patch antenna, designed and developed by VSSC/ISRO. This antenna uses a high dielectric constant ceramic substrate ($\epsilon_r=65$) to achieve size reduction. The ceramic substrate is also indigenously developed by VSSC/ISRO and its technology is also available for transfer.

Portable navigation devices require compact antennas that can be accommodated with minimum space requirements. Compact L5 antenna can be effectively utilized in the NavIC receivers which requires a right circularly polarized (RCP) antenna operating at L5 (1176MHz) frequency with return loss less than 10dB and axial ratio less than 3dB.

13.1 Applications area

1. Can be used in navigation devices that work with NavIC/IRNSS or any other navigation system working on L5 frequency.
2. Compact size of the proposed antenna makes it
3. best suited for portable applications.

Parameter	Value	Remarks
Frequency	1176 MHz	
Band width	+5	@10 dB return loss
Peak Gain	-2 dBi	
Polarization	RCP	
Axial Ratio	<3 dB	@1176 MHz
Beam Width (3 dB)	120°	
Feed type	Coaxial	
Dimensions	25 mm x 25 mm x 4 mm	

13.2 Technology Transfer from ISRO

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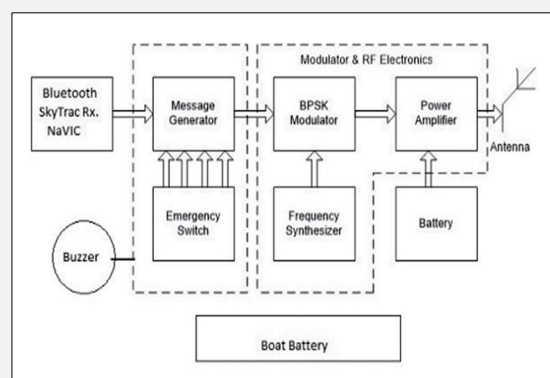
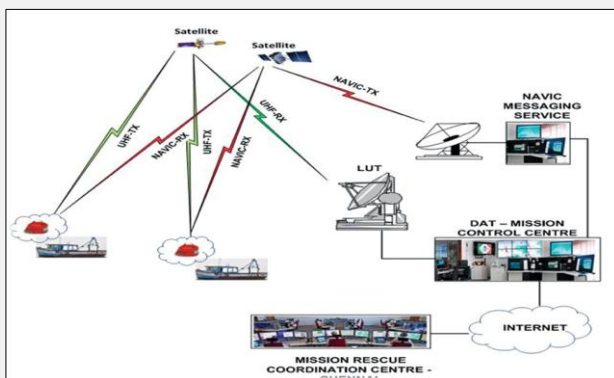
14 Distress Alert Transmitter (DAT-SG)

Space Applications Centre (ISRO) has developed the Distress Alert Transmitter-Second Generation (DAT- SG) which is a UHF transmitter based on NavIC receiver module. This NavIC receiver module supports position determination as well as broadcast messages reception called NavIC messaging service. The end users are mainly fishermen of small boats who can use this device for emergency messages reporting with position information and the unit can also help them receive useful information like Potential Fishing Zone, weather alerts etc. as supported by NavIC messaging service.



14.1 Features

Modulation	BPSK/QPSK
Data Rate	300bps
Amp. Imbalance	± 0.3 dB
Phase Imbalance	± 3 deg.
Waveform	BPSK with rate $\frac{1}{2}$ FEC
Output Power	5 W [37 dBm \pm 1 dB]
Power supply	7.2V Primary Lithium Battery



14.2 Features

1. Emergency message reporting from Deep Sea to
2. Control Station
3. Processing and display of alert received at the Control Center (HUB) and dissemination of received emergency
4. information to Maritime Rescue Coordination Centers

5. Transmission of emergency position and Distress alerts

14.3 Technology Deliverables

1. Schematics, Gerber
2. Hex code for firmware
3. Limited Support for Development

14.4 Present Platform details

1. Microcontroller: MSP 430
2. Frequency: UHF
3. NavIC: SkyTraQ

14.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

15 Personnel Tracker

15.1 Salient Feature

1. Position information in TDMA / Aloha mode of
2. operation
3. Supports Small message as well as data transfer
4. through satellite
5. USB/Bluetooth user data Interface
6. Handheld with battery operated
7. Light weight and size within bond of
8. 220x80x40 mm



15.2 Specifications

1. Single Patch antenna with minimum 2.5 dBi gain over ± 45 deg beam-width
2. Terminal EIRP: -1 dBW with 0.5W Power Amplifier
3. Burst Mode Transmission at 1.2/ 2.4 kbps with maximum payload of 80 char
4. Convolution rate $\frac{1}{2}$ coding for forward error correction
5. BPSK/QPSK modulation Channel spacing: 10.0 KHz



15.3 MSS Network

1. MSS Network with five user beams covering India
2. User position display on GIS map in real-time
3. Received user message forwarding from MSS HUB through Email, FTP etc.
4. Web Based GIS support available



15.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

16 Two Way MSS Terminal For Vessel Tracking

SAC, ISRO has developed low data rate two-way MSS terminal for tracking of small boats using in-house developed modem ASIC.



End usage: Vessel Tracking

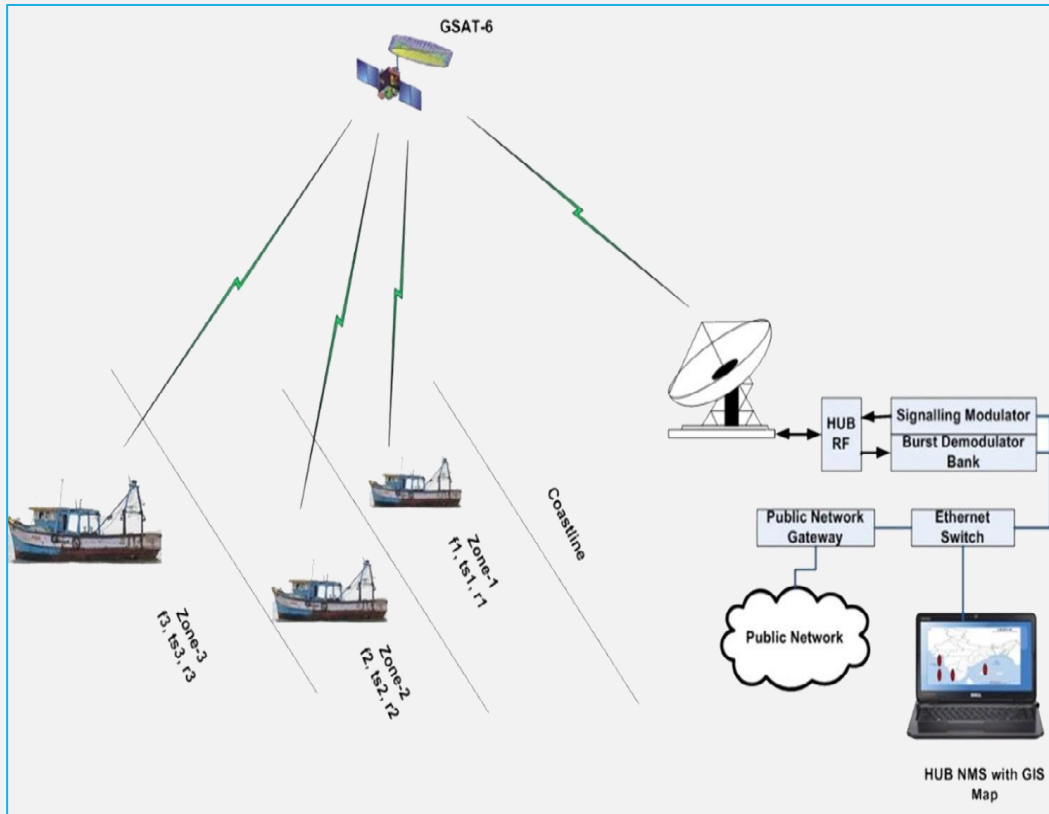
16.1 Specifications

1. Single patch antenna having 2.5 dBi gain over ± 45 deg beam-width
2. Terminal EIRP: 3.0 dBW min.
3. 250 ms time slot for reporting
4. Rate $\frac{1}{2}$ forward error correction
5. QPSK Modulation
6. Channel spacing 10.0 KHz

16.2 Salient Features

1. Forward Link: 9.6 kbps
2. Return Link: 2.4 kbps
3. Channel Access- Dynamic TDMA
4. In-built GAGAN/ NavIC for position
5. Bluetooth/Wi-Fi user interface
6. Mast mountable
7. IP65 compliance package
8. Battery backup & light weight





16.3 Applications

It is developed for tracking of small boat; Other possible application be used for:

1. Message Services
2. Disaster warning dissemination
3. Potential fishing zone dissemination
4. Asset Tracking Services

17 Mobile Satellite Services Terminal (Broadcast receiver)

Broadcast receiver (handheld receive only terminal for multichannel reception of audio and Video)

17.1 Features

1. Reconfigurable DVB-S Receiver: 512 Kbps to MSPS
2. USB Powered
3. Supports Windows / Android OS
4. Power Consumption: < 1.8W
5. Weight: 180 gm (Without tablet/display)
6. Broadcast Receiver for multichannel video, news,
7. emergency message etc.



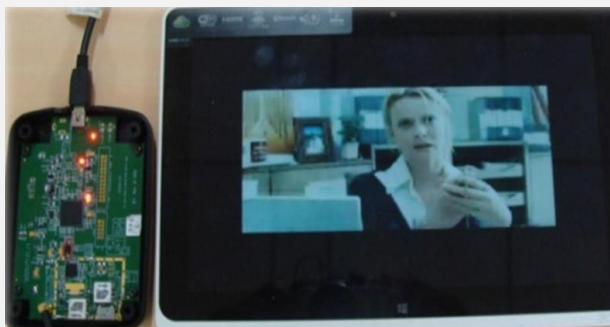
17.2 Specifications

1. Single patch antenna having 2.5 dBi gain over ± 45 deg.
2. Terminal G/T: -23.0 dB/K
3. DVB-S Waveform: QPSK Modulation with 1/2
4. Convolution + RS encoding (204,188)
5. Bandwidth required: 1.5 MHz @ 1.024 Mbps
6. Single carrier broadcast.



17.3 Major Applications

1. Multichannel Reception of Audio, Video & Data (From Hub to terminal)
2. Usable on moving vehicles



18 Mobile Satellite Services Terminal (Portable Multimedia Terminal)

Portable Multimedia Terminal

18.1 Features

1. Support video, voice and data communication between terminals
2. Portable terminal
3. QPSK Modulation
4. Size: 400 x 200 x 55 mm
5. Weight: 3.0 Kg



18.2 Specifications

1. 8 patch antenna having 15.5 dBi gain
2. Terminal EIRP: 17.0 dBW at 2W power amplifier
3. Terminal G/T: -9 dB/OK
4. Data rate: 144 Kbps
5. FEC: Convolution rate $\frac{1}{2}$ / (Rate $\frac{1}{2}$ Convolution +
6. RS Code (112,126))
7. Bandwidth required: 194.4 KHz
8. Channel spacing: 200 KHz



18.3 Major Applications

1. Video-conferencing
2. Two-way IP based data-transfer
3. Mobile Hot Spot
4. IP Telephony



19 Mobile Satellite Services Terminal (Reporting Terminal)

Reporting Terminal (Handheld Data Reporting Terminal)

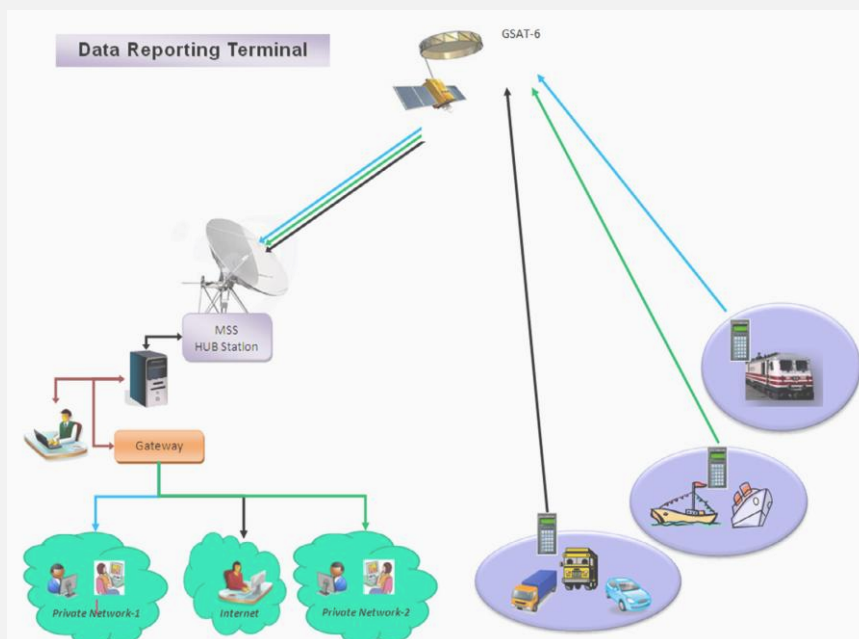
19.1 Features

1. Support 1.2 Kbps data rate from terminal to HUB
2. Small message reporting
3. In-built GPS to provide position
4. RS232/USB/ Bluetooth user data interface
5. Low Power & Weight



19.2 Major Applications

1. Terminal to Hub Location Reporting
2. Data collection platforms
3. Short Message Services
4. Asset Tracking Services



19.3 Specifications

1. Single patch antenna having 2.5 dBi gain over ± 45 deg
2. Terminal EIRP: -1 dBW at 0.5W power amplifier
3. Burst mode transmission rate 1.2 Kbps (Terminal
4. to HUB)
5. 1 sec. time slot to accommodate large no of
6. terminal in single carrier
7. Rate $\frac{1}{2}$ forward error correction
8. BPSK Modulation
9. Band width required 3.2 KHz
10. Channel spacing 10.0 KHz

20 Mobile Satellite Services Terminal (Satellite Mobile Radio)

Satellite Mobile Radio (Handheld Terminal for Two-Way Voice and Text Message Comm.)

20.1 Features

1. Support voice communication between terminal and any other telecom network PSTN & Mobile network
2. Small message communication between terminals
3. Handheld with Size: 155 x 200 x 80 mm
4. Weight: 1.25 Kg

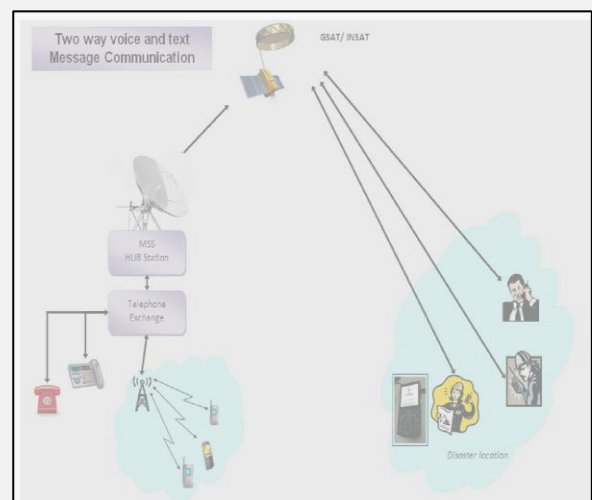


20.2 Specifications

1. Antenna with 2.5 dBi gain over ± 45 deg
2. Terminal EIRP: 0.5 dBW at 1 W power amplifier
3. Terminal G/T: -23.0 dB/0K
4. Voice compression at 2.4 Kbps gives voice quality better than 3.5 MOS
5. Transmission rate: 2.7 Kbps
6. Convolution Rate $\frac{1}{2}$ forward error correction
7. BPSK/QPSK Modulation
8. Band width required: 3.7 KHz
9. Channel spacing: 10.0 KHz

20.3 Major Applications

1. Voice communication
2. Terminal to Terminal
3. Terminal to PSTN/Mobile Network
4. PSTN/Mobile Network to Terminal
5. Small Text Message Communication



21 Two-Channel Digital Monopulse Tracking Receiver for Earth Station

The two-channel digital monopulse tracking receiver for earth station is a 70-MHz monopulse tracking receiver. The monopulse tracking receiver is one of the sub-systems of monopulse antenna tracking system in large earth stations. It generates DC error signals proportional to antenna off-pointing by processing the input IF signals in digital domain. These output error signals are used to drive the antenna in appropriate direction to correct the off-pointing error.



Salient Features

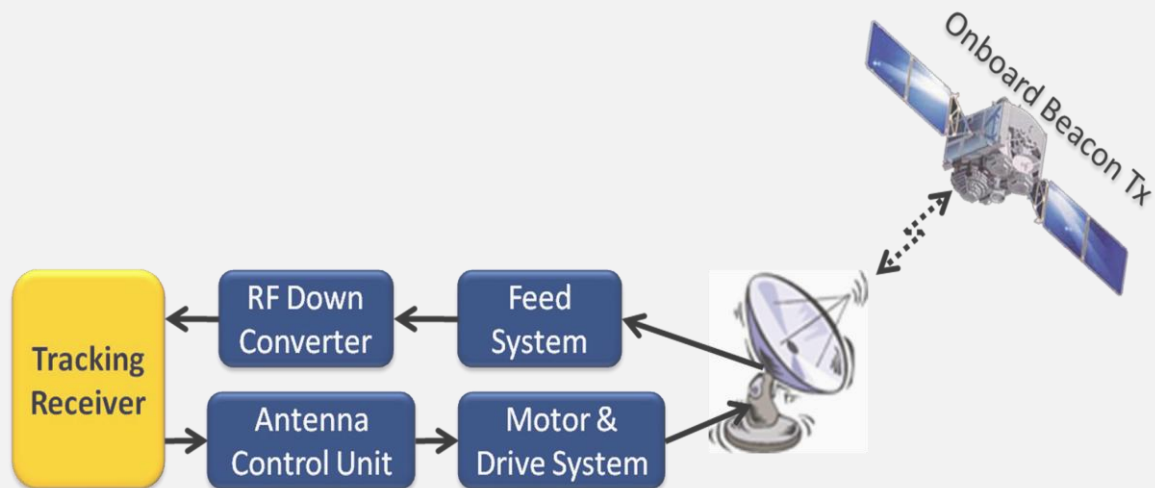
- i. Wide Tracking Range : 70 MHz \pm 250 KHz
- ii. Wide dynamic range: 80 dB
- iii. Selectable loop BW: 300 Hz, 1 KHz and 3 KHz
- iv. Low input C/No threshold : 36 dBHz
- v. Selectable Tracking Range: 50 KHz, 150 KHz & 250 KHz
- vi. User friendly Monitoring & Control for Local and Remote operation
- vii. Save/ Recall configuration for different satellite
- viii. DC Error signals output : Analog and Digital
- ix. Low cost, flexible, easier production
- x. 19 inch rack mountable 3U chassis

Testing

- i. POC model has been tested using Stimulus Generator in laboratory
- ii. Completed in-system-testing at MCF, Bhopal
- iii. and successfully tracked various satellites

Applications

- i. GEO Satellite Earth Station Antenna Tracking
- ii. LEO Satellite Earth Station Antenna Tracking



21.1 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

22 NAVIC Messaging and Positioning Receiver

22.1 Introduction

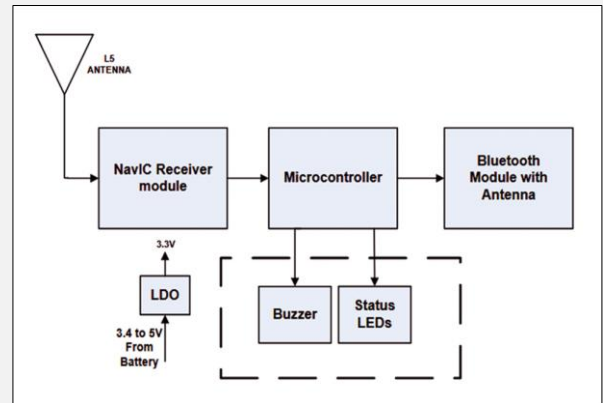
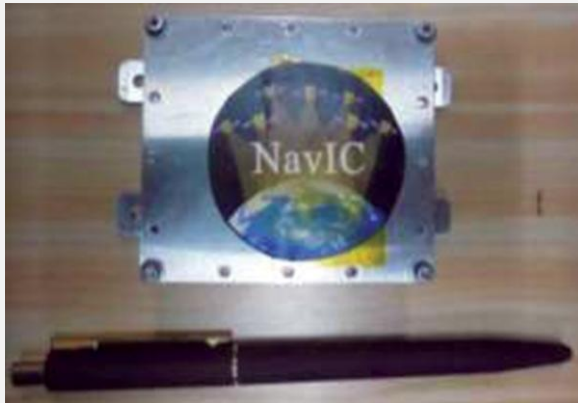
NavIC Satellite Constellation have a wide coverage area up to 1500 km around the Indian main land. They are mainly designed for Regional Navigation Services. In addition to their primary functionality, they allow broadcasting of additional short messages. These messages can be related to alerts, forecast and directives on the occurrence of natural disasters like floods, earthquake, tsunami, cyclones, landslides etc. and dangers for the safety of life in areas with poor or no communication infrastructure. The NavIC Messaging Receiver is conceptualized and developed at Space Applications Centre (SAC), ISRO, Ahmedabad for reception and display of these messages. The receiver transmits raw data over Bluetooth link. An application running on a smart device like mobile phone or tablet having Bluetooth connectivity can decode and display the messages for users. This receiver is designed as battery operated low power device. This note describes hardware architecture and requirement for product.

22.2 Objective

SAC has developed working prototype hardware. Product can also be used by fishermen/ marine applications in deep sea. IP67 packaging is to be designed by vendor along with battery charging option. Vendor participation is invited for production of same hardware in large numbers.

22.3 Design

NavIC Messaging receiver has been designed to provide positioning along with messaging. NavIC module can be procured from ANTRIX Corporation Limited, Bengaluru, a commercial arm of ISRO. In addition to the NavIC chipset, it uses ATmega328P microcontroller and HC-05 Bluetooth (BT) module. The controller provides configuration for chipset and BT module. Microcontroller acts as an interface between chipset and BT. The TPS73633DBVT LDO converts 5V to 3.3V. It is designed to draw power from battery or power bank. The power consumption of the receiver is around 100mA @ 5V. The receiver can work for about 4 days using a 10000mAh power bank. The block diagram of NavIC messaging and positioning receiver is as shown in Figure-1. Currently all the data from NavIC receiver is passed over BT to mobile which is consuming more power in both receiver and mobile. The blocks in dotted section are getting implemented as future enhancement. The idea is to save power in both mobile and device. This will be achieved by filtering out the messages in microcontroller and pass only needed messages to the mobile application. Figure 2 shows actual photograph of NavIC messaging receiver. The current size of PCB is 41mm x 46mm. The size of PCB with enhance feature is 70mm x 50mm.



NavIC Messaging and Positioning Receiver Setup with power bank and Antenna

Above figure shows set up of receiver which has external antenna and it is drawing power from power bank. The receiver has been developed, tested, demonstrated and delivered to many users. An Android application is also developed to display the messages on Mobile phone / tablet. Messages by INCOIS can be received using this application.

22.4 NGE’s Responsibility

Interested NGE has to fabricate the receiver PCB and design packaging including all the three components. The package has to be IP 67 compliant. The option of using power bank or some rechargeable battery is left to vendor.

22.5 Technology Transfer from ISRO

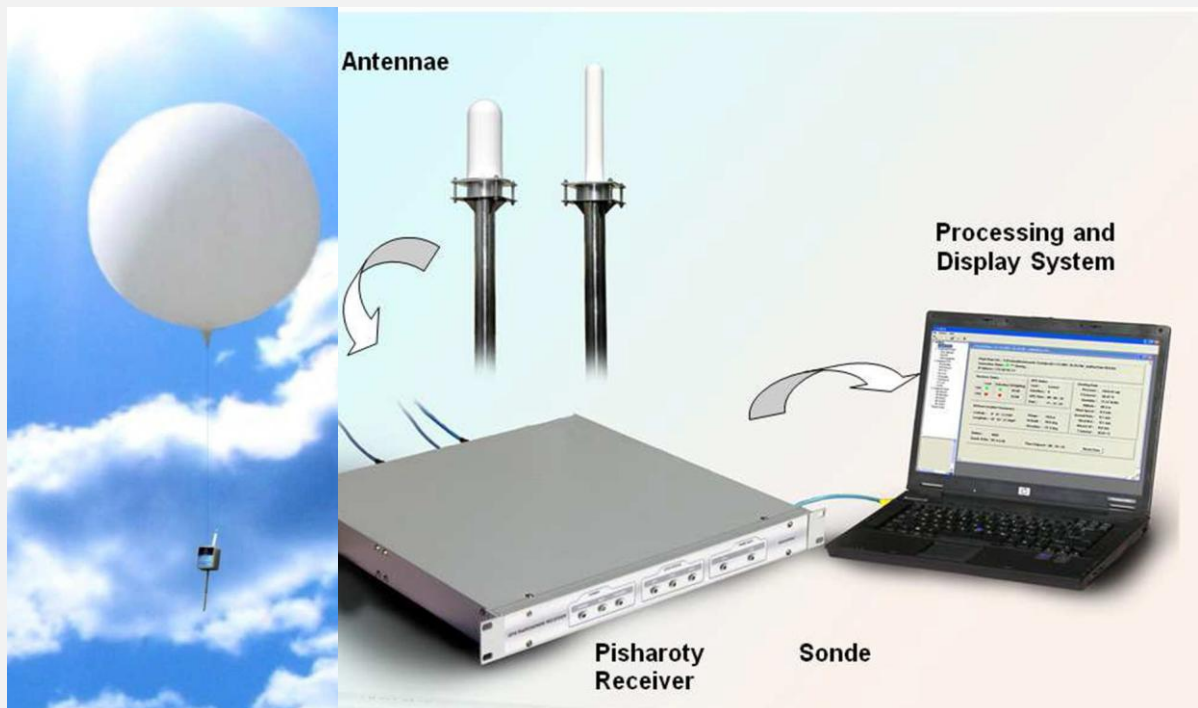
ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

23 Radiosonde

PisharotySonde system is an indigenous GPS Sonde (Radiosonde) system developed by VSSC/ ISRO using commercially off the shelf components (COTS) for high quality atmospheric parameter measurement.

The Sonde system consists of the balloon borne segment referred as PisharotySonde and the ground segment referred as PisharotySonde Ground Station. PisharotySonde uses sensors for measuring the atmospheric temperature & relative humidity and GPS receiver module for acquiring the wind parameters, altitude, date and time. Pressure information can be derived from the height and temperature information using software. Sensor and GPS data are processed and transmitted to ground station. PisharotySonde Ground Station consists of the Antenna Assembly & LNB, Receiver and Data Processing & Display unit. Sonde system incorporates the software for solar radiation correction on temperature measurement.

The Sonde system also generates the WMO specified 'temp' messages for reporting the data. This indigenous low-cost system is compact and light weight (125 grams). PisharotySonde system is validated by comparison ascents with various internationally available Sonde systems and the performance is confirmed. The system performance is evaluated independently by IMD and cleared for meteorological applications. More than 12000 Sondes have been already realized by ISRO.



23.1 Specifications of PisharotySonde SystemDescription

Description:	Range	Accuracy	Resolution	Response time
Pressure*	0 to 1030 hPa	±1.4 hPa (>100hPa) ±0.5 hPa (≤100hPa)	0.01hPa	NA
Temperature	-90 to 60 °C	±1°C	0.1°C	1s
Relative Humidity	0 to 100%	±5 %	0.1%	5s
Velocity range	0 to 500 m/s	0.1 m/s	0.01 m/s	NA

Pressure is derived from altitude

23.2 Sonde

1. Frequency : 400 to 406 MHz (user programmable)
2. Power : 17 dBm (50 mW)
3. Size : 12 cm x 11.5 cm x 9 cm
4. Weight : 125 gm
5. Battery : up to 4 hours operation

23.3 Ground Station Receiver

1. Frequency :400 to 406 MHz (user programmable)
2. Sensitivity :117 dBm @ 1x 10⁻³ BER
3. Connectivity : Ethernet
4. Power Supply:220-230 V AC, 50 Hz
5. Battery Backup :6 Hours
6. Size :47.5 cm x 23.5 cm x 4.5 cm (19 “rack mountable)

23.4 Applications

The PisharotySonde System is used by scientists for boundary layer studies and upper atmospheric observations. PisharotySonde system is used by Space Physics Laboratory (SPL) VSSC, MET TERLS VSSC, MET/SHAR, SAC, NESAC, NRSC and various universities for atmospheric studies. Data from the System is used regularly to support ISRO’s satellite launches. The System is identified as part of network of weather stations for thunderstorm observation in SAARC countries. Huge market demand also exists in atmospheric measurements by IMD, defence and academic institutions.

23.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

24 Satellite Gateway Unit (SGU)

The Satellite Gateway Unit (SGU) is useful to interface two different types of networks - LAN and synchronous serial communication over satellite. The SGU is a low-cost solution to transport IP/Ethernet frame over satellite network. It supports both unicast and multicast mode of communication. It can handle satellite channel signaling and conferencing call signaling that is useful in many SATCOM applications. All commercially available gadgets for packet-based data communication like - VoIP, Video phone etc., are having LAN interface, to introduce that equipment into satellite network, SGU required that efficiently converts the IP data format into a synchronous HDCL format and vice versa. It is having proper routing/ filtering mechanism to restrict unwanted traffic flows into the satellite link.

Satellite Gateway unit converts data between RS-422 to Ethernet. The unit is designed to work with internal clock or external clock selectable via jumper selection. The unit consists of total 8 communication channels and 1 control channel. The control channel is used to individually reset the communication channel via Ethernet port or via RS 485 port.



Front panel of 9-channel SGU



Back panel of 9 channel SG

24.1 Applications area

1. MSS services Hub base band systems as a gateway between synchronous serial interface of satellite systems and IP based hub baseband systems
2. VOIP phone over satellite network

24.2 Specifications:

No. of Communications Channels : 8, can be configured independently
 No. of M&C port/channel : 1, can be configured independently
 No of Processors per channels/m&c : 1, RABBIT 6710 (total 9 processors)

Ethernet ports at Front panel per channel : 1, 10/100 Ethernet RJ45 with Link

and Activity Indicator Ethernet Protocols

supported	: TCP, IP, UDP, RTP, HTTP
Communication Interface Data, Rx clock)	: RS422 synchronous (Tx data, Tx Clock, Rx Data, Rx clock)
Input Data Rate	: 2.4 Kbps to 384Kbps or higher
Clock selection	: Internal, External, Selectable
Communication interface protocols	: HDLC, Bi-sync, selectable
Communication Interface Connectors	
Back panel	: 9 PIN D type -male per channel
Communication LEDES Panel	: 3 nos (RXD, TXD, link) per channel Front Panel
Operating System	: Rabbit Bios
M&C interface	: RS485 and RS232, selectable
M&C Interface connectors- Back Panel	: 9 PIN D type -female
M&C LEDES- Front Plate	: 3 nos. (RXD, TXD& link)
Push type master reset switch	: On Front Panel
Enclosure	: Standard 19”, standard 1U size,
Rack Mountable Cooling Fan	: 2, one as inlet and second as outlet
Power supply with EMI/RFI filter Connector on Rear panel with Power supply cable	: 230VAC with standard 3 pin
Power on/off switch - front panel	: Yes
Power indicator-front panel	: Yes
Temperature range	: 0 to +50 deg C
Humidity	: 5% to 95%, non-condensing

SGU is being used as a part of operational GSAT-6 MSS services Hub base band system for portable multimedia services and satellite Mobile Radio services (two-way voice communication) at DES and at AES.

24.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

25 Low Cost Multi Standard Satellite Receiver (Data DTH) Technology

Integrated module, size:1U (can be further decreased by vertical PCBs stacking)

Space Applications Centre (SAC) has developed a low-cost satellite receiver by interfacing a USB TV tuner and Raspberry pi supporting multiple digital TV standards such as DVB-C/T/S/S2/S2x with tuning range from 950-2150 MHz at 1-45 Msps symbol rate for DVB-S/S2 standard and is successfully tested with GSAT-19 satellite link for the reception of Audio, video and data simultaneously for different symbol rates. In-house developed Akashganga application (A data repository application for admin and client side) is successfully deployed and tested on developed low-cost receiver. The developed system can serve as an improvement for existing DTH set top box with data port at low cost.



25.1 Specifications

1. A common power supply has been designed for the integrated module working at standard 230V AC for easy operation. Earlier design required separate power supplies for both Tuner and Raspberry Pi.
2. Receiver supports multiple standards such as DVB-C/T/S/S2/S2x with tuning range from 950- 2150 MHz at 1-45 Msps symbol rate for DVB-S/S2.
3. Receiver works on Linux based Operating System (Raspbian) which offers added security aspect as compared to windows.
4. Single line terminal commands to scan, tune and lock the receiver.
5. Receiver is IPTV supportable.
6. Wi-Fi functionality in receiver allows user to connect it via mobile/Tablet and access information/data remotely.

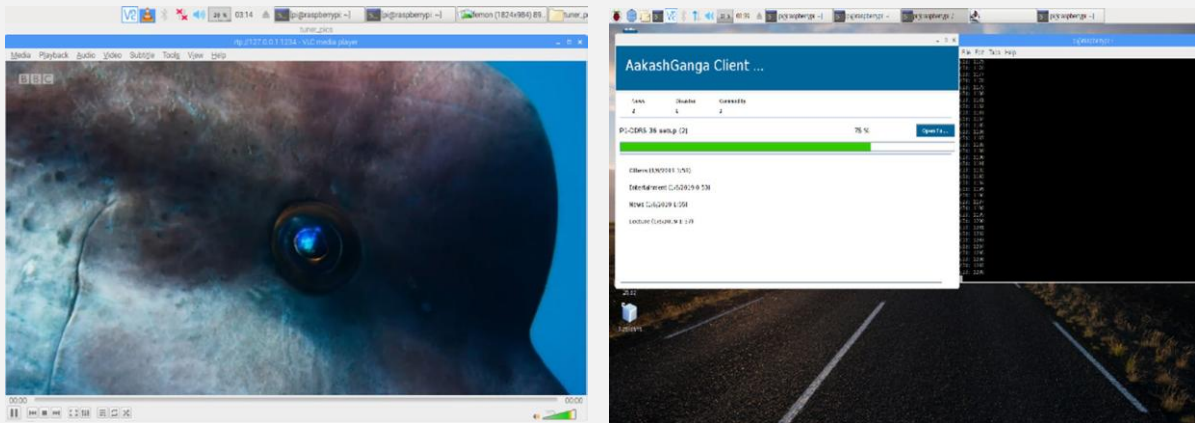
7. Standard F-Type(Female) RF/LNB input
8. connector.
9. Lock state and power indicator LED is provided.
10. Small size and low cost.

25.2 Future developments

1. System modification in progress to make it DVB- S2X reception compatible too which will further enhance its performance.
2. To make it more compact and portable i.e. battery operated.

25.3 Program Linkage/Application Areas

1. ISRO's Tele-Education broadcasting program and Disaster Warning System.
2. Can be deployed at information Kiosks at remote locations where terrestrial network is not available.

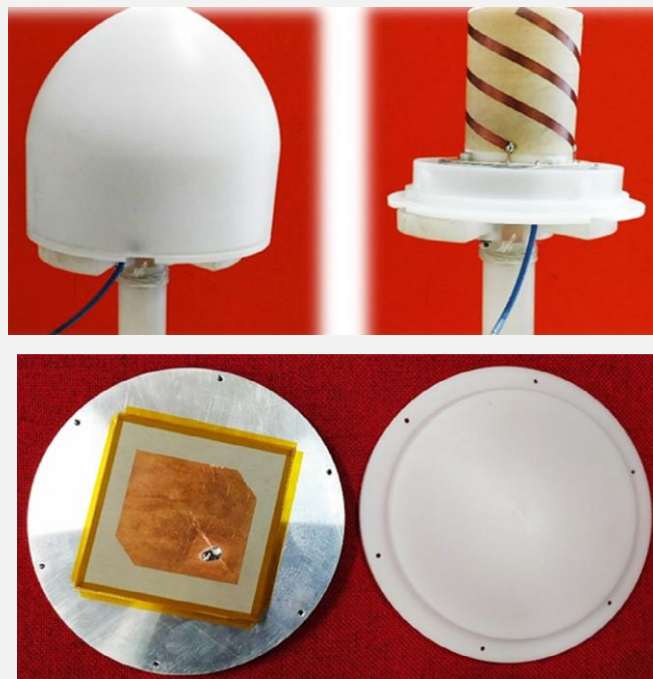


25.4 Technology Transfer from ISRO

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26 Pseudolite Based Navigation System

Space Applications Centre (SAC) has developed Pseudolite based navigation system (PBNS) which is a standalone ground-based navigation system and provides an alternate means for navigation without using any Global Navigation Satellite System (GNSS). PBNS is a kind of NavIC system on ground with coverage up to 10 km range. Pseudolite Based Navigation System has two major segments which includes Ground Segment and User Segment. Ground segment consists of 10 pseudolite transceivers which generate BPSK modulated navigation signals and transmits them at S-band frequency in pulse-CDMA mode. User receiver which is on-board an aircraft receives signals from ground-based transmitters and processes them to compute user position after time synchronization.



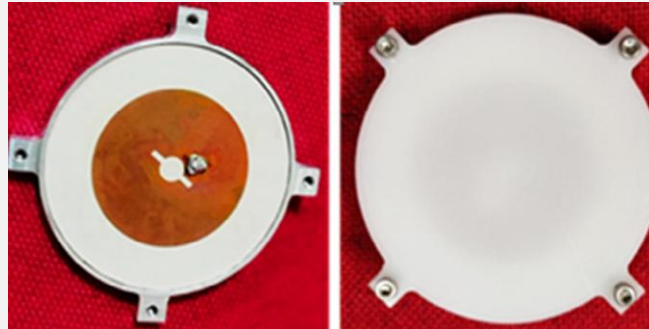
Pseudolite System Parameters

Parameter	Unit	Value
Transmit Frequency	MHz	2414.28
EIRP	dBW	6 (maximum)
Transmit Mode	0 to 100%	Pulsed
Duty Cycle	%	10

26.1 Application Areas

The developed system will be helpful in minimizing the impact of the degradation of the GNSS services when used with in combination with GNSS as well. PBNS is also expected to support the positioning services for key operational capabilities for aircraft landing while maintaining full system capacity and also will support GAGAN for Cat III precise landing in future. PBNS will also be useful for navigation

of unmanned aerial vehicles in both civil and strategic domains and interplanetary missions such as navigation on Mars as well.

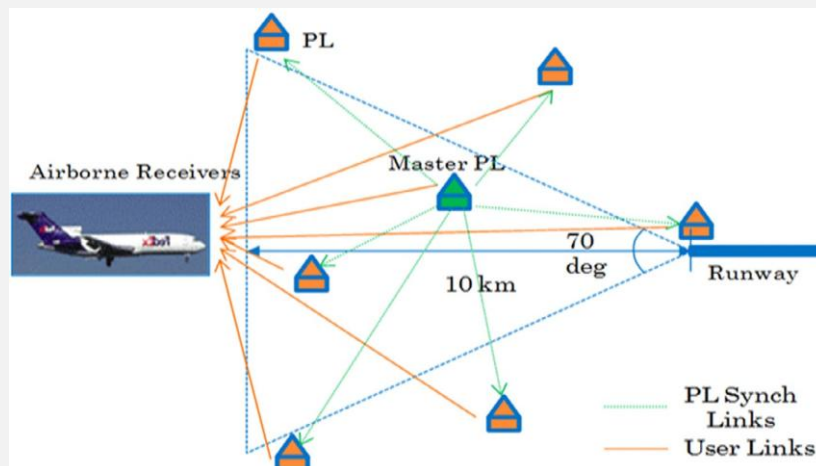


Such a standalone system will also be worthy in scenarios where:

1. GNSS is not available
2. GNSS is compromised/denied
3. GNSS is not feasible to be use

26.2 Specifications:

1. PBNS is a standalone system which works without any GNSS.
2. PBNS works with low-cost pseudolite transceivers and do not use atomic clocks.
3. PBNS is a passive ranging self-synchronized system.
4. PBNS uses S band ISM license free spectrum.



Concept of Pseudolite-Based Navigation System

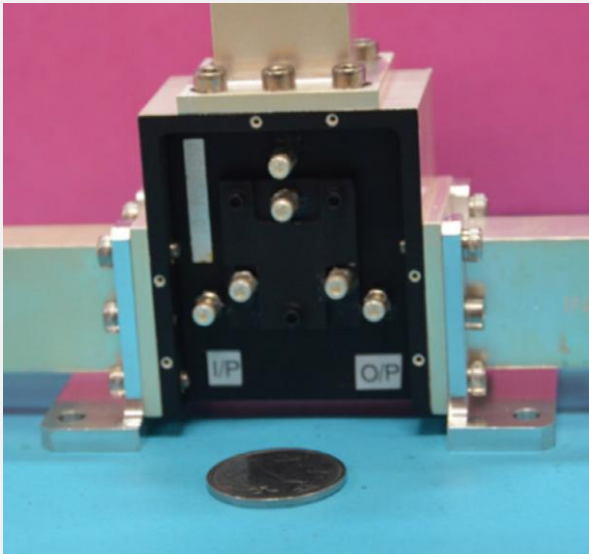
26.3 Technology Transfer from ISRO

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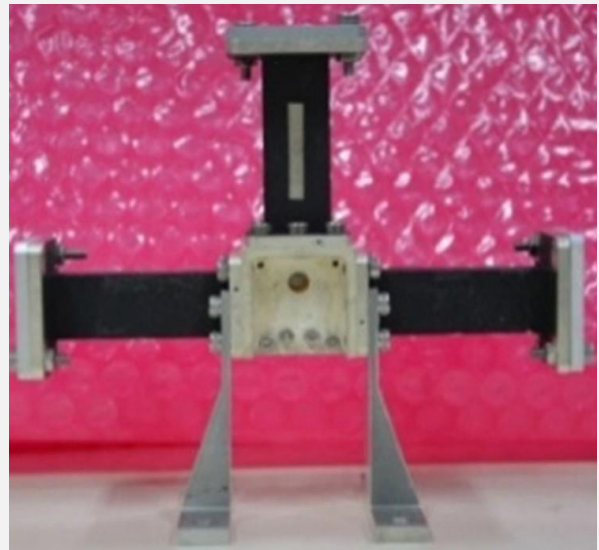
27 Ferrite Based Wave Guide Circulators and Isolators

Space Applications Centre (SAC) has developed Ferrite based high power waveguide circulators at Ku band and Ka band and low power isolators at Ka band have been successfully qualified for space use.

A circulator is an important non-reciprocal device which has wide applications in conventional communication and radar systems both as a duplexer and an isolator. It is used to provide perfect match conditions to devices connected at its input and output by isolating them.



Ku Band HP WG Circulator



Ka Band HP WG Circulator



Ka Band Low Power Isolator

27.1 Applications area

Industries involved in the development of high-power transmitters and low power

receivers for space based and terrestrial applications at these frequencies are the potential users.

27.2 Specifications:

1. Y-junction ferrite waveguide circulator
2. State of the art design with similar performance
3. Thermally stable performance over -10 to 75 °C due to excellent thermal design for handling high power
4. Wide band design to cover entire allocated frequency bands at Ku and Ka band

S. no.	Parameter	Specification		
		Ku Band High Power	Ka Band High Power	Ka Band Low Power
1	Frequency Range (GHz)	10.7-12.75	17.7-20.7	27.5-30.5
2	Insertion Loss (dB)	< 0.15	< 0.2	< 0.2
3	Return Loss (dB)	> 21	> 21	> 20
4	Isolation (dB)	> 21	> 21	> 20
	Power Handling (W)			
5	Average (Forward+Reverse)	210	130	Low Power
	Peak	840	520	

27.3 Technology Transfer from ISRO

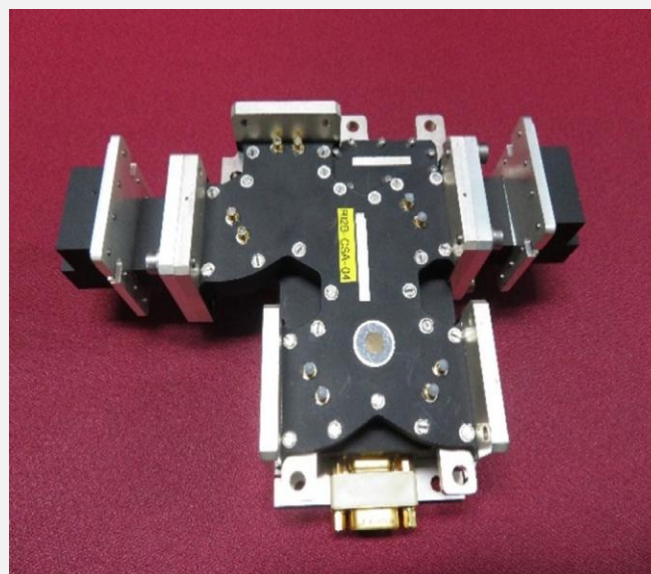
ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment

28 High Power Circulator-Switch Assembly

The X-Band circulator-switch assembly is a 3-port system for signal duplexing between the payload transmitter and receiver systems in SAR payloads where a single antenna is used for both transmission and reception of signals. It protects the receiver during transmit window and isolates the transmitter during receive window. It consists of 01 ferrite circulator and 02 ferrite switches inside each unit. It has switching time of under 2.5us and is capable of handling up to 2kW peak power and 440W average power in space. The switches are commanded by a 5V TTL input from the payload controller which synchronizes the CSA with the transmit and receive timings of the payload.

28.1 Specifications:

1. Very fast switching speed of under 2.5 us
2. Isolation of 60dB between transmitter and receiver during transmit window.
3. Transmit loss of 0.25dB and receive loss of 0.85dB over 600 MHz at operating temperature range
4. Capable of high RF power handling. Tested for power handling and multipaction up to 500W average and 6kW peak RF power at thermo- vacuum conditions.
5. In-built driver for generating magnetic flux based on external TTL input.
6. The unit has undergone thorough space qualification including
7. S-parameter characterization from -150C to 550C at vacuum
8. Qualification level vibration & mechanical shock.
9. Multipactor & vacuum power handling testing at 6kW peak and 440W average power respectively



28.2 Applications

The Circulator-Switch Assembly is the crucial front-end element of high power microwave remote sensing payloads where a common antenna is shared by the high power transmitter and the low power receiver. It protects the receiver by providing more than 60dB of isolation during the transmit window. With switching speed as low as 2.5us, it is also the duplexing mechanism between transmit and receive signals of the payload.

The CSA is subject to the full payload output power and hence tested up to 6kW of peak power and 440W average power. Typical transmit loss of the unit is better than 0.25 and receive path loss better than 0.85dB over 600 MHz bandwidth at 9.6 GHz center frequency.

Specifications for 8 X 8 Butler Matrix	
Parameter	Specifications
Frequency	9.3 – 9.9 GHz
Transmit path Loss (over 600 MHz) (from -150C to 550C)	0.25 dB (max)
Receive path Loss (over 600 MHz) (from -150C to 550C)	0.85 dB (max)
Return Loss (600 MHz)	16 dB(min)
Peak Power Handling	2 KW
Average Power Handling	440W
Full power operating temperature (base-plate)	-100C to 500C
Switching Speed	2.5us (max)
Interface	WR90 waveguide
Mass	0.7 kg (max)

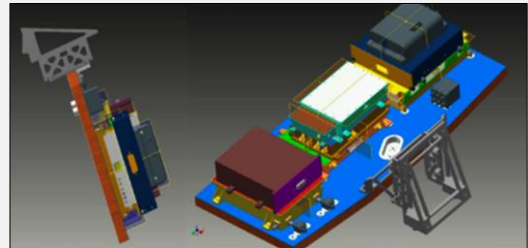
28.3 Technology Transfer from ISRO

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29 Mini SAR: X Band Airborne SAR

29.1 Salient Features

1. A miniaturized airborne synthetic aperture radar@X band.
2. Spatial resolution of around one foot.
3. Swath: 5 km.
4. Imaging in stripmap mode.
5. Single, dual or circular polarization.
6. Weight: 5.5kg SAR electronics.
7. SAR designed for airborne platform height of 3km to 10 km @ maximum Velocity of 120 m/s.



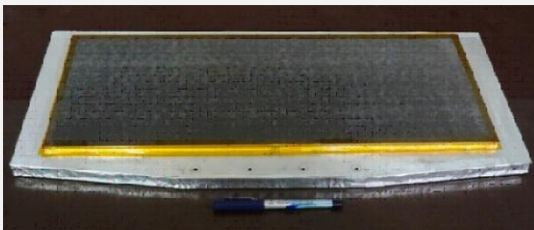
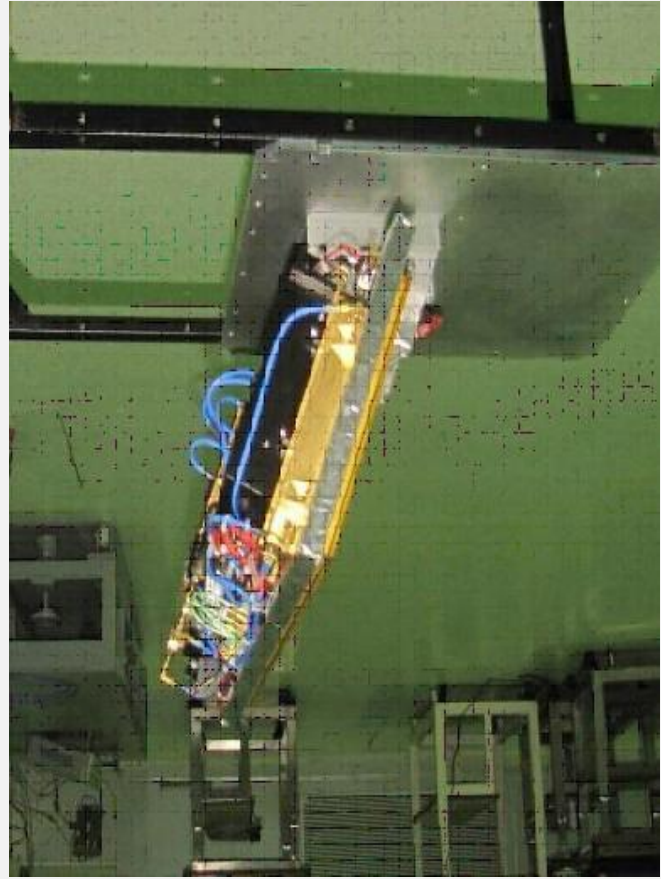
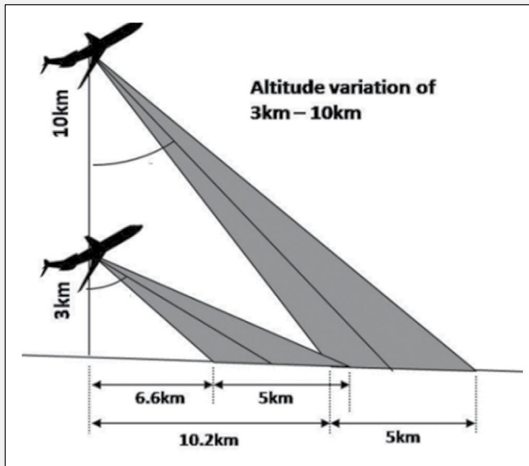
29.2 Mini SAR: Technology

1. Light weight, dual polarized, broadband, X-band, planar Antenna.
2. Compact GaN MMIC based dual polarized Solid state Power Amplifier with pulse modulators.
3. MMIC based multi frequency and broadband X Band LFM Frequency Generator on single board.
4. LTCC based dual polarized, Low noise, high gain Receiver.
5. Miniaturized Pulsed/CW electronic power conditioners.
6. High speed quad channel digitizer and High speed, wide band direct digital chirp synthesis-based Chirp Generator.
7. Inbuilt Payload Controller for Control, Coordination and status monitoring and timing and control signal generation for different subsystems.
8. Operator Console software.
9. High speed miniaturized Solid State Recorder.

29.3 Potential Applications

1. High resolution imaging
2. Disaster management
3. Urban planning
4. 'Anytime imaging', day or night from

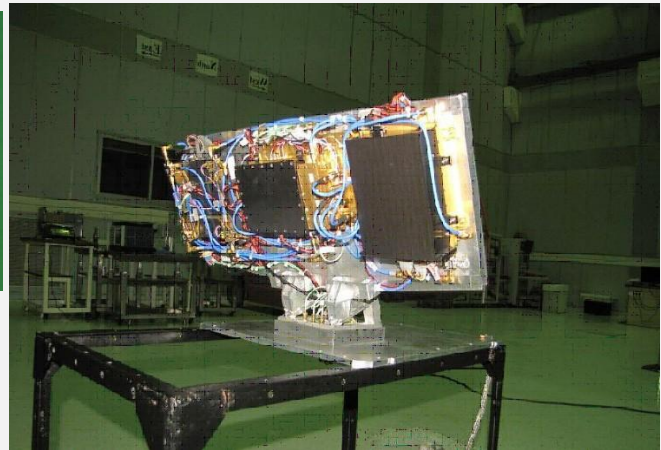
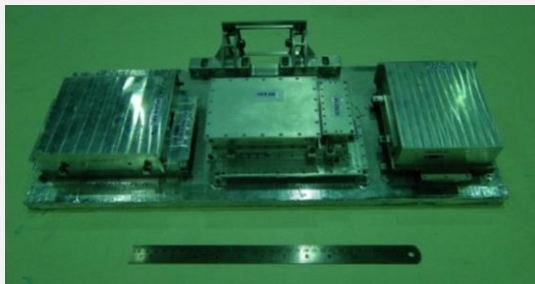
5. airborne platform



Weight : 5.5Kgs

Size : 260mm X 590 mm X 110mm

DC Power : 130W



29.4 Technology Transfer from ISRO

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30 SCPC Modem IP Core

SAC has designed and developed a SCPC modem IP core performs modulation & demodulation for enabling two communications through satellite network. Modem takes binary data from user, performs scrambling, FEC encoding & pulse shaping operations and provides modulated complex baseband samples for DAC. Similarly, it demodulates the modulated signal & performs FEC decoding & descrambling operations and provides binary data at output. SCPC modem has serial synchronous data interface with HDLC encapsulation option for packet type data.

Modulation	BPSK/QPSK
Data Rate	32Kbps-2Mbps
Data Interfaces	Serial Synchronous
Forward Error Correction(FEC)	Conv. (K=7, R= 1/2, 3/4) +Reed Solomon (short)- optional
Scrambler	V.35 (IESS-308)
Phase Ambiguity	Differential Encoding/ Decoding
Acquisition Range	< ±Symbol Rate/8
Encapsulation	HDLC / Custom (details to be provided)
Required Eb/No for BER of 1x10-6	6.0 dB (including implementation margin)
Dynamic Range	30 dB
ADC/DAC interface	12 bit I/Q Samples

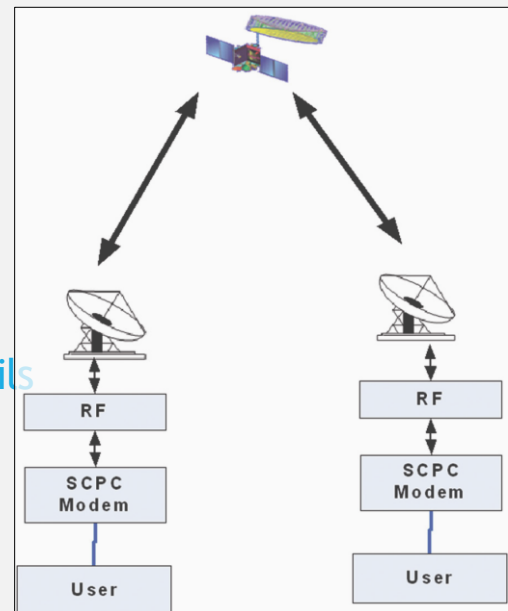
30.1 Applications

1. In SATCOM Hub stations & terminals for enabling two-way point to point communication in continuous mode
2. Two-way Audio/video & data communication over satellite network

30.2 Deliverables: Present Platform Details

FPGA	Xilinx Artix-7
RF Transceiver	AD9364/AD9361
Tx/Rx Frequency	L-Band
Data Interface	Serial/Ethernet

- Bit file/Encrypted Netlist of the HDL IP is provided.
- One time(limited) HDL IP porting support is



30.3 Technology Transfer from ISRO

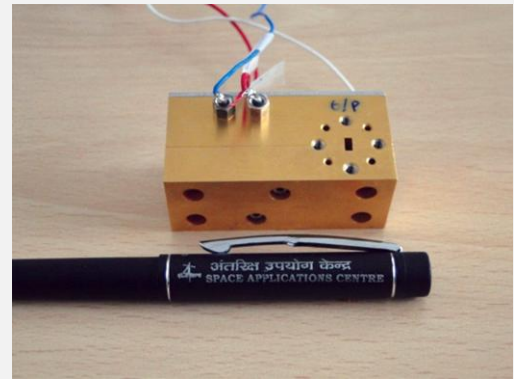
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31 V Band Low Noise Amplifier

Space Applications Centre of ISRO has developed a low noise amplifier designed at V band. It operates at 50 - 60GHz and gives a gain of 7-10dB. The typical noise figure is less than 5dB. It is also a medium power amplifier with 14 dB output power at 1dB gain compression. The amplifier has waveguide WR-15 interface at the input and output

31.1 Typical Applications

1. EW Receivers
2. Weather & Military ultra-wideband radar applications
3. Ultra-wideband communication networks



31.2 Salient Features

1. Frequency : 50-60GHz
2. Noise Figure : 5 dB
3. Gain : 8.5dB (Higher Gain option available)
4. Output Power at (@P1dB) : 14dBm
5. DC power consumption : 80mA, 3V
6. Input / Output : Waveguide WR15

Frequency (GHz)	Gain (dB)	noise Figure (dB)	P1dB (dBm)	DC Bias
50-60	8.5dB±1.5dB	5	14	3V,80mA

31.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

32.21 NA Pressure Transducer

Indian Space Research Organization (ISRO) at its Liquid Propulsion Systems Centre has developed a novel 21 NA Pressure Transducer, which will find wide industrial and commercial applications.

32.1 Principle of Operation

21NA Pressure transducers which is space qualified has outstanding features such as light weight, high accuracy and ruggedness. These transducers are intended for absolute pressure sensing. The active element is a stainless-steel membrane which senses the pressure to be measured. The membrane transmits a force in proportion to the pressure, to an isostatic beam on which four active strain gauges are bonded in a wheat stone bridge circuit. These transducers are totally enclosed, adequately temperature compensated and are designed to operate even under adverse environmental conditions. They are hermetically sealed and suitable for high humidity environment as well. Any failure of the sensing element will be contained within the sensor and no catastrophic damage outside is ensured. These transducers have a heritage of long-term use in satellites as well. These sensors have 30 years heritage in ISRO launch vehicle programmes. These transducers are mainly meant for application in the areas of aerospace, process industries, air and gas compressors, oil and gas, wind tunnel studies etc.

32.2 Advantages & Salient Features

1. Compact & Light weight
2. Hermetically Sealed
3. Can withstand Shock 50grms
4. Vibration resistance upto 30grms
5. High Dynamic response
6. Compatible with corrosive fluid environments.

32.3 Application

1. Aerospace
2. Defense
3. Process Industries
4. Atomic energy
5. Air and Gas Compressors
6. High Dynamic response



7. Compatible with corrosive fluid environments.
8. Oil and gas industry.
9. Automobiles Wind
10. Tunnel Studies etc.
11. Oceanography

32.4 Specifications:

Measuring Ranges (Bar)	0-3, 0-5, 0-7, 0-10, 0-15, 0-20, 0-30, 0-50, 0-70, 0-100, 0-200, 0-300 and 0-330 Bar.
Nominal Excitation	10 V DC \pm 5 m V
Safe over load For 0-3 to 0-20 bar For 0-30 bar For 0-50 to 0-200 bar For 0-300 to 0-330 bar	2X Nominal pressure 40 bar 2X Nominal pressure 500 bar
Full Scale Output (FSO) For 10 Volts Excitation	20 to 21 m V
Non-Linearity + Hysteresis For 0-30 to 0-300 Bar For 0-330 Bar	\leq 0.7% FSO \leq 0.85% FSO
Hysteresis	\leq 0.5% FSO
Sensitivity	2-0. -0.1 mV/V
Zero & Nominal point drift in temperature	\leq 2 X 10 ⁻⁴ / FSO/ 0C
Noise Due to Vibration	\leq 1% FSO
Mass	\leq 100 grams
Electrical interface	Multi-pin hermetically sealed connector

32.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

33 Differential Pressure Transducer (DPT)

Indian Space Research Organization (ISRO) at its Liquid Propulsion Systems Centre has developed a novel Differential Pressure Transducer (DPT), which will find wide industrial and commercial applications.

33.1 Principle of Operation

A DPT is used where the difference in pressures at two points are to be measured. The forces developed due to these pressures (say P1 and P2) act on a balanced beam called sensing element. Four resistance foil strain gauges are bonded on this sensing element beam which deforms proportionately to the difference between P1 and P2. The electrical output signal is positive when P1 is greater than P2 and vice versa. A mechanical stopper limits the deflection of sensing beam within the specified limits.

The DPT can be used for liquid medium or gaseous medium or even a combination of both. They are hermetically sealed and suitable for high humidity environment as well. Any failure of the sensing element will be contained within the sensor and no catastrophic damage is caused to the system.

33.2 Advantages & Salient Features

1. Rugged
2. Hermetically Sealed
3. Vibration resistance
4. Compatible with corrosive fluid environments.

33.3 Application

1. Aerospace
2. Atomic energy
3. Process Industries
4. Air and Gas Compressors
5. Oil and gas industry's



33.4 Specifications:

Differential pressure range	$\pm 3, \pm 5, \pm 7, \pm 10, \pm 20$
Line pressure	65 bar Safe
overload	75 bars
Excitation	10 V \pm 5 mV
Output	10m V \pm 5 mV
Non-Linearity + Hysteresis	$\leq 0.5\%$ F.S. O
Hysteresis	$\leq 0.3\%$ F.S. O
Sensitivity	$\pm 1\text{mV/V} \pm 0.1$
Zero & F.S.O drift in temperature	$\pm 3 \times 10^{-4}$ /F.S. O/o C
Noise due to vibration	$\leq 1\%$ F.S.O Mass ≤ 950 gms
Maximum current	28 mA @ 10 V.D.C
Wetted parts	Stainless steel, 316L/304L
Electrical interface	Multi-pin hermetically sealed electrical connector

33.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

34 HLP-85 Temperature Sensor

Indian Space Research Organisation (ISRO) at its Liquid Propulsion Systems Centre has developed a novel HLP-85 Temperature sensor, which will find wide industrial and commercial applications.

34.1 Principle of Operation

Accurate and reliable measurement of temperatures in high pressure gaseous and liquid media requires dedicated and specialized thermocouple probes. The Thermocouple probe HLP-85, developed at ISRO, is qualified for measuring temperature under severe environmental conditions posed by the propellants high pressure and corrosive nature. The sensor has a heritage of 25 years in ISRO launch vehicle programmes.

The sensor uses basic elements like Chromel / Alumel with sheath and thermo well materials like 5.5 AISI 304/316/Inconel. The sensor uses unique construction techniques to obtain noise immunity and high response.

34.2 Advantages & Salient Features

1. Fast response
2. Wide Temperature ranges
3. Less Weight
4. Shock & Vibration resistance
5. Highly linear

34.3 Application

1. Space application
2. Process Industries
3. R&D Laboratories
4. Defence Application
5. Atomic
6. Commercial Application
7. Oil & Gas Industries



34.4 Specifications:

Temperature Range	-196 °C To +250 °C
Thermo Couple	K Type (0.5 Φ) Chromel-Alumel

Junction	Ungrounded
Pressure (Max)	350 Bar
Time Constant	≤ 0.3 s
Material Of Sheath	AISI 304 L/Z2 CN 18-10 (SS)
Insulating Material	MgO
Sensitivity	41μV/°C
Accuracy	0 to 100 °C ±3 °C; 0 to -196 °C ±7 °C
Mass	
Electrical interface	Multi pin hermetically sealed connector.

34.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

35 IDLV Pressure Transducer

Indian Space Research Organisation (ISRO) at its Liquid Propulsion Systems Centre has developed a novel IDLV Pressure Transducer, which will find wide industrial and commercial applications.

35.1 Principle of Operation

The IDLV stands for Integral diaphragm type pressure transducer, which is an absolute pressure sensor that is space qualified. The transducer has the unique characteristic like high accuracy output, rugged construction and hermetic sealing.

It has 5 fabricated parts and is especially suited for high volume production due to ease of fabrication and assembly. It has a machined diaphragm made of stainless steel for 0-30 bar to 0-500 bar pressure ranges. Four foil strain gauges are bonded on the diaphragm to measure the strain developed in it. The diaphragm is specially cryo treated to ensure high long-term stability. In order to reduce power consumption 1000Ω strain gauges are selected.

Another advantage of this transducer is that it can be customized to operate in any range from 30 bar to 500 bar. Additionally, any damage to the sensing element will be contained within the sensor thus avoiding any sort of catastrophic damage in the system.

35.2 Advantages & Salient Features

1. Any range from 30 to 500 bar can be custom designed and manufactured.
2. Compatible with corrosive & Harsh fluid environments
3. Fully Stainless Steel Constructed
4. E.B Welded and hermetically sealed
5. Low Cost
6. High Accuracy
7. Rugged
8. Shock 50grms
9. Vibration resistance upto 30grms
10. High Dynamic response



35.3 Application

1. Space

2. Defense
3. Oceanography
4. Atomic energy
5. Oil and gas industry
6. Automobile
7. R & D laboratories
8. Biomedical engineering
9. Mining safety etc.,
10. Process industries

35.4 Specifications

Range in bar	30, 50, 70, 100, 200, 300, 330 & 500 Bar (currently manufactured ranges).
Safe overload (Proof Pressure)	2 times operating pressure for all ranges
Secondary Containment Pressure	Upto 800 Bar
Nominal Excitation	10V DC nominal
FSO for 10V Excitation	20 mV + mV
Temperature drift of zero and FSO	$< \pm 2.0 \times 10^{-4} / \text{FSO} / ^\circ\text{C}$
Non linearity + Hysteresis	$< \pm 0.5 \% \text{ FSO}$
Sensitivity	$2 \pm 0.1 \text{ mV/V}$
Dimension / Mass	$\Phi 25 \times 72 \text{ mm} / 105 \text{ gms.}$
Electrical interface	Multi-pin hermetically sealed connector

35.5 Technology Transfer from ISRO

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36 MEMS based Pressure Transducer

Indian Space Research Organisation (ISRO) at its Liquid Propulsion Systems Centre has developed a novel MEMS Pressure Transducer, which will find wide industrial and commercial applications.

36.1 Principle of Operation

MEMS Stands for Micro Electro Mechanical System. In the MEMS pressure transducer, the Silicon technology integrates the mechanical sensing with the signal conditioning electronics making the sensor highly compact and equally accurate. In addition to its reduced weight the sensor requires only lesser power and offers high system reliability. These sensors are fabricated fully with stainless steel material and are hermitically sealed using EB welding process.

36.2 Advantages & Salient Features

1. Low power
2. High accuracy
3. Miniature / Low cost
4. Less Weight
5. High output
6. Extremely low hysteresis
7. Shock and vibration resistant
8. High dynamic response
9. High long-term stability
10. Suitable for low pressure measurement with high accuracy



36.3 Application

1. Suitable for control systems in all industries
2. Automotive
3. Defence
4. Oceanography
5. Atomic
6. Vacuum pressure measurement
7. Process and chemical Industries

8. Automatic weather stations
9. Space applications

36.4 Specifications

Pressure Range	1 bar to 250 bar (Absolute)
Excitation	5 ^{+0.1} V DC -0.0
Output Span	4 ^{+0.1} V DC (Optional) -0.0
Sensitivity	3.9 to 4.1 V/bar (Optional)
Accuracy	
Non-Linearity + Hysteresis	< 0.3% FSO
Mass	75 gms
Dimensions	Ø25 x 55 mm length max
Electrical interface	Multipin hermetically sealed connector.

36.5 Technology Transfer from ISRO

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37 PtS-84 temperature Sensor

Indian Space Research Organisation (ISRO) at its Liquid Propulsion Systems Centre has developed a novel Temperature sensor, which will find wide industrial and commercial applications.

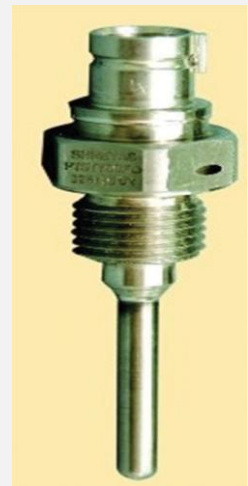
37.1 Principle of Operation

Accurate and reliable measurement of temperatures in high pressure gaseous and liquid media requires dedicated and specialized thermocouple probes. The PTS-84 an RTD type temperature sensor, developed at ISRO, is qualified for measuring temperature under severe environmental conditions posed by the propellants high pressure and corrosive nature.

The basic element used here is a wire wound platinum sensor which has 100Ω at 0°C and encapsulated with S.S AISI 304/316/Inconel material. The sensor uses unique construction techniques to achieve noise immunity and high response.

37.2 Advantages & Salient Features

1. Accurate
2. Reliable Measurement
3. Linear
4. Rugged
5. Less weight
6. Can withstand high flow rate
7. Stable



37.3 Application

1. Space application
2. Process Industries
3. Atomic Purposes
4. R&D Laboratories
5. Defense Application
6. Commercial Application
7. Oil & Gas Industries

37.4 Specifications

Temperature Range	-196°C To 250 °C
Time Constant	≤ 3.0 s
Material of Sheath	AISI 304L/Z2 CN 18-10 (S.S.)
Sensitivity	0.39 $\mu\text{V} / ^\circ\text{C}$
Accuracy	
Resistance at 0°C	100.0± 0.25 ohms
Mass	≤ 100 g
Max. Pressure	300 Bar.
Electrical interface	Multi-pin hermetically sealed connector.

37.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

38 TCP-84 temperature Sensor

Indian Space Research Organisation (ISRO) at its Liquid Propulsion Systems Centre has developed a novel TCP-84 Temperature sensor, which will find wide industrial and commercial applications.

38.1 Principle of Operation

Accurate and reliable measurement of temperatures in high pressure gaseous and liquid media requires dedicated and specialized thermocouple probes. The Thermocouple probe TCP-84, developed at ISRO, is qualified for measuring temperature under severe environmental conditions posed by the propellants high pressure and corrosive nature. The sensors have been tested for the temperature range of 0°C to 1100°C. The sensors have a heritage of 25 years in ISRO launch vehicle programmes.

The sensor uses basic elements like Chromel / Alumel with sheath and thermo well materials like S.S AISI 304/316/Inconel. The sensor uses unique construction techniques to obtain noise immunity and high response.

38.2 Specifications

Temperature Range	0 To 800°C
Thermo Couple	K Type (Chromel-Alumel)
Junction	Ungrounded (Φ 1.0)
Pressure (Max)	350 Bar
Time Constant	≤ 0.3 s
Material Of Sheath	AISI 304 L or Equivalent
Insulating Material	MgO
Sensitivity	41μ V/ °C
Accuracy	0 to 400 °C ± 3 °C 400 °C ± 0.75% of Reading
Mass	
Electrical interface	Multi-pin hermetically sealed connector.

38.3 Advantages & Salient Features

1. Fast response
2. Wide Temperature ranges
3. Less Weight
4. Shock & Vibration resistant

38.4 Application

1. Space application
2. Process Industries



3. R&D Laboratories
4. Defense
5. Application
6. Commercial
7. Application
8. Oil & Gas Industries

38.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

39 Ultrasonic Liquid Level Sensor (USLS)

Indian Space Research Organisation (ISRO) at its Liquid Propulsion Systems Centre has developed a novel level sensor, which will find wide industrial and commercial applications.

39.1 Principle of Operation

USLS does the function of sensing the presence of liquid medium between its sensing gap. The Standard sensor is typically integrated with the sensing element called the “SENSOR HEAD” and electrically connected to a 5 pin Lemo electrical connector. The sensor is constructed using AISI 304L stainless steel.

Immersion Length	125mm (Approx.)
Level detection	75 mm below mounting flange
Working liquids	N2O4, UDMH & water
Fluids pressure	10 bar (Abs)
Test pressure	15 bar (Abs)
Operating Temperature	0 to 70°C
Material	SS 304 L
Vibration Resistant	13.5g, 20-2000 Hz Random
Electrical interface	Multipin electrical connector

One Ceramic disc the “TRANSMIT TRANSDUCER” is used to convert electrical signal to an ultrasonic signal which is then transmitted across the sensing gap. The other Disk “RECEIVE TRANSDUCER” receives the ultrasonic signal and converts it into an electrical signal. The attenuation of ultrasound signals between the transmitter and receiver varies with the medium. The attenuation is high for air and low for liquids. This change in signal level enables the electric control unit (separate unit) to sense the presence or absence of liquid.

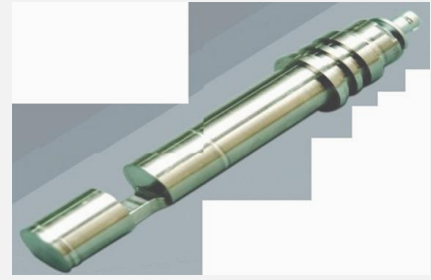
39.2 Advantages & Salient Features

1. Miniature/low cost
2. Less Weight
3. High output
4. Low hysteresis
5. Shock and vibration resistant
6. High dynamic response

39.3 Application

1. Automotive
2. Defense

3. Oceanography
4. Vacuum pressure measurement
5. Process and chemical Industries
6. Automatic weather stations
7. Space applications



39.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

40 Burst Demodulator IP Core

Space Applications Centre (ISRO) has developed a burst demodulator which performs the demodulation of PSK modulated signal being transmitted in burst mode. The demodulator expects the quantized, complex baseband samples from analog to digital convertor and recovers timing, frequency and phase of the complex baseband symbols. In addition, core handles the Viterbi decoding, Data De-scrambling & HDLC decoding for data. The core can forward the data on UART/Ethernet interface.

40.1 Applications

1. As Signalling demodulator in SATCOM Network at HUB station.
2. In receive station enabling burst mode of communication for services like Position reporting, Asset tracking etc.

40.2 Features

- | | | |
|----------------------------|---|-------------------------|
| 1. Modulation | : | BPSK/QPSK |
| 2. Data Rate | : | 1.2 Kbps/2.4 Kbps |
| 3. Forward Error | : | Convolutional Rate Half |
| 4. Correction (FEC) | : | $\frac{1}{2}$, K=7 |
| 5. Scrambler | : | $1+x+x^{15}$ |
| 6. Data Integrity Check | : | HDLC (CRC-16) |
| 7. Eb/N0 | : | 7 dB & above |
| 8. Packet Error Rate (PER) | : | 1% or less at 7 dB |
| 9. Dynamic Range | : | 10 dB |
| 10. Input Format | : | 12 bit I/Q Samples |
| 11. Data Output | : | UART / Ethernet |

40.3 Deliverables

1. Bit file/Encrypted Netlist of the HDL IP is provided.
2. One time(limited) HDL IP porting support is provided

40.4 Present Platform Details

- | | | |
|-------------------|---|---------------|
| 1. FPGA | : | Zynq7035(SDR) |
| 2. RF Transceiver | : | AD9364/AD9361 |



- 3. Receive Frequency : L-Band
- 4. Output Interface : UART/Ethernet

41 Solid State Recorder (SSR)

SAC has designed and developed a Solid-State Recorder (SSR) based on non-volatile flash memory for applications requiring high speed large volume data recording. Industry standard NAND Flash has been used to take advantage of their ever-increasing density and cost reduction as technology advances. These SSRs make ideal data capture media for airborne imaging sensors as well as other applications requiring high data ingest rate real-time capacity including ground testing and archival of data. The architecture has been specially optimized for imaging sensor applications and mass, volume and power parameters. Various input connectivity options allow these recorders to be readily applied with most data heavy sources.

41.1 Features

1. Real-time recording
2. ONFI Flash device-based storage
3. Scalable and Flexible Design
4. Optimized for mass and power
5. Host-based file management



41.2 Applications

1. Imaging Data Recording
2. High Speed Sensor Data Acquisition
3. Airborne Applications
4. Ground Testing and Data Archival

41.3 Technical Specifications

Parameter	Specifications
Sustained Input Data Rate	1.0 Giga Baud
Storage Capacity	4 Tb
Temperature Range	-20°C to +75°C
Storage Medium	NAND Flash
Mass	< 0.75 Kg
Power	< 8 Watts
Data Retrieval	USB 2.0
Input Interface	SERDES / LVDS Serial / LVDS Parallel / RS422 serial and RS232 serial
Operational Voltage	5-12 Volts (non-isolated) 9-36/18-72 Volts (Isolated)
Package Size	220 mm x 50 mm x 25 mm
Operator Interface	Custom Utility (Windows)

42 Transmit-Receive Module

Space Applications Centre of ISRO has developed a transmit receive (TR) module which is very useful as both transmit and receive chains are accommodated in a single small housing for achieving higher gain. This MMIC based TR module is flown in Radar Imaging Satellite (RISAT- 1). It is a building block for radars and finds its applications in weather radar, ground based radar etc. Each TR Module consists of a low power TR switch to select either of the transmit or receive paths. It has a weight of 420 gms.

Parameter	Specifications
Frequency	5350 GHz
Bandwidth	225 MHz
Phase Control	6 bits,360 deg range/ 5.625 deg step
Gain Control	6 bits,31.5 dB range/ 0.5 dB step
Coupling of Coupler	20 dB

42.1 transmit Path Characteristics

Input Power	-10 dBm
Peak Output Power	10W
Transmit Pulse Duration	20 μ s, 10% duty

42.2 Receive Path Characteristics

Noise Figure	4 dB
Gain @ 0 dB Attenuation	30 dB
SPST Isolation	35 dB



42.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

43 Power Conditioning and Processing Unit

SAC has developed a Power Conditioning and Processing Unit (PCPU) for use in microwave remote sensing missions. PCPU is a very complex multi output dc - dc converter that delivers around 100W of peak power and around 10W of average power. Here, Planar magnetics is used for the first time which was realized using 18- and 16-layer PCBs.

43.1 Technological Features

1. Thick film technology
2. SMT technology
3. Planar Magnetics
4. Magnesium alloy for weight reduction
5. Hybrid Micro- Circuits



43.2 Salient Features of PCPU

1. Powers a pair of V&H TR Modules and a TRC unit
2. 10 outputs: 8 pulsed+ 2 continuous
3. 59W pulse output power
4. 9.1W average output power
5. High BW pulse modulators for fast rise & fall times
6. on pulsed outputs
7. In-built EMI filter isolates the satellite bus from the
8. pulsed load transient



ISRO offers to license this technology of PCPU to industries with adequate experience and facilities. Enterprises interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities to us.

44 L-Band True Time Delay Phase Shifter

Space Applications Centre of ISRO has developed an integrated 6-bit GaAs MMIC digital phase shifter featuring two MMIC dies catering to 1024 ps delay requirement. It operates at 1.25 GHz with 250 MHz bandwidth, providing 1024ps of delay coverage, with a resolution of 16 ps. It features very low RMS delay error of 8 ps. This TTD Phase shifter requires an external driver circuit and works on negative control logic of 0/-5V. It is internally matched to 50 ohms and is ideal for integration into Multi-chip Modules (MCMs) due to its small size.

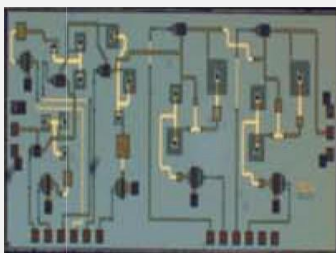
44.1 Typical Applications

1. EW Receivers
2. Weather & Military ultra-wideband Radars
3. Beam Forming Modules

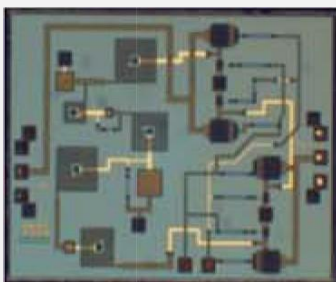
44.2 Salient Features

1. 6-bit TTD-Phase Shifter
2. Wide Dynamic range: 1024 ps
3. Fine Resolution: 16 ps
4. Novel Topology of self-switched band pass network for 256 ps delay bit
5. Novel topology of compensated network for 512 ps delay bit

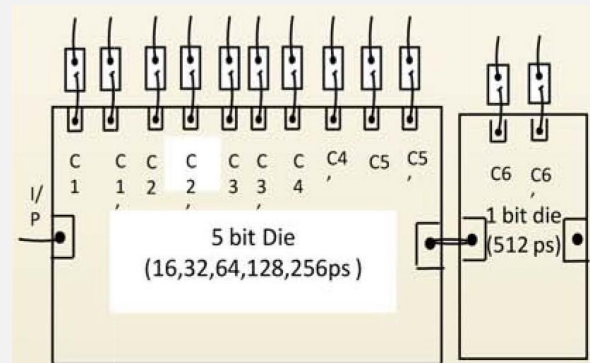
44.3 Interface Diagram



LSB1-LSB5 bit -5.5 mm X 2.3 mm



LSB6 Bit 3 mm X 2.3 mm



Switch Control from external
TTL-MESFET driver -5V = OFF
state 0 V = ON state

44.4 Typical Applications

1. EW Receivers
2. Weather & Military ultra-wideband Radars
3. Beam Forming Modules

44.5 Salient Features

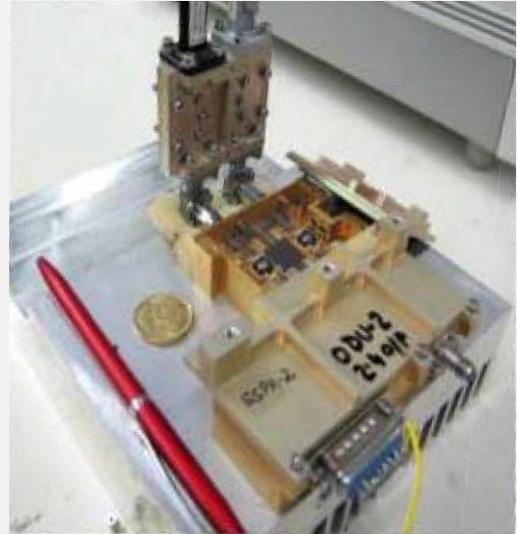
1. 6-bit TTD-Phase Shifter
2. Wide Dynamic range: 1024 ps
3. Fine Resolution: 16 ps
4. Novel Topology of self-switched band pass network for 256 ps delay bit
5. Novel topology of compensated network for 512 ps delay bit

Frequency (Ghz)	Max. Insertion Loss (dB)	Delay Range (ps)	I/o Return Loass Max. (dB)	Max. RMS error (ps)	Control Input
1.25 ± 0.125	15	16 to 1024	12	8	0/-5V

ISRO offers to license this technology of L band true time delay phase shifter to industries with adequate experience and facilities. Enterprises interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities to us.

45 Ka Band 5W Solid State Power amplifier

5-watt Ka-Band (29.6 30.2 GHz) SSPA was successfully designed, developed and integrated in the ground terminal of GSAT-4 project. The technology has also been transferred to the industry (ASTRA MW).



45.1 Salient Features of SSPA

The MMIC based SSPA at Ka-Band (30 GHz) with 5 Watt of output power is first time developed in SAC, India. It makes use of indigenously developed waveguide based extremely low loss symmetric 3 dB Quadrature coupler to derive the 5 Watt of output power

45.2 Major Specifications:

1. Frequency Range : 29.6 - 30.2 GHz
2. Output Power : 37 dBm
3. Small Signal Gain : 40 dB
4. Gain Flatness: : ± 0.6
5. Return loss : > 17 dB

45.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

46 15W C Band Solid State Power amplifier

The GEOSAT program of ISRO is conceived to address the nation's growing need for satellite-based connectivity for broadcast, communications and networking applications. The growing demand for bandwidth to support such applications is calling for a large number of transponders to be deployed in the coming years.

Solid State Power Amplifiers (SSPAs) are used extensively in such transponders. Space Applications Centre (SAC), ISRO has developed and qualified a design for normal C band operation, tailored to meet this requirement on board GEOSAT satellites. ISRO invites interested and capable parties to whom this technology can be transferred. Under this arrangement, qualified vendors will be enabled to undertake fabrication, testing, optimization and delivery of the RF assemblies required in these SSPAs. The SSPA consists of RF Assembly and an Electronic Power Conditioner [EPC] Assembly.

46.1 Attenuators

The SSPA has two PIN attenuator circuits. One is a two-section commendable attenuator providing up to 24 dB of attenuation for on-board gain control. The second attenuator is used for compensation of gain variation against temperature. Each attenuator section employs 3 dB large couplers with two PIN diodes.

The commendable attenuator is externally controlled through serial commands. These commands are processed within the SSPA using a decoder comprising integrated circuits CD4050, CD40174, CD4015, CD40106 and CD4051. This decoder, along with biasing arrangements for all devices, is implemented on a PCB which is housed in a separate section of the RF assembly. The temperature compensation network is also included on this card.

46.2 RF Amplifier

The RF assembly consists of low, medium and high-power amplifier stages along with two attenuators.

The nominal RF output power of the SSPA is 15 Watts (41.8 dBm) in the specified operating frequency band. Nine amplifier stages provide the required

86 dB gain. The small signal stages employ five CFY25-20 devices in a 3 + 2 chain. These small signal stages will drive the medium power stages based on MGF2407 & MGF2430. All these stages are housed in one section of the RF package. The output of this section (i.e., small and medium power stages) is fed to the Power Amplifier section of the same housing, via co-axial cable.

The Power Section houses the MGF38V and MGF44V devices, the latter being a 25-



Watt output device. The space between the low power and high-power sections is occupied by interconnections and harnessing.

46.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

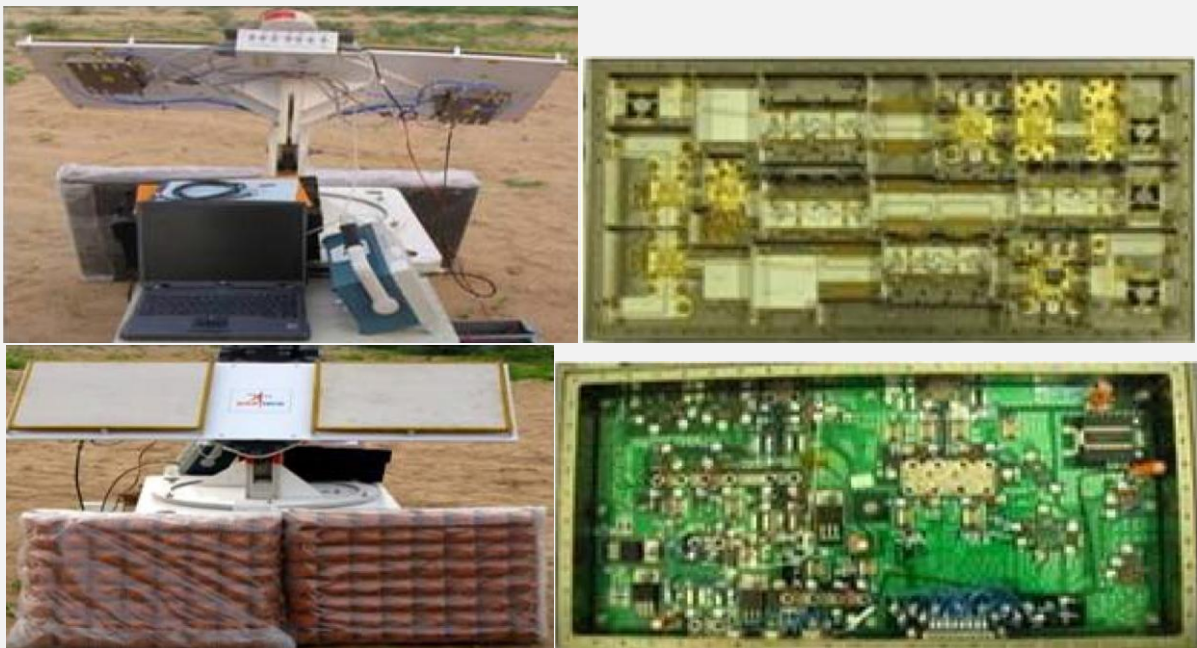
47C Band Active Radar Calibrator

SAC has developed a C band active radar calibrator for calibration of microwave imaging sensors. It is a ground-based equipment developed indigenously.

47.1 Features:

1. Can calibrate individual Like and Cross-Polarised C-band SAR Channels; W, HH, VH, HV & Circular Polarisation using two ARC Rxs.
2. Dual Polarized broadband (7%) multilayer microstrip antenna of 23 dB gain and cross polarization better than -40 dB.
3. Antenna protected by radome using inverted patch.
4. Receiver Input Signal range: -25 to -60 dBm, Max Tx signal: +20 dBm.
5. Each Channel contains Selectable Gain with Digital control (Step: 1dB) & 6bit Digital Phase Control in steps of 5.625 deg.

ISRO offers to license this technology of Active Radar Calibrator to industries with adequate experience and facilities. Enterprises interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities to us.



47.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

48 Miniaturised High Frequency DC-DC Converter

Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed a Miniaturized, High Frequency, Surface Mount Technology (SMT) based DC-DC Converter. These converters are designed for aerospace applications and can also be used for commercial/Industrial applications.

SMT DC-DC CONVERTERS have usage heritage in all ISRO's launch vehicles Programme and orbital platform experiment. These DC-DC converter modules can meet the environments of aerospace applications and can withstand Vibration test, Shock test, Humidity test, Temperature soak tests. The converters are based on fixed frequency single ended forward topology with magnetic feedback and have an internal built in EMI filter to meet the conducted emissions and conducted susceptibility requirements of MIL-STD-461C. These converters are production friendly as these are based on surface mount technology. Thermal management is provided by conductive heat transfer and by using potting compounds. Design is tested at an ambient of 70°C for 320 hours.

48.1 Features

- Input voltage range 26 V to 32 Vdc
Note: Can be modified to 24V-40 Vdc or 12V- 24Vdc
 with minor modification

- Built in EMI filter to meet MIL STD 461 C
- Voltage feedforward topology
- Single and dual output models
- Up to 50 watts of output power
- Indefinite short circuit protection

+5V/1.8A, +5.25V/1.8A, +7.5V/1.2A,
 +10V/2.5A, +15V/1A, +28V/0.9A, ±5V/0.5A &
 ±15V/0.5A

- Without Short circuit protection
 +5V/1.8A, +5.25V/1.8A, +7.5V/1.2A,
 +10V/2.8A, +15V/1A, +24V/1.5A, +28V/1A,
 +28V/1.8A, +32V/1A, ±5V/1A & ±15V/0.5A

Note: Can be modified to any other voltage levels (from 5V- 32V) by minor design modification

1. Fully isolated, magnetically coupled feedback
2. Isolation resistance : 100MΩ @ 50V DC



3. Fixed High Frequency switching
4. Efficiency from 70-80%
5. Typical output ripple is 50 mV
6. Load regulation < 1%
7. Line regulation < 0.2%
8. Case size : 97 mm × 44 mm × 24.5 mm (Flanged)
9. Weight : 125 gms

48.2 Technology transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs/industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

49 Supercapacitors

Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed the technology for processing Supercapacitors (2.5 V) of varying capacitance values viz., 5 F, 120 F, 350 F and 500 F for catering to specific applications related to Space and Societal needs.

Supercapacitors form a new class of electrochemical energy storage device poised to play an important role providing very high electric power boost demanded by applications. The beauty of this electrochemical component “Supercapacitor” is that it can be charged in seconds rather than hours; discharged as very high pulse current over million recharge cycles. Unlike batteries, it is environment friendly, maintenance free, efficiency level 98%, can operate at wide temperature range of - 40°C to + 70°C, it covers life span of 15 years without any quick ageing.

49.1 Operation and design:

Conventional capacitor stores the electrical energy between two parallel plates by charge separation under the influence of electric field, whereas in super capacitor the charge is stored in an electrical double layer between electrode-electrolyte interfaces through oppositely charged ion adsorption in the interface manifested within Angstrom (Å) distance. Basic materials considered for processing such electrodes exhibit very large surface area (1500 - 3000 m²/g), paving way to achieve greater specific capacitance values (1-1000 F) along with high specific power. By this way, Super capacitors emerge to fill up the gap between conventional dielectric capacitors (for high power delivery) and batteries (for high energy supply). In addition, Supercapacitors are similar to batteries in design and configuration, but undergo charge and discharge operations continuously without significant degradation that batteries suffer.

49.2 Advantages:

Supercapacitors can complement a primary energy source such as an internal combustion engine, fuel cell or a battery which cannot repeatedly provide quick bursts of high power. Using hybrid energy/power systems consisting of supercapacitors and battery in parallel, repeated pulse power needs can be met with, in which supercapacitor handles the peak power delivery while the battery provides sustained energy for load and recharging the supercapacitor. There will be significant advantage due to reduction of mass and size of battery as well as improved battery life and thus cost effective.

49.3 Applications:

Aero Space: Delivery of peak/high pulse current for ignition systems, separation systems, actuators etc., Such high-power capability envisages high power

communication during interplanetary missions as well as in conventional electronics.

Societal: Applications include automotive industry, hybrid transportation systems, grid stabilization, utility vehicles and rail-system power models. Supercapacitors could play an interesting role in consumer electronics powering electronic gadgets and cell phones to squeeze out extra energy and help a cell phone last longer.

49.4 Salient features of the systems (500 F typical)

1	Rated Capacitance	500 F
2	Maximum ESR DC, initial	2.5 mΩ
3	Rated Voltage	2.5 V
4	Absolute Maximum Voltage	2.7 V
5	Absolute Maximum Current	1000 A
6	Leakage Current at 25°C	5 mA
7	Maximum Stored Energy, (Wh/kg)	> 5.5
8	Specific Power, Pmax	5.4 kW/kg
9	Short Circuit Current, typical (A)	600-700 A
10	Operating Temperature	-20 to 65°C

Currently, VSSC has established the technology in lab level with equipment such as electrode preparation, dry assembly and testing. Interested parties may scale-up the technology as per their market demands.



49.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

50 Ultrasonic Burning Rate Measurement System (UBRMS)

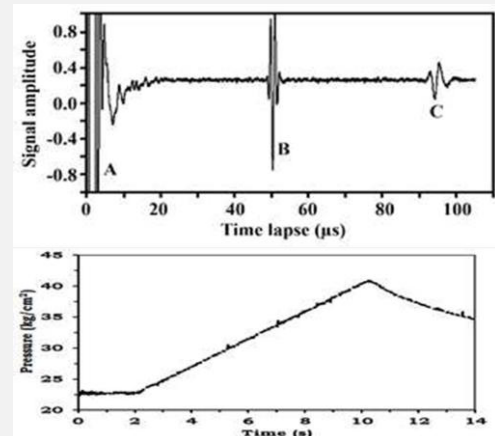
Ultrasonic Burning Rate (UBR) measurement system is technique developed by VSSC for measuring burning rate of solid propellants. The system employs ultrasound pulses to measure thickness of burning solid propellant.

The UBR measurement system consists of three units:

1. Hardware unit: The hardware unit of the system is a test setup in which the propellant specimen is burned.
2. Electronic unit: The electronic unit consists of
 - i. ultrasonic transducer-based electronics capable of acquiring data at very high sampling rate,
 - ii. data acquisition electronics to process the sensor data,
 - iii. computer to store/analyses the acquired test data, and
 - iv. ultrasonic and pressure transducers.
3. Processing Software: The entire operation of the UBR measurement system including electronic unit works upon a set of user-friendly graphical software packages. Commercially available data acquisition cards for processing of ultrasonic sensors can also be used, for which the software for initialization and data acquisition has to be developed separately.

50.1 Application:

The UBR measurement system is used for measuring burning rate of solid rocket propellant. This system can be set up in a small space for routine measurements in propellant plants or research purpose in laboratories. The system is safer, has better measurement accuracy, and requires low manpower with considerable savings in cost and time compared to conventional method of propellant burning rates determination.



50.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs/ industries/ institutions/ organizations in India. Capable parties interested in acquiring this know-how, may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

51 MEMS Acoustic Sensor

MEMS Acoustic sensor is used to monitor the Acoustic Levels generated during the launch of a satellite launch vehicle. It is a piezoelectric, MEMS sensor with built-in electronics. MEMS technology enables miniature devices to be precision batch fabricated. The sensors work in harsh environments and can withstand Vibration test, Shock test, Humidity test, Temperature soak tests. It is the first indigenously developed MEMS sensor flight-tested in an Indian Launch Vehicle and has operational heritage of 12 successive PSLV flights.

51.1 Salient Features

1. Bulk micro machined silicon diaphragm with Piezoelectric sense layer on Silicon
2. Range - 100 to 180 dB (2 Pa to 20 KPa)
3. Frequency Range - 31.5 Hz to 6.3 KHz in 1/3rd
4. Octave centre frequencies
5. Sensitivity- 150 to 200 uV/Pa
6. Amplitude Linearity - 2 dB
7. Frequency response - 3 dB
8. Weight-120 grams
9. Operating temperature range - -40 to +125oC
10. System design done at ASCD/AVIONICS/VSSC
11. Process design & fabrication at CEERI, Pilani
12. Built in electronics and hence smart
13. Elimination of external signal conditioners
14. Reduction in cabling and ease of integration



51.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

52 Thermal Sensors

Indian Space Research Organisation at its Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram has developed thin foil heat flux sensors (Gardon Gauge) and temperature probes. They have applications in a variety of heat measurements like radiative and convective heat flux measurement for short durations in flight, aerodynamic heat transfer measurements on moving bodies during flight, plume heat flux measurement at nozzle exhaust, flame temperature measurement at nozzle exit, hot gas temperature measurement inside combustion chambers etc.

Sensor Name	Measured parameter	Range	Sensor output at full range	over range	accuracy
Thin foil heat flux sensor (uncooled)	Heat flux	10 and 30 W/cm ²	Linear output, 10 mV	25% of rated heat flux	±5%
Thin foil heat flux sensor (cooled)	Heat flux	10 and 30 W/cm ²	Linear output, 10 mV	25% of rated heat flux	±5%
Gas Temperature probe	Temperature	77 to 2500K	75mV	-----	±2%

VSSC is willing to offer the process know-how of processing these sensors to eligible interested parties who are working in the domain of heat transfer/sensors.

Interested entrepreneurs are requested to contact the address given below with all relevant particulars regarding their line of current activity, infrastructure available, market assessment of the product, financial arrangements made, turn over and sales of their products for the past years and a copy of their latest annual report

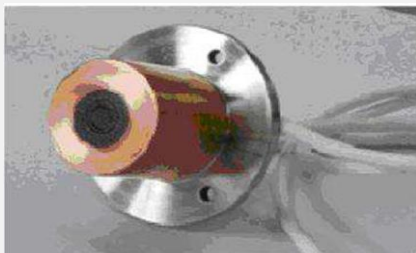


Fig1. Thin foil Heat Flux Sensor (Uncooled)

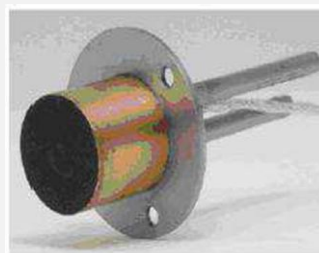


Fig2. Thin Foil Heat Flux Sensor (cooled)



Fig3. Gas Temperature probe

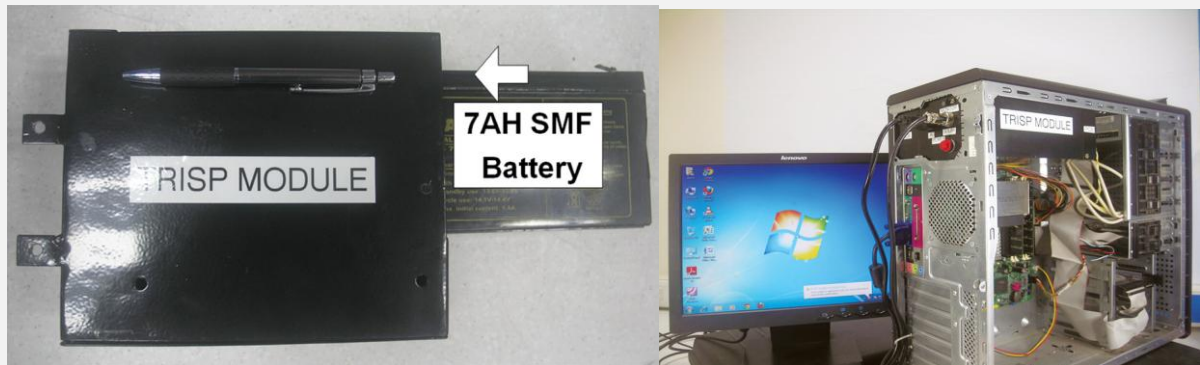
52.1 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

53 TRISP (Triple Input Smart Power Supply)

Desktop PC equipped with inbuilt UPS functionality and direct solar interface, saving 65% power, is materialised using TRISP.

TRISP is an innovative power module with in-built UPS function to power Desktop PCs. The novel concept of TRISP can be adapted to any system which uses DC as its final power source and require power backup. With this configuration, during sunny days, a desktop PC consumes no power from the mains, whereas a conventional 1KVA UPS powered system consumes around 120 watts on an



average.

53.1 Features

1. Eliminates UPS and replaces SMPS in Desktop PCs
2. Utilizes one of the three power sources including non-conventional power ie, solar power, mains power, and battery power.
3. Ensures seamless change over between solar,
4. utility and battery sources

53.2 Advantages

1. 5-fold back up time compared to 1KVA UPS powered PC.
2. Smartly uses green energy whenever it is available. Drastically reduces power line pollution.
3. Power saving for 100000 PCs - around 1.5 million
4. units per year (Rs.1.25 to 2 Cr).
5. Mass production cost - one fourth cost of a 1KVA Online UPS.
6. Ideal for use in remote settlements.
7. Minimum maintenance, better reliability and Safety
8. Provision for powering DC input LCD/LED displays

VSSC is willing to offer the technology of TRISP to eligible interested parties who

are in the field of manufacturing of PCs. Incorporation of TRISP in to the next generation of PCs will be a boon to the industry. Manufacturers of PCs can adopt this technology to tap the potential of green energy and to have energy saving for the nation. Manufacturers of power systems/modules can manufacture TRISP modules which can be used to convert conventional PCs to TRISP PCs. Interested entrepreneurs with the above-mentioned background are requested to contact the address given below with all relevant particulars regarding their line of current activity, infrastructure available, market assessment of the product, financial arrangements made, turn over and sales of their products for the past years and a copy of their latest annual report.

53.3 Technology Transfer from ISRO

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54 Dual Polarized, S&X Band Mono Pulse Feed for Tracking LEO Satellites

A dual polarized S/X Band feed has been designed and developed to cater for data reception from remote sensing satellites, which adopts frequency re-use for data transmission. The development of feed has enhanced the data rate capability of ground station, which is essential to acquire high resolution imagery data from future missions. The feed comprises of S and X band radiating elements, polarizer, comparator for extracting Sum and Difference signals (AZ &EL). Instead of using conventional radiating elements such as four horns, five horns or multimode horn, dielectric rod radiating elements with high aperture efficiency, rotationally symmetric beams with low side lobe levels have been used. The feed is a single channel mono pulse tracking feed which provides high tracking accuracy to auto track the satellites in X- Band and S-band. The dual polarized feed is capable of tracking in four modes, such as X-RHCP, X- LHCP, S-RHCP and S-LHCP, providing enormous flexibility to the ground station as it has the capability of switching to either of these modes.

The feed system has been integrated with a reflector of 7.5 m diameter in Cassegrain configuration and the system is made functional at National Remote Sensing Centre, ISRO to receive data from Low Earth Orbiting Earth Observation Satellites. The antenna & feed system provides a high G/T to receive data through LHCP and RHCP signals simultaneously. The dual polarized feed designed for frequency re- use facilitates high data rate signal reception, which otherwise is impossible, due to limited bandwidth available in X-Band signal reception.



Integrated X-Band feed assembly



X-Band radiating element

54.1 Salient features:

1. The feed, designed for mono pulse tracking, provides high tracking accuracy in X-band. The criticality of the tracking in X-band with very narrow beam

width has been achieved.

2. It is a composite feed, which performs tracking and receiving data in S&X-band. S-band feed contains circular helices and X-band contains dielectric rods.
3. This dual polarized feed is capable of tracking in four modes, such as X-RHCP, X-LHCP, S- RHCP and S-LHCP. This provides the user great amount of flexibility as it has the capability of operating in either of these modes which one is receiving more signal strength or according to user's choice.
4. Instead of using conventional four horns or five horns as feed element, here dielectric rod radiating elements with high aperture efficiency, rotationally symmetric beams with low side lobe levels, have been used.
5. A septum polarizer is designed to separate LHCP and RHCP component and produce linear polarized signal for the for-comparator output. Septum polarizer exhibits good return loss and isolation between two ports, which receive orthogonal polarized components.
6. S-band elements are composed of 20 turn tapered helix wound on a nylon former. Total eight helices are used four for RHCP and four for LHCP and capable of tracking in both orthogonal polarized modes.

54.2 Application:

The feed system has been integrated with a reflector of 7.5 m diameter in Cassegrain configuration and the system is made functional at National Remote Sensing Centre, ISRO to receive data from Low Earth Orbiting Earth Observation Satellites. The antenna & feed system provides a high G/T to receive data through LHCP and RHCP signals simultaneously.

54.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

55 Integrated Tracking System for Satellite Auto Track

Integrated Tracking System (ITS) has been designed, developed and made operational in remote sensing satellite ground station at NRSC. With the advent of this system, a new methodology has been adopted for deriving the tracking error information from single channel mono pulse tracking feed for precision satellite tracking. The Integrated Tracking System is a Digital Signal Processor based tracking system. The system amplitude demodulates the tracking IF signal consisting of tracking video and extracts Elevation and Azimuth DC errors. These error signals are then fed to servo control system for correcting the antenna position and track the satellite automatically. Earlier to this development, a total of 5 subsystems were used to realize all the functions required for satellite auto track. The ITS has brought out technology change, cost effectiveness and miniaturization in satellite ground station Design and Engineering.

55.1 Application:

Mono pulse analog signal processing is done in IF domain to estimate elevation and azimuth pointing errors and auto track the satellites. The analog RF electronics involved are dual channel X-band Tracking Receivers for X-band, single channel S-Band Tracking receiver, Phase Shifter controller unit, scan code pulse generator and Tracking Demodulator Unit. All the above functions have been designed and realized in digital domain by using the state-of-the-art technology of DSP and embedded systems as Integrated Tracking System.



Integrated Tracking System

55.2 Salient features:

1. Miniaturization obtained by this Integrated Tracking System.
2. DSP, FPGA based technology.
3. Double channel X-band tracking receiver(input:720MHz)-one LHCP, another RHCP.
4. Single channel S-band tracking receiver (input:70MHz)
5. Auto diversity in channel selection.
6. Built in error de-modulator.
7. Tracking chain optimization for phase shift.

8. Scan code pulse generation.
9. Multi mission tracking capability and storage of optimized parameter for various missions.
10. Flexibility in changing the parameters for optimization purpose.

56 Programmable IF Matrix

The main objective of the Programmable IF matrix is to facilitate total automation of the data reception chain including the RF signal routing path. The main function of the IF Switching Matrix is to facilitate the connectivity between any Antenna Terminal IF to any Demodulator.

Programmable IF matrix is designed for automatic operation by eliminating the manual intervention in the routing of various signals in the data reception chain. It eliminates the problems associated with manual patch panel like loose contact problems, mechanical wear and tear of the patch chords due to frequent operations, human errors etc., which in turn improves the reliability of the system while increasing the flexibility and reducing the complexity.

The in-house developed programmable IF matrix is an 8 x 10 switching matrix. It supports 4 input ports in the RHCP chain and another set of 4 input ports in the LHCP chain. The 4 RHCP Inputs can be routed as desired to a set of 4 demodulators and the inputs to another set of 4 demodulators can be routed as desired either from RHCP IF or LHCP IF. This Programmable IF matrix Unit also includes a Stand by port in both RHCP and LHCP signal path that acts as hot standby to any one of the 4 Terminal IFs. Programmable IF matrix also supports a monitoring port for all the input signals, this facilitates measurement of the input signal level on a Spectrum Analyzer. The configuration of this unit is done using Front Panel Key Pad in local mode or with TCP/ IP or RS -232 in remote mode. The mode selection is done with the help of Local/ Remote switch provided on the Keypad on the front panel. In remote mode the Keypad option is also available to the user apart from the TCP/ IP or RS-232 interface.

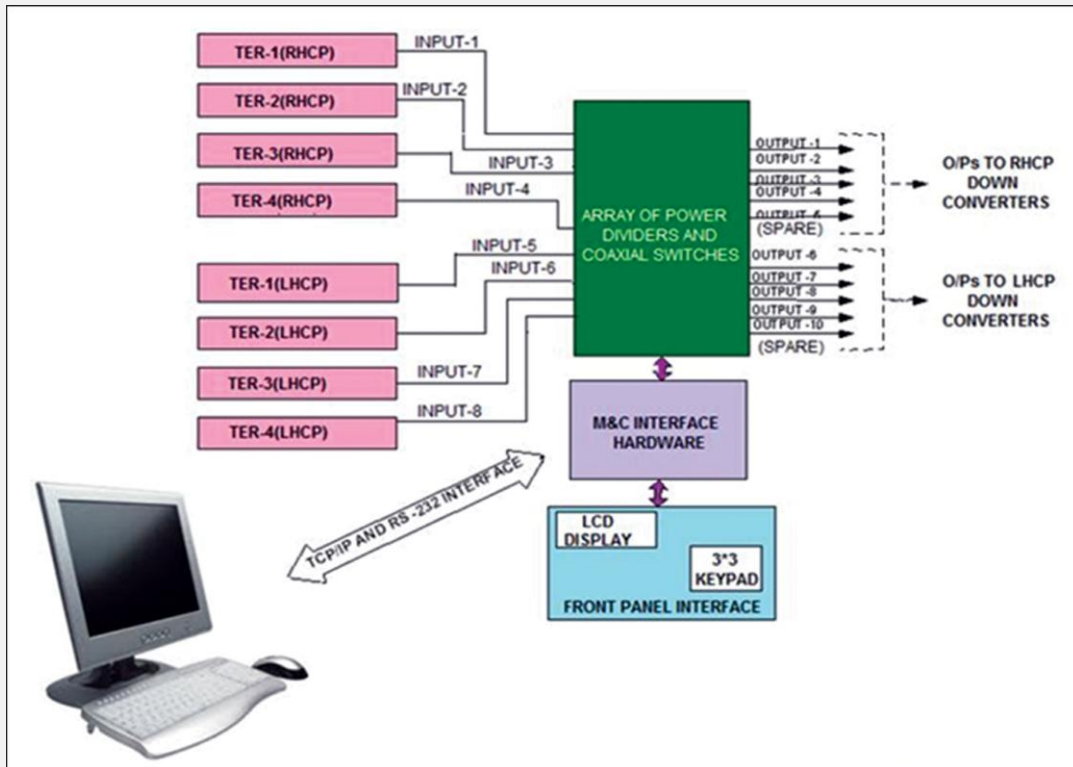
56.1 Specifications

Electrical	
Frequency Range	DC - 4GHz
Matrix Size	8 (Inputs) X 10 (Outputs)
Matrix Type	Non-Blocking
Insertion Loss	20 dB (aprox.)
Port to Port Isolation	90dB
VSWR	1.2 :1
Key Pad	3x3Matrixtype
LCD screen	240x128GraphicsLCD
Remote interface	Ethernet and RS-232

Power supply (external)	
Input Power Supply	230V+/-10%AC@50Hz+/-3Hz
Operating voltages	+5V,+15Vand+24V

Environmental	
Operating Temperature	+5° C to +40°C
Storage Temperature	-10° C to +60°C

The functional block diagram of IF Switching Matrix with all the support interfaces is as shown below



56.2 Salient features:

1. Facilitates Multi-port Matrix operation.
2. Port-to-port isolation in DC-4GHz band is more than 100 dB.
3. The Path length of all the signal paths has maintained constant with in the Programmable IF matrix. Hence, this mode of configuration has lesser Insertion loss and better VSWR.
4. Loads default configuration after Power ON.
5. User can modify the inputs any number of time s before configuring the signal path. Remote configuration through TCP/ IP or RS -232

56.3 Applications

Routing various RF signals in a multi-mission ground station.

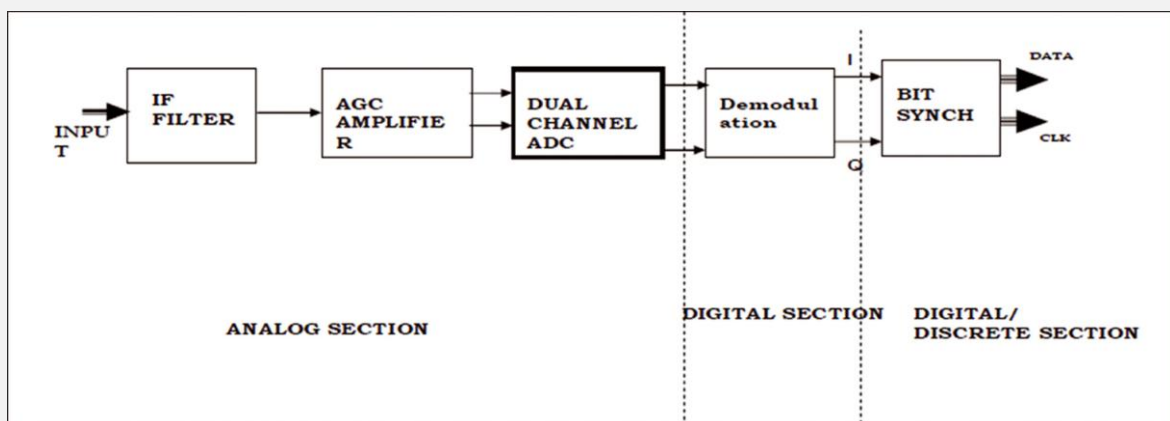
57 Design & Development of FPGA Based Digital Demodulator

As different Satellites use different modulation schemes with variable data rates, in order to cater to the multi-satellite data reception requirements of a ground station, it is necessary to have greater flexibility and programmability features embedded in the design of demodulators. The demodulation techniques for Binary/Quadrature Phase shift Keying (BPSK/ QPSK) are well established and understood when implemented with analog circuits. Recently, state-of-the-art digital technology allows Radio Frequency (RF) signals to be processed in the digital time domain. Modulated RF signals are digitally sampled and then demodulated in real-time using digital signal processing techniques implemented on FPGAs. Because of the usage of FPGAs, the design can have low power consumption, size and cost reduction. Furthermore, these digital demodulators can be reconfigured and upgraded to enhance the data rates in future.

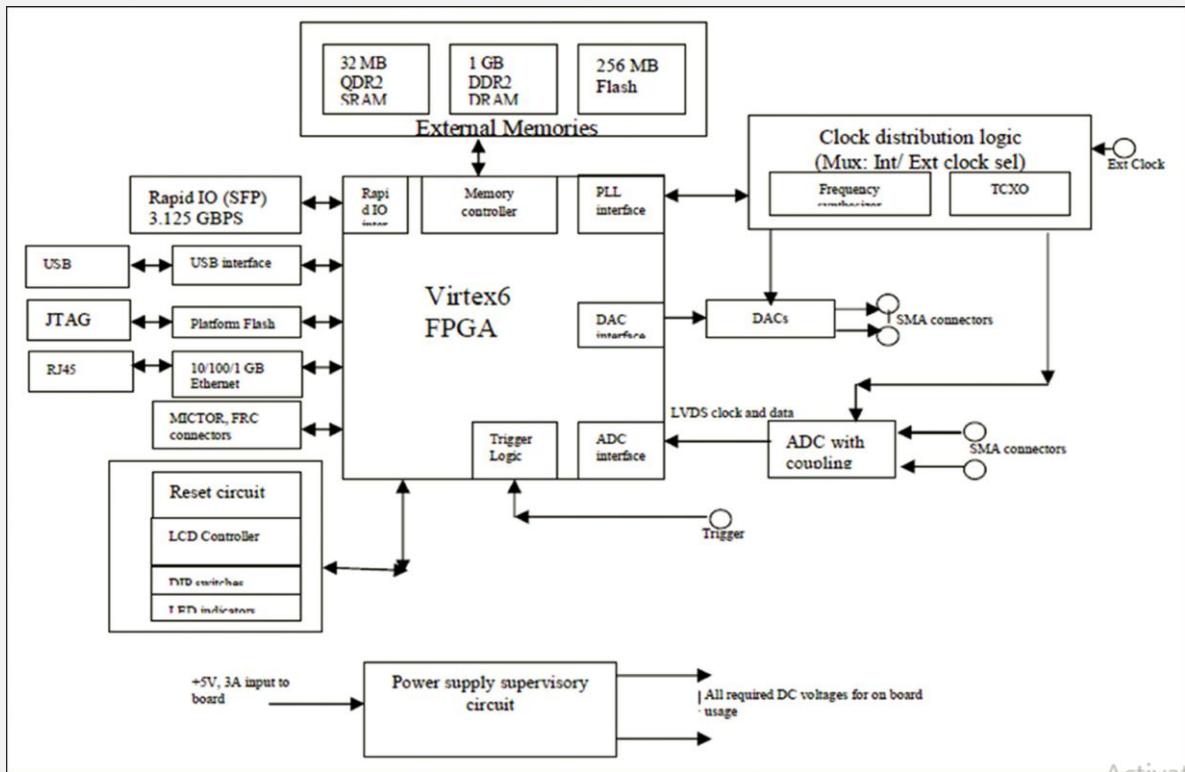
The BPSK/ QPSK can be demodulate by different techniques such as squaring loop, Costas loop and others in analog domain. The Costas loop technique has adopted for developing the demodulator in digital domain as in this the carrier recovery and data demodulation can be done simultaneously with block level design. The high data rate digital demodulator is planned to perform IF amplification, filtering and analog to digital conversion of the received IF signal followed by a Digital demodulator. The basic design strategy includes a configurable data rate BPSK/ QPSK demodulation with COSTAS loop circuitry utilizing the flexibility of FPGA implementation.

The IP core development for the demodulation including carrier recovery have been tested for the 8 Mbps BPSK and 42.4515Mbps QPSK as shown in the block diagram. The Prototype Hardware implementation has done using separate ADC and FPGA evaluation board s. The final realization of the demodulator logic has implemented on an integrated ADC -FPGA board.

Block diagram of proposed demodulator



Block diagram of the final hardware with necessary interface circuitry



Block diagram of the final hardware with necessary interface circuitry

57.1 Conclusion:

The design of demodulator is proven for 8MBPS data rate BPSK demodulation and 42.4515MBPSQPSK demodulator and the test results are presented. The results show a promising inference for further scope of improvisation with respect to data rate and programmability.

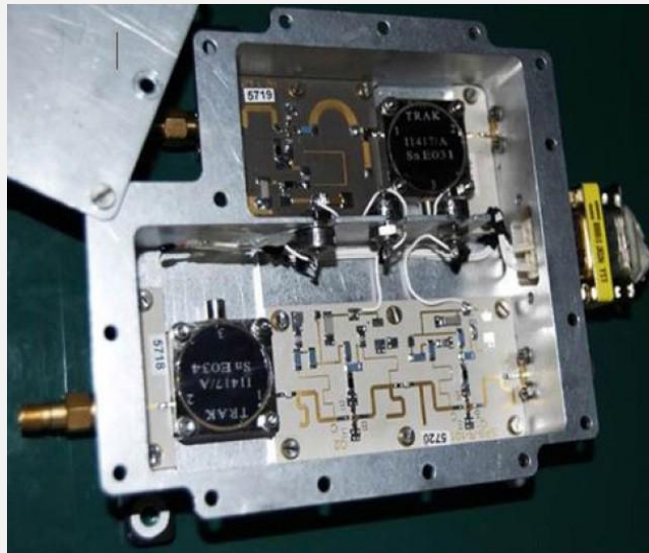
57.2 Applications

High Data rate demodulation for remote sensing data reception system.

57.3 Specifications

Sampling frequency (F_s)	125 MHz-250 MHz
Carrier frequency	30 MHz (BPSK), 70 MHz (BPSK/QPSK)
Data Rates (F_b)	8 MBPS (BPSK), 42.4515 MBPS (QPSK)
Low pass filters used	Raised Cosine FIR
FIR sampling frequency	$(F_s/10)$ for 8 MBPS data rate And $(F_s/4)$ for 42.4515 MBPS data rate
FIR Cut-off frequency	$1.5*(F_b/2)$ for BPSK and $1.5 * (F_b/4)$ for QPSK
Loop filter used	1st order Butter worth IIR
Loop filter cut-off frequency	200 KHz

58 Low Noise Amplifiers (LNAs) And RF Amplifiers for GNSS & VHF Bands



58.1 Specifications:

1. Low Noise Amplifier (LNAs):
2. GNSS LNAs realized in L1 & L5 bands based on hetero-junction & bi-polar transistor-based designs offering excellent noise figure to amplify very weak signals.
3. VHF band LNAs support low noise amplification needs for receivers for automatic identification of ships.
4. RF Amplifiers:
5. Low-power designs based on hetero junction & bi-polar transistors.
6. Developed for use in GNSS bands of L1 & L5 as well as VHF bands.

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has

developed Low Noise Amplifiers and RF Amplifiers for GNSS & VHF bands application.

58.2 Major Specifications

Low noise Amplifiers	
Frequency bands	VHF (155-165MHz) GNSS L1 & L5
Gain	>20dB
Noise Figure	Better than 1db
RF Interface	SMA
Operating Voltage	5V
RF Amplifiers	
Frequency bands	VHF (155-165MHz) GNSS L1 & L5
Gain	>30dB
RF Interface	SMA
Operating Voltage	5V

58.3 Technology Transfer from ISRO

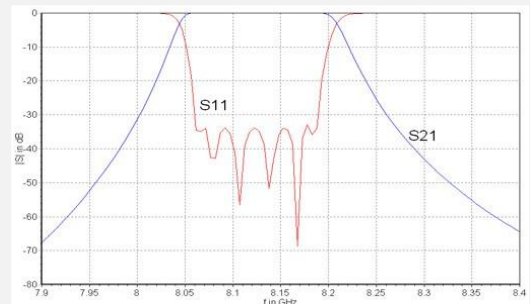
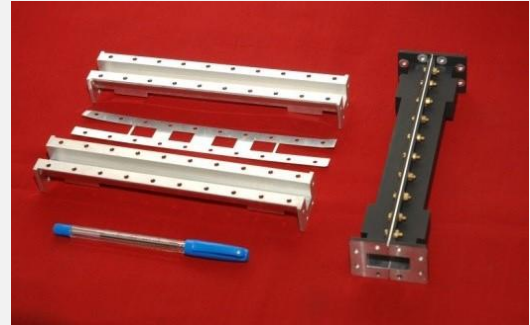
ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

59 E-Plane Filter

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed Low loss, high Q band pass filter with high power handling capability designed for data transmission applications in LEO satellites.

59.1 Specifications:

1. Waveguide filter with high Q.
2. Low insertion loss.
3. Moderate bandwidths (1 to 7%).
4. Easy to change centre frequency and bandwidth.
5. Handles RF powers beyond 2kW.
6. Simple in construction.
7. Mass production suitability.



59.2 Major Specifications:

Centre frequency : 8.2 GHz.

Bandwidth : 160 MHz.

Insertion loss : 0.5 dB max.

Return loss : 17 dB min.

Group delay : 6 n sec max.

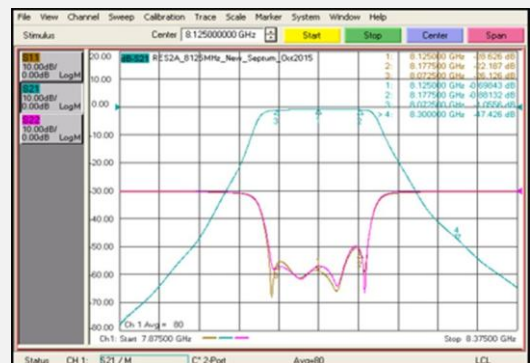
Rejection : 90 dBc for lower frequency

Power handling : 200 W CW at vacuum conditions.

RF interface : WR112 waveguide flange.

Size : 50 x 35 x 200 mm³.

Mass : 200 grams.

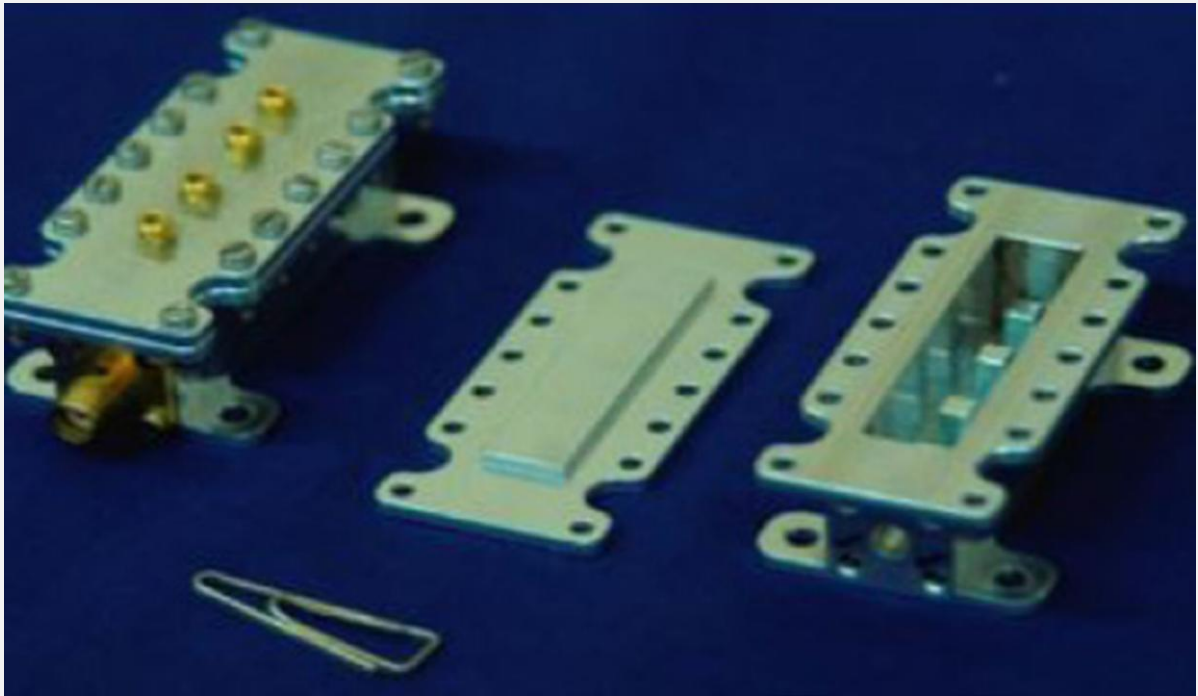


59.3 Technology Transfer from ISRO

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60 Evanescent Mode Filters

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed a Low loss microwave band pass filter designed for X-Band Data transmitter to allow required band of frequencies and rejecting all other frequencies.



60.1 Specifications:

1. TEM mode operation in cavity.
2. Narrow bandwidth.
3. Symmetric skirt response.
4. High rejection bandwidth.
5. Coaxial interface.
6. Compact and light weight.
7. Mechanically robust.
8. Mass production suitability.



Measured Response of X Band Filter

60.2 Major Specifications:

1. Centre frequency : 8.2 GHz
2. Bandwidth : 360 MHz
3. Insertion loss : 0.35 dB

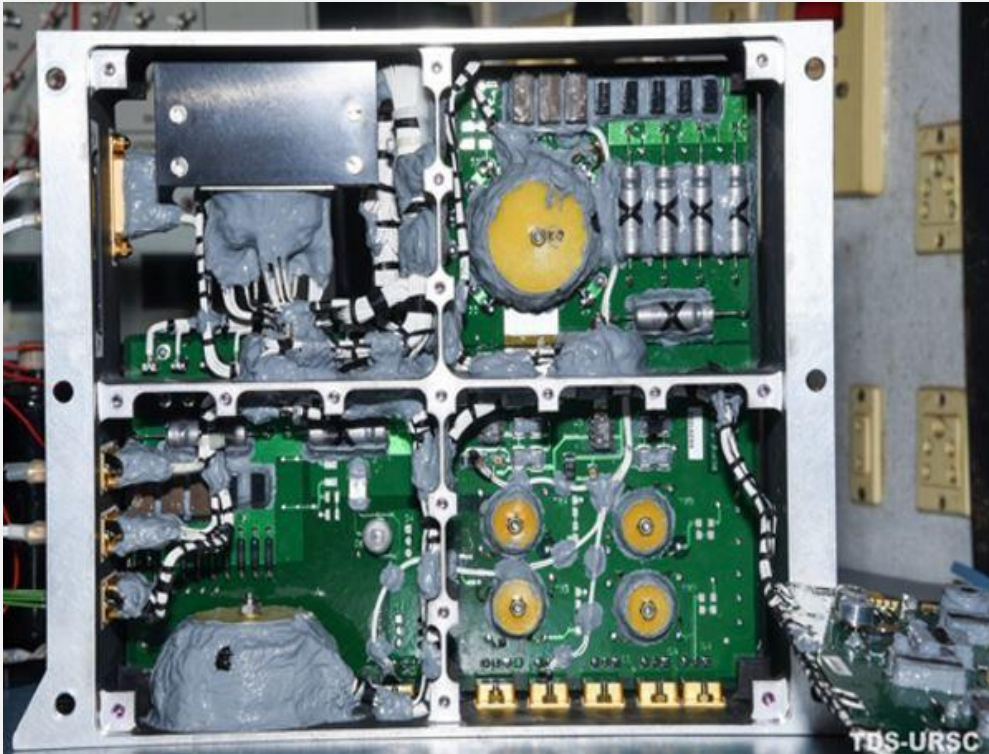
4. max Return loss : 17 dB min
5. Group delay : 4 n sec max
6. Rejection : 90 dBc up to 2f₀
7. Power handling : 20 W CW at vacuum conditions
8. RF interface : SMA jack
9. Size : 15 x 15 x 40 mm³
10. Mass : 50 grams

60.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

61 Battery Charge Regulator (BCR)

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed Battery Charge Regulator (BCR) for battery charging and bus regulation. Battery charge regulator (BCR) is designed with Constant Current-Constant Voltage (CC-CV) and BUS priority loop to cater to LEO as well as GEO Satellites. The main feature of the BCR is that it has a mechanism to give priority to the load requirements in preference to battery charging whenever there is a power generation deficit in the solar array.



Battery Charge Regulator (BCR)

61.1 Specifications:

1. TEM mode operation in cavity.
2. Narrow bandwidth.
3. Symmetric skirt response.
4. High rejection bandwidth.
5. Coaxial interface.
6. Compact and light weight.
7. Mechanically robust.
8. Mass production suitability.

61.2 Major Specifications:

1. Dimensions (L × W × H)	:	286×70×212 [mm]
2. Mass	:	2500 gram
3. BUS Voltage	:	71 Volts
4. Power Dissipation @ BCR Pout =700W	:	< 30 Watt
5. Current TM	:	0-5V
6. Output Current (Selectable)	:	0 -> 10A (00H -> FFH)
7. Output Voltage (Selectable)	:	0 -> 67.2V (00H-> FFH)
8. Output Power Capability	:	800Watt (Max)
9. Efficiency @ BCR Pout =700W	:	>95%
10. Output Current	:	10A
11. Over Current Protection	:	> 12A

61.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

62 Battery Discharge Regulator

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed a Battery Discharge Regulator to maintain the bus regulation during eclipse and peak power requirement periods to avoid the off- optimal operation of the solar array and consequent over sizing of battery. BDR is a Boost Regulator, which regulates the bus voltage in-spite of the variations in the battery voltage. This results in 3 to 4% improvement in the overall efficiency of the user DC-DC and TWTA converters. BDR is modular in nature and can be scaled according to the load requirement.

62.1 Specifications:

1. Average Current Mode programming for load current sharing.
2. Alternate path for fuse blow current and turn on inrush currents.
3. Current transformer sense for implementing OCP.
4. MVL based inclusion/exclusion.
5. Protection Circuits:
6. Pulse by pulse type output over current limit protection.
7. Over voltage limit protection for Output over Voltage.



62.2 Major Specifications:

- | | |
|--------------------------|---|
| 1. Input Voltage (V) : | 45 to 67V |
| 2. Output Voltage (V) : | 69.5±0.5 |
| 3. Output Power (W) : | 1000W |
| 4. Topology : | Non-Isolated Boost |
| 5. Efficiency (%) : | >94% |
| 6. OVP Limit (V) : | 77V (110%) |
| 7. Current Limit (%) : | 120 % of Full (100%) Load Current Telemetry |
| 8. Analog : | Output Voltage, Output Current |
| 9. Digital : | Ovp Relay & On/Off Relay Status |
| 10. Dimensions (L*W*H) : | 86*70*212(mm3) |



11. Package Mass : 2.5kg

62.3 Technology Transfer from ISRO

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63 Eddy Current Damper

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed Eddy current Damper, a deployment rate control device. It is passive in nature and makes use of the resistive eddy currents developed when a nonmagnetic conductive disc rotates in a magnetic field. The damper employs a gear train to amplify the resistive torque generated. The damper is used to control the deployment rate of the solar array and bring down the latch up shock on the panels. The resistive torque developed is proportional to the rate of rotation of the disc and hence rate of deployment of the panels is self-regulating.

63.1 Specifications:

1. Very high damping rate.
2. Wide temperature range.
3. Non-contact type and good reliability.
4. Good temperature stability.



63.2 Major Specifications

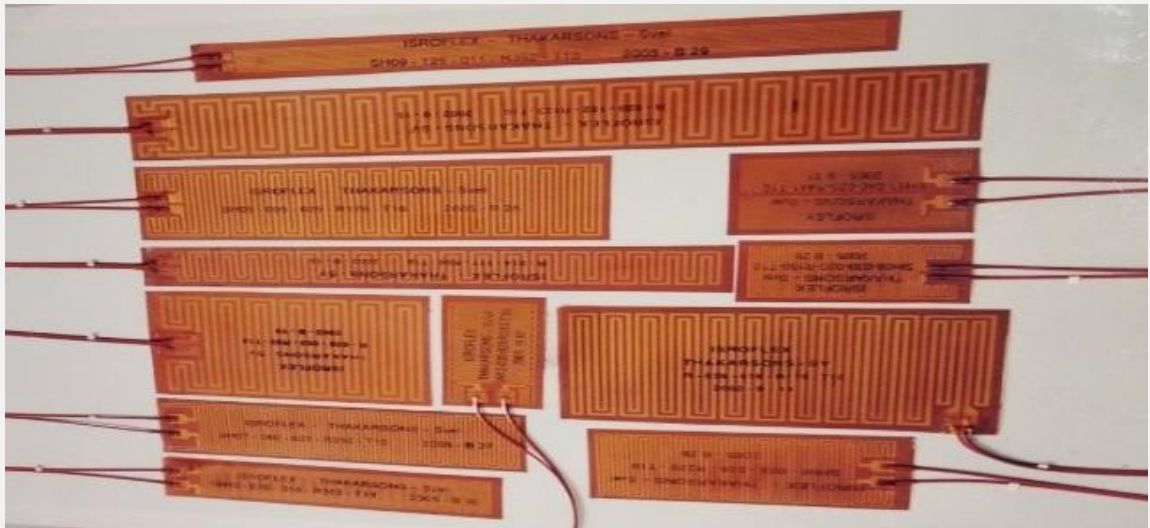
Salient Damper Specifications	
Damping Rate	0.9, 2.2, 2.8 kgf-cm/rad/s
Mass	0.5 kg
Magnet Type	Samarium Cobalt
Gear Type	Spur Gear / Planetary

63.3 Technology Transfer from ISRO

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64 Foil Heaters using Pyralux® Adhesive

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed Kapton® Foil heaters using Pyralux adhesive for power rating of 2.5 Watts per square inch. Using the technology, heaters of different sizes and resistances are fabricated, tested and implemented on the satellite components for temperature rise so that components are maintained above its lower operating limit.



Foil heaters

64.1 Specifications:

1. The heaters are thin flexible heating elements laminated between insulating layers of Kapton®
2. Heater sizes and Resistances can be varied as per the requirement.
3. Heaters are qualified to NASA-GSFC-S-311-79 standard.
4. Heaters of insulation resistance more than Gohm.
5. Dielectric strength is more than 500 Vrms.

64.2 Major Specifications:

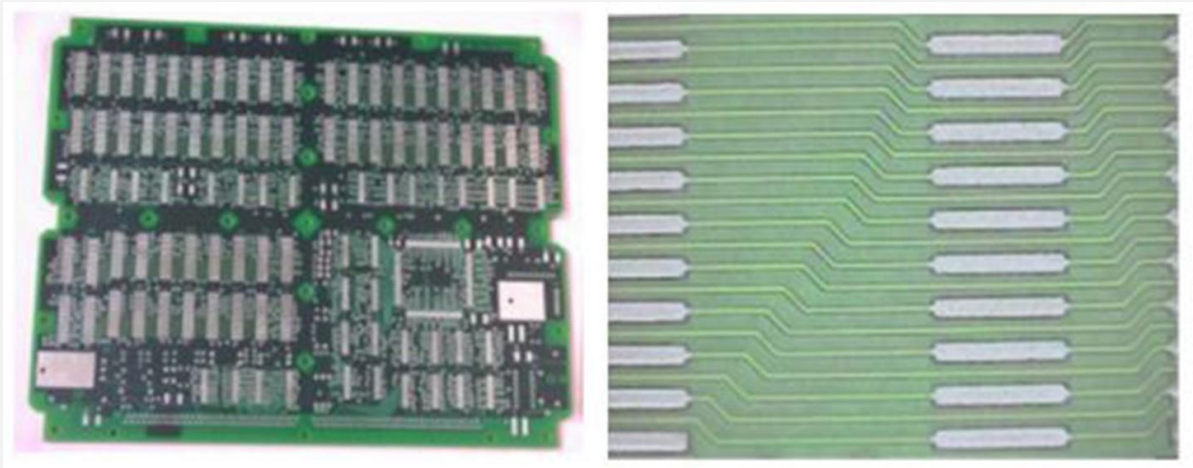
Power Rating	:	2.5 Watts per sq.in in still air
Heater leads	:	26AWG, Kapton insulated and 0.5 m long
Resistance tolerance	:	±10%
Operating temperature range	:	-65 OC to +150 OC
Mounting Method	:	Using transfer adhesive

64.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

65 Fine Line PCB Technology for Fine-Pitch Surface Mount Devices

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has develop and qualify the technology for PCBs with fine conductor features of 5 mil trace width and 4 mil spacing to cater for various fine pitch surface mount devices in the Solid-State Recorder (SSR) packages of high-resolution imaging LEO



Satellites.

65.1 Salient Features & Major Specifications.

Laminate material	:	High-Tg FR4
Total PCB Thickness	:	2.25 mm ± 0.15 mm
Minimum through hole size	:	0.40 mm (16 mils) finished Minimum
Drilled hole size	:	0.50 mm diameter
Standard through hole size	:	0.80 mm (32 mils) finished Minimum
Pad diameter	:	1.0 mm (40 mils) by design Standard

*Fine Line SSR Multiplayer PCB
Replaced 6 Normal MLBs*

*Fine Lines Replaced with Liquid
Photo imageable Resist*

Hole pad diameter	:	1.5 mm (60 mils) by design
Minimum Trace width	:	0.125 mm (5 mils) by design
Minimum spacing	:	0.100 mm (4 mils) by design
Minimum Dielectric separation	:	100 µm (4 mils)
Outer layer basic copper	:	½ oz (17.5 microns)
Outer layer Copper thickness	:	52.5 (± 10) µm (External) finished
Inner layers Copper thickness	:	30 (± 05) µm, Internal

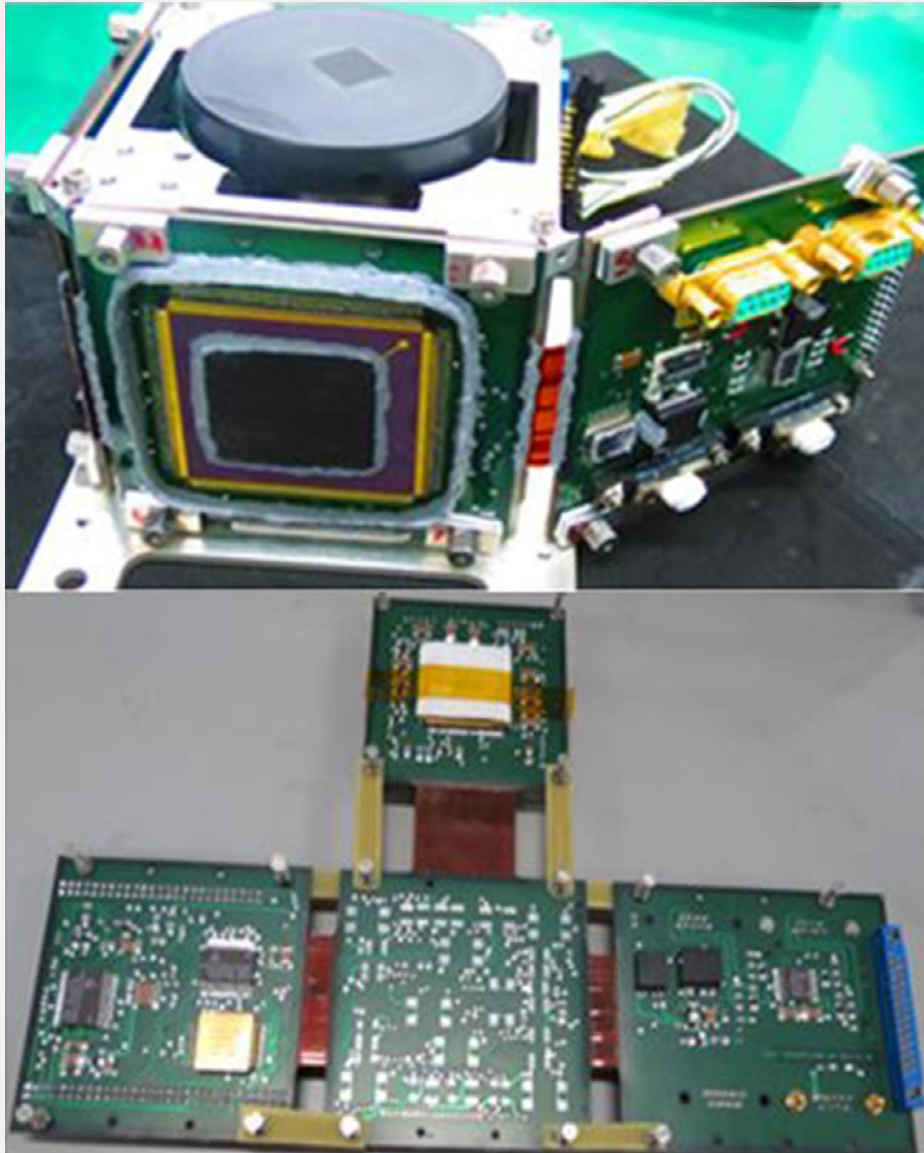
Multilayer Construction	:	Laminate type construction
Technique	:	Fabrication Subtractive type, Electroless Copper,
SMOBC Solder mask	:	
material	:	Electra EMP110, Carapace
Surface finish	:	Eutectic Solder (Sn-63 / Pb-37)

65.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

66 Rigid-Flex Multilayer PCB Technology

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has Rigid-flex multilayer PCB Technology for high reliability 3D packaging applications in space electronics. The rigid-flex multilayer PCB technology provides several benefits with minimized connectors, harness, and motherboard assemblies, eliminates human errors, and also results in reduced weight and volume for interconnecting different functional electronics through flexible structures in 3D Packaging.



Rigid-Flex Multiplayer PCB

66.1 Specifications:

1. 3D packaging feasibility.
2. Reduced Weight & Volume with minimized Harness & Connectors.

66.2 Major Specifications

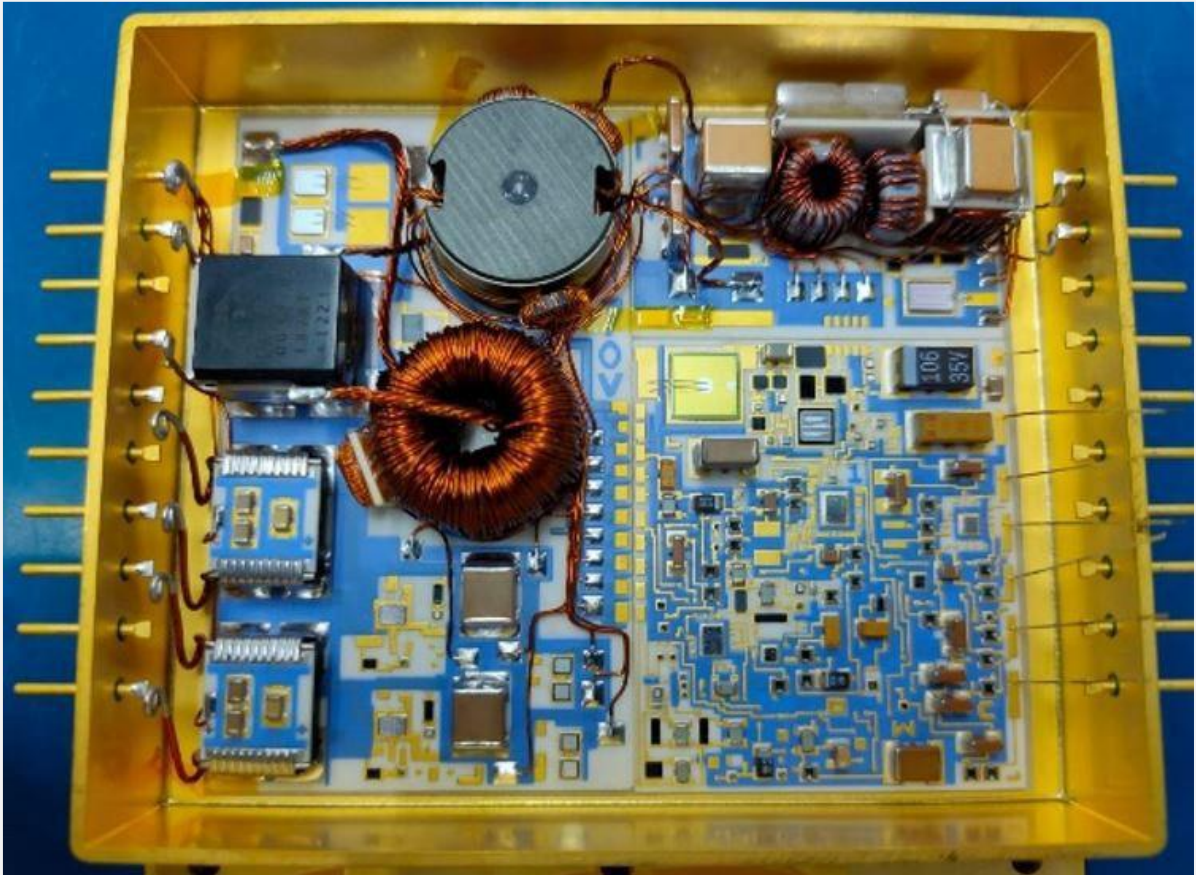
Parameter	Specifications
Type of PCB	Rigid-flex combination with one (or) two layers of flex
No. of Layers	3 layers to 14 layers total, as per layer stack diagram
Total PCB Thickness	Minimum 1.6mm to 2.3 mm maximum (Rigid portion) 0.2 mm to 0.4 mm (Flexible portion)
Material for Rigid Laminate	Glass-polyimide, Tg > 240oC, complying to IPC 4101/41 specifications
Material for Flexible Core	All polyimide, adhesive-less, Tg > 210oC, complying to IPC 4204/11 specifications
Material for Flexible Coverlay	Kapton film (25 to 50 microns thick) with adhesive on one side, complying to IPC 4203/1 specifications
Material for Bonding flex and Rigid Layers	Low-flow glass-polyimide, complying to IPC 4101/41 specifications
Inner Layer Copper Thickness	35 microns for double side flex 35 microns (or 70 microns) for single side flex 35 microns for all rigid layers
External Layer Copper Thickness	Total 52 microns to 70 microns, including 35 microns plated copper, as specified in layer stack diagram
Etchback	Positive etchback of 5 to 15 μ m, complete desmear is also acceptable, negative etchback is not allowed
Multilayer Construction	Laminate type construction
Fabrication Technique	Subtractive process, Electroless Copper, SMOBC
Solder Mask Material	Electra EMP110 (or) Taiyo PSR-4000BN
Surface Finish	Solder or Electroless Nickel Immersion Gold (ENIG)
Solder Specifications	Tin - 63% / Lead - 37%
ENIG Specifications	0.05 microns gold with 3 to 6 μ m Nickel undercoat
Bare board test (BBT)	Rigid-flex PCB shall pass electrical test for continuity and isolation

66.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

67 HMC DC-DC Converters (30W)

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed 30 W HMC DC-DC Converters to meet Electrical performance with High Reliability requirements for Space Application with minimum size and weight. HMC DC-DC Converters developed for Space Application adopting Innovative Thick Film Process technology developed and qualified for Space application.



30W HMC DC - DC Converter

67.1 Specifications:

1. Meets Electrical performance with High Reliability requirements for Space Application.
2. Minimum size and weight.

67.2 Major Specifications:

The main features of the 30W HMC DC-DC Converter are as follows:

1. Converter design meets high reliability requirements and provides output voltages of +5V, +15V and -15V.
2. Components (in die form) used are compliant to MIL-38534 QML-V or Class-K

3. Hybrid design and fabrication processes comply to ISRO-PAS-206 guidelines.
4. Innovative thick film process technology with special subassemblies adopted for realisation of the power
5. hybrid which is housed in custom designed package of Molybdenum base and Kovar ring.
6. The Converter performance suits typical space electronic systems up to 30W, covering requirements of EMI,
7. regulation, thermal dissipation and standard protection features.

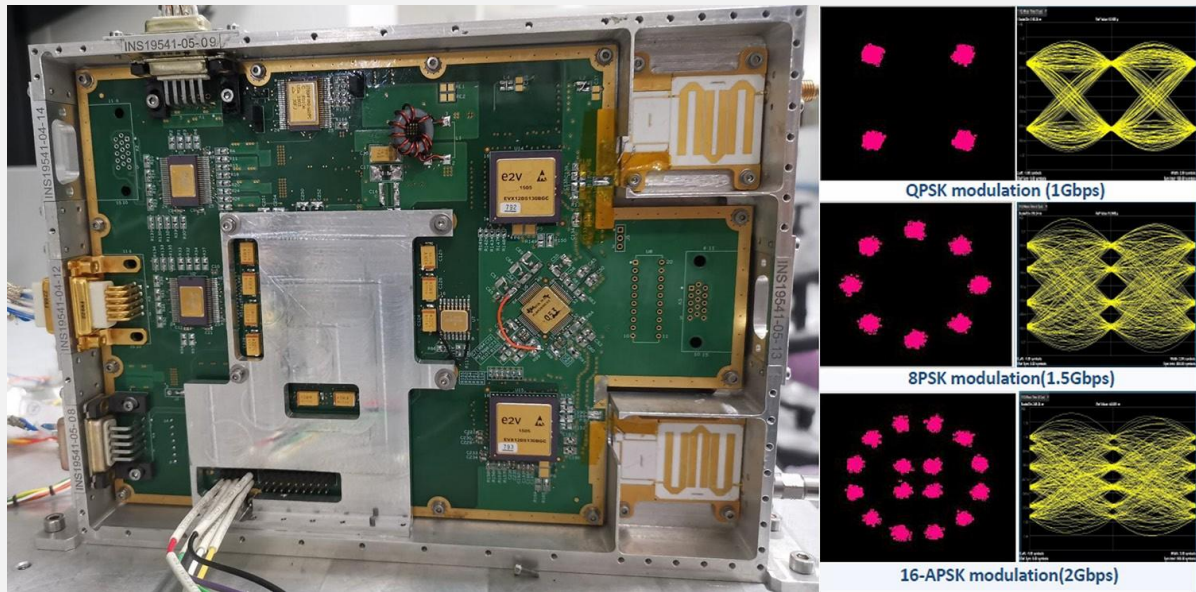
The main specifications are as follows:

1. Input voltage range : 26-42V
2. Triple outputs ($\pm 15V$ and $+5V$) delivering up to 30W
3. Built-in EMI filter capable of meeting ISRO Standards (based on MIL-461C)
4. Converter shutdown feature
5. Efficiency : 75%
6. Switching frequency : 250 KHz
7. Short circuit, over load and under voltage lockout protections
8. Telemetry monitoring feature
9. Size : 3.5"x3.5"x0.65"
10. Weight : 245 gms

67.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

68 Advanced High Data Rate Modulator



Advance High Data Rate Modulators

68.1 Salient Features:

1. Complete Digital implementation for GEO-optical payload
2. Telecommand configurable modulation schemes
3. 16-APSK modulation: 2Gbps/ 675MHz BW
4. 8-PSK modulation : 1.5 Gbps/ 675MHz BW
5. QPSK modulation : 1 Gbps/ 675MHz BW
6. Root raised cosine filter with $\alpha=0.35$
7. Two 1.575Gbps SERDES interface for data acquisition, Virtex-5 FPGA, Wide band clock synthesizer, High speed DACs
8. DAC and RF Gain flatness response compensation in FPGA
9. Two DAC synchronization for external IQ modulator
10. Temperature cycling completed in -10°C to 60°C

68.2 Technology Transfer from ISRO

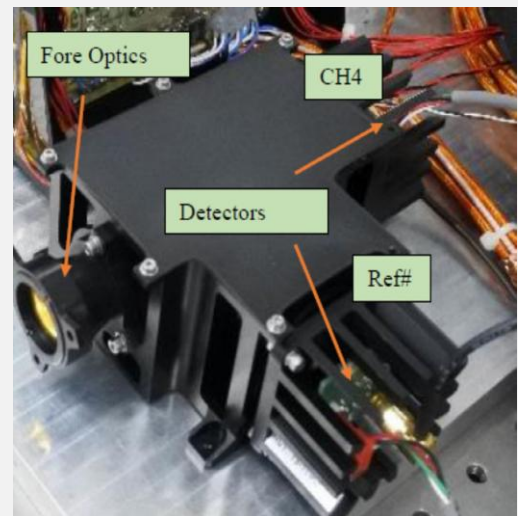
ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

69 Miniaturized Methane Sensor Based on Grin Lens

Space Applications Centre (SAC) has developed a miniaturized methane sensor using GRIN lens and small etalons is developed which is well capable to measure Earth methane and to fly on airborne platform to map Earth’s methane. This is a first of its kind of sensor based on GRIN lens. The lens is 1.8 mm clear aperture and 4.54 mm of length. The collecting lens was chosen such that the spot size is lesser than the clear aperture of the GRIN lens so that the entire energy can be coupled with the GRIN lens. The sensor can be flown from spaceborne platform (for Earth’s Methane observation) with proper qualification and modification in electronics and including necessary interfaces.

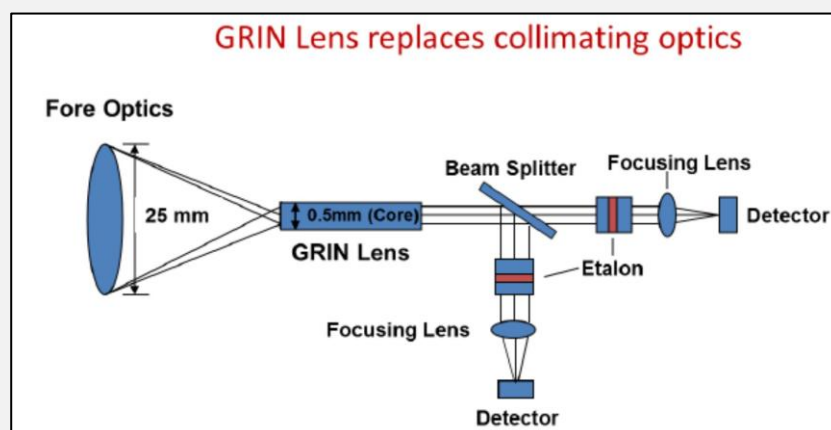
69.1 Applications area:

The potential application areas are Industries, agricultural department/universities, dairy research, paddy cultivation, Livestock, Environmental science departments. The payload is primarily designed for airborne platform. The performance achieved is suitable to use it for airborne measurement. The weight and power of the instrument is also suitable for nanosatellite.



69.2 Salient Features:

Parameters	Values
Detector Type	InGaAs, Single Pixel detector, One for each Channel
Detector size	1 mm
Fore optics diameter	24.5 mm
Focal length	25.4 mm
IFOV	39.3 mrad
Responsivity	1 A/W
Targeted Methane concentration measurement and	1800 ppb of Earth’s atmospheric column with



SD	SD ~100 ppb.
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69.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

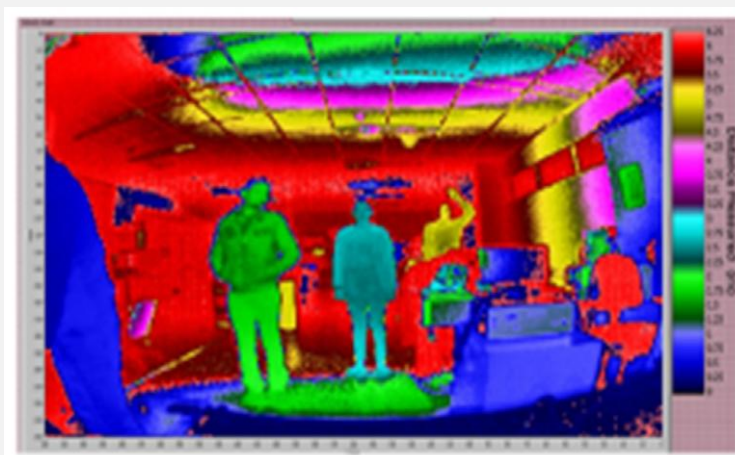
70 Active 3D Imaging Lidar Camera

Space Applications Centre (SAC) has developed an Active 3D imaging Lidar camera that works on Time-of-Flight (ToF) principle. The camera measures the depth of scene points using flash LIDAR (Light Imaging Detection and Ranging) technology. The depth information is determined by correlating the reflected light signal from the scene with the transmitted reference signal. The three-dimensional data obtained from ToF sensor can be used for many control and navigation applications. This technology is useful to generate intensity and depth profile of targets irrespective of ambient lighting condition.

70.1 Applications areas of the Technology:

This technology can also be primarily useful for following other application areas:

1. People Detection and counting in heavily crowded place
2. Mobile postal parcel size measurement for large scale logistics
3. Machine Safety using depth measurement
4. Helicopter Near Terrain flight assistance for assisted landing
5. Hazard detection for Car Collision avoidance system. 3D Point Cloud
Depth Map Using this Camera
6. Hazard detection for Pedestrian detection and braking system
7. Body size measurement predicting the waist, hip size and further prediction of lifestyle issues.
8. Man, Machine Interface like gesture recognition devices in mobile phone, TV, Xbox gaming sets, etc.
9. 3D distance measurements, volumetric mapping of objects
10. Space Docking between 2 docking satellites
11. Interplanetary Soft Landing: Hazard Detection



70.2 Salient Features:

Sl no.	Parameters	Specifications
1	Lidar Technology	Phase detection
2	Wavelength	860 nm
3	Depth Range	up to 12 meters
4	Depth Accuracy	< 10 cm for range up to 5 m
5	Update Rate (Camera)	5 Fps
6	FOV	90°x60°
7	3D Points Per frame	76800 Points per frame
8	Dimension	370 x 275 x 246 mm
9	Mass	8 Kg
10	Power	42 W (Average)

70.3 Camera Features:

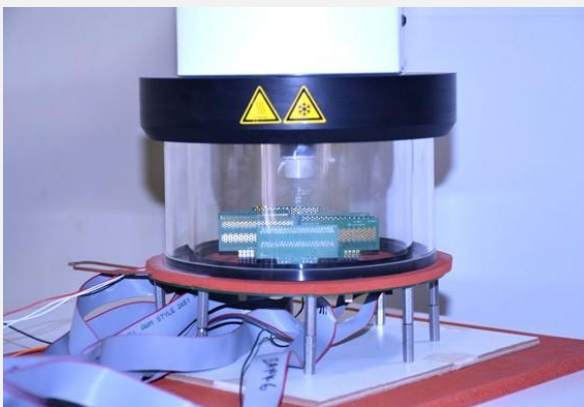
1. Option to view the Intensity image or the color-coded depth point cloud
2. Unique ambient light suppression, the camera can be used under full sunlight condition.
3. Absolute accuracy in the sub-centimeter range with appropriate setup and calibration
4. Dual phase mode for Motion blur reduction
5. 2*2 Binning option for range enhancement.
6. Dual Integration time mode (High Dynamic Range, HDR mode)
7. Sensor Measurement rate up to 20 TOF frames per second and camera about 5 TOF frames per second.
8. Region of interest setting to maximize the Frame rate in KHz.
9. Programmable exposure time to adjust the SNR and hence the depth accuracy. Real time display to fine
10. Tune the exposure to achieve the maximum depth accuracy while avoiding pixel saturation.

70.4 Technology Transfer from ISRO

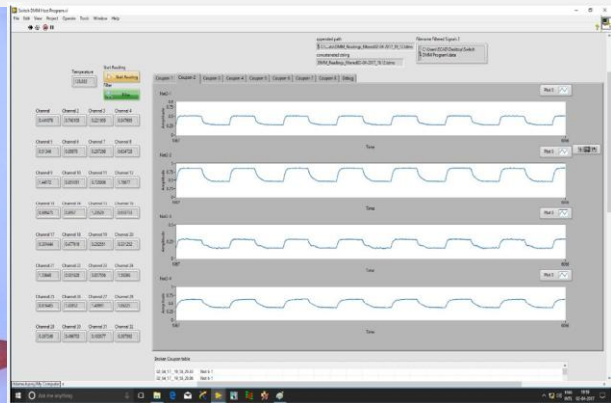
ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

71 Highly Accelerated Thermal Shock (Hats) System for Assessment of PCB Via Reliability

Space Applications Centre (SAC) has developed indigenous Highly Accelerated Thermal Shock (HATS) System for assessment of PCB via reliability. The system is realized by assembly and integration of thermal conditioning system, which is used to give thermal shock and preconditioning simulation, and specially designed instrumentation, which acquires and processes the 4-wire resistance measurement data in real time. The data acquisition and monitoring application is developed in-house. Another offline data processing application is also developed to process the data and find the peak resistance variation of all nets of each PCB coupon (total 32 nets).



HATS Test Setup



Front Panel of Software Application

71.1 Advantages:

1. Indigenously developed system,
2. Quick in testing of samples (within 3.5 days),
3. Highly configurable and scalable system and test parameters,
4. System design as per the requirements of IPC-9151D standard,
5. Simple and easy to operate, no specialized training required,
6. Testing cost and duration are significantly less than foreign test service providers

71.2 Systems Operations:

The via reliability assessment is done by subjecting the PCB samples (coupons) to a thermal shock from -40 °C to +145 °C and vice versa, within 120 sec and maintaining the samples at extreme temperatures for 180 sec. This forms a single thermal cycle. The cycle is repeated for 500 times. Each PCB coupon has electrical circuits (nets) which are comprised of vias and trace interconnects. The precision 4-wire resistance of each circuit is monitored and logged throughout the test. The peak resistance of each net is determined for every thermal cycle and percentage

variation of second peak onwards is calculated with respect to very first peak. As per the IPC protocol, a variation of more than 10%, observed any time during the test, is not acceptable and that particular sample is deemed as failed. There is also a provision to conduct assembly preconditioning before the test, where the samples are subjected to 6 cycles of reflow soldering profile, so that assembly stresses are captured by the samples and any serious degradation is subsequently detected by the HATS test.

71.3 Applications:

This test setup can be used for Batch Acceptance Tests for FM bare PCBs, Vendor Qualification, Material Qualification, Incremental Qualification, VOQ (verification of qualification), project specific qualification requirements, Qualification of new PCB technologies like HDI, Rigid-flex and Hybrid PCBs etc.

71.4 Technology Transfer from ISRO

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72 Electronic Safety Handheld Ohmmeter (ESHO 4.5)

ESHO is a low voltage, low power electronic safety handheld ohmmeter for safe measurement of squib resistance.

72.1 Salient Features

1. Low power design - Operates at 1.5V
2. Digital display for monitoring
3. Wide range of measurement (0-20 k Ω)
4. Better resolution (1m Ω in lower range)
5. Inherently safe design - no energy storage components used in the squib line
6. Maximum fault current in squib line limited to 10mA
7. Health monitoring feature - Inbuilt battery voltage and multiplier circuit health monitoring

Range	Resolution	Accuracy & Repeatability	nominal squib current
SRM (0-20 Ω)	0.001 Ω	Better than 0.25% of Full-Scale Range (FSR)	5.4mA
ISOLATION (0-20 k Ω)	1 Ω	Better than 0.1% up to 10k Ω & better than 0.5% of FSR up to 20k Ω	7.2 μ A

72.2 Technology Transfer from ISRO

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73 Piezo-Electric Vibration Sensor (PEVS)

Piezo-Electric Vibration Sensor with in-built Electronics (PEVS) integrates piezoelectric crystals with electronics - a Charge-to Voltage Converter with Buffer. It has a simple integration process and provides millivolts output proportional to the - applied acceleration.

73.1 Specifications

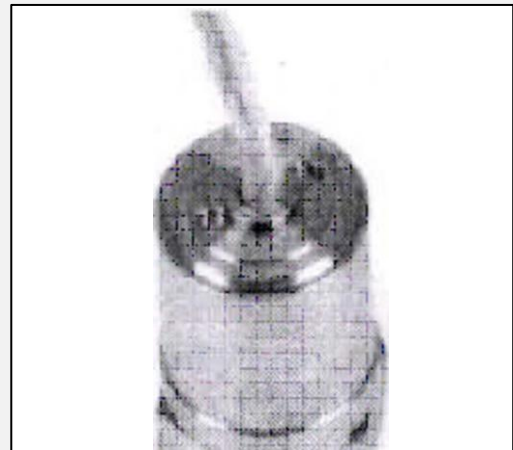
Parameter	Specification	Remarks
Voltage Sensitivity	25 mV/g	'.
Range	$\pm 100g$	
Frequency range	20Hz to 2000Hz	
Mounted resonance	12 KHz	
Frequency flatness	$\pm 3\%$	upto 2kHz
Non-linearity	$< \pm 0.5\%$	
Lower Frequency cut-off	< 5 Hz	
Power Supply	$\pm 5V, 5mA$ or $\pm 15V, 5mA$	
Electrical interface	Pigtail wires	4-core, Twisted Shielded, 28AWG
Weight	36grams	1-metre pigtail

73.2 Salient features

1. Built-in electronics, eliminates external signal conditioning
2. Ease of integration

73.3 Technology Transfer from ISRO

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74 Ribbon Stack Heat Flux Sensor

Ribbon stack heat flux sensor can be used for measuring heat flux upto 30W/cm². The sensor is a thermopile type realised by stacking alternatively a series of Chromel and Alumel ribbons embedded inside a ceramic cement matrix. The construction is using metal ribbons, hence, it is named as Ribbon Stack Heat Flux Sensor.

74.1 Salient Features

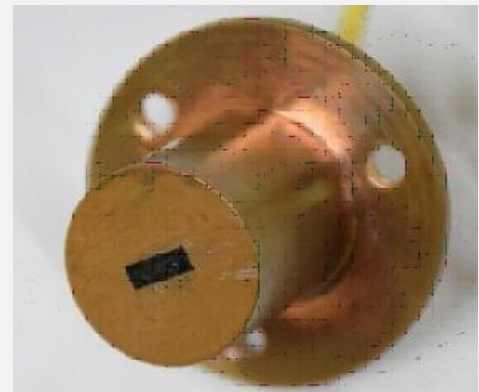
- | | | |
|-----------------|---|------------------------|
| 1. Type | : | Heat flux sensor |
| 2. Sensor range | : | 0- 30W/cm ² |
| 3. Output | : | 0-20mV (linear) |
| 4. Accuracy | : | ±6% |

74.2 Applications

Radiative and convective heat flux measurements in flight and ground use.

74.3 Technology Transfer from ISRO

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75 Precise Timescale

ISRO Telemetry, Tracking and Command Network (ISTRAC) has developed a Precise Timescale which can act as the reference time for the satellite navigation constellations (e.g. NavIC, etc.) as well as for any other precise application such as national timekeeping (e.g. Generation of Indian Standard Time), VLBI, precise time dissemination for financial institutions etc

75.1 Major Features

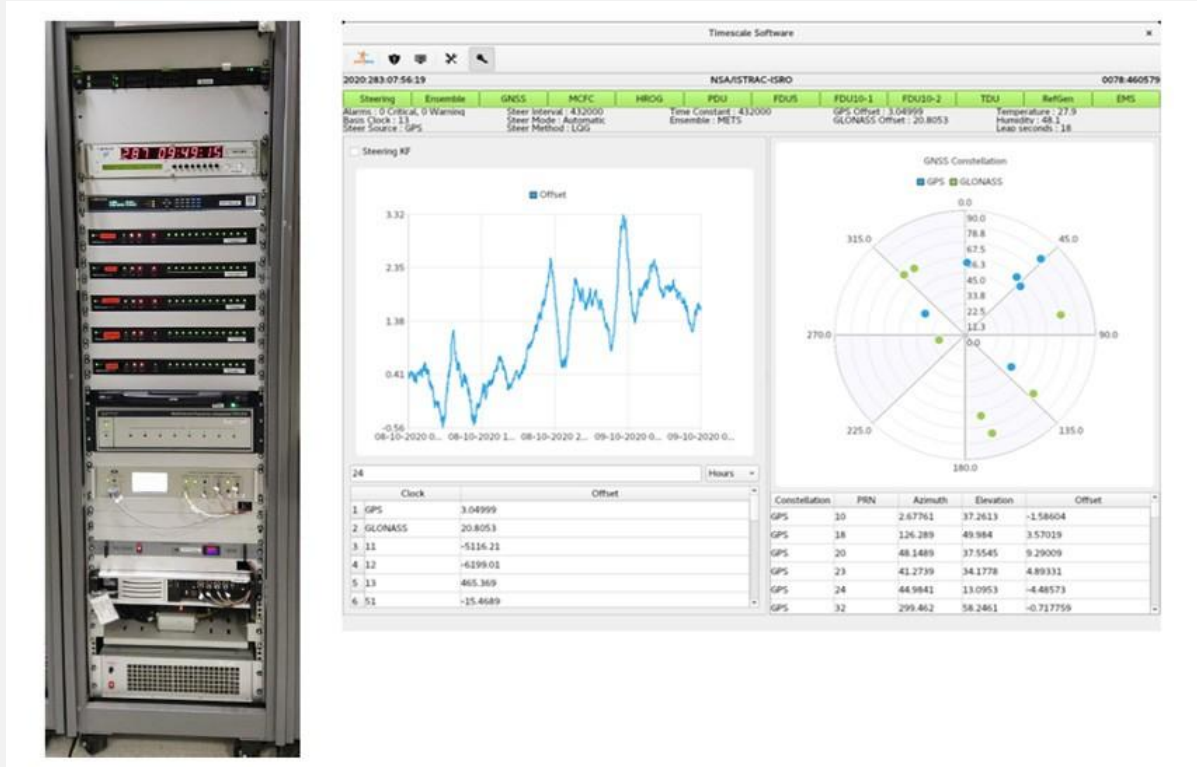
1. Two user-selectable methods of Ensemble and steering, respectively
2. Seamless integration of any type and any number of clocks
3. Auto Steering using Time transfer data via GNSS/ NavIC Common View, TWSTFT and Manual steering using user inputs
4. User configurable Steer Interval and Steer Time Constant
5. Time transfer capability via GNSS/NavIC Common-view, TWSTFT
6. Flywheel Mode in case of loss of reference
7. Automatic and manual weight assignment for physical clocks
8. Automatic Clock anomaly detection and corrective action
9. Isolating the faulty clock from timescale ensemble
10. UTC Measurement anomaly detection and corrective action
11. Protection of user in case of timescale output non-availability
12. Outputs generated: 5 MHz, 10 MHz, 1 Pulse per second, IRIG, NTP, PTP

75.2 Major Specifications

Steered to Coordinated Universal Time (UTC) such that the difference $|UTC-TS|$ shall be less than 30 ns (2σ) for any yearly time interval. This requirement is compiled for both Automatic and Manual steering modes of timescales.

The frequency offset of the timescale (normalized to UTC) : $< 5 \times 10^{-15}$ (2σ) averaged over a day.

In case of non-availability of UTC, timescale is maintained in flywheel mode within an uncertainty of 20 ns, (2σ) for at least 10 days.



75.3 Technology Transfer from ISRO

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76 Cal-Val Systems for Spaceborne Ocean Colour Sensors

The CAL-VAL systems consist of a pair of buoys named “Optical & Met” in deep ocean & a robotic sun-photometer on the island. A discuss type wave following buoy, filled with Polyurethane foam, for deep sea application is used as a platform to mount the sensors. This buoy type has 2.2m diameter and 2100 kgs reverse buoyancy weight and a central pipe structure of 5m length with three 1.75m arms extending sideways.

the in-situ parameters available are: optical, meteorological, biological, physical & atmospheric.

76.1 Objectives

ISRO has developed successfully CAL-VAL site at Kavaratti for India’s OceanSat-II OCM-II sensor’s vicarious calibration and its geo-physical product validation. The recent observations from various instruments are analysed along with OCM-I & OCM- II radiance products and other contemporaneous satellite sensors.

76.2 Potential utilization & applications of the site/data

1. Vicarious in-flight calibration of Ocean colour sensors
2. Validation of OceanSat-II Geo-physical products
3. Bio-optical algorithm development and its validation
4. Time series studies and inter-sensor comparison
5. Near real time data evaluation



77 Photosynthesis Irradiance Incubator

Space Applications Centre (ISRO), Ahmedabad has designed and developed a photosynthetic irradiance incubator (photosynthetron) for marine and fresh water applications. This is used to measure the photosynthetic-rate parameters (PI) of phytoplankton, the microscopic, photosynthesising green plants of the ocean. PI parameters constitute an important element for modelling and estimating oceanic primary production using remote sensing data. The major components of the photosynthetron are the main incubation chamber, source lamp, lamp housing chamber, flat rectangular bottles on a movable rack, temperature sensor, submersible pump, motor and gear box.



77.1 Method of Operation

1. The photosynthetron incubates a sample of phytoplankton with a tracer under controlled light gradient provided by a light source and a series of optical screens, designed to simulate light depths of aquatic environment.
2. The incubation chamber houses linearly arranged twelve bottles on a rack containing phytoplankton sample and the rack is attached with a gear system for continuous tilting motion to allow phytoplankton to remain in suspension as in natural environment.
3. The chamber is filled with water which is continuously circulating. A temperature sensor monitors the temperature of the water bath, which helps in maintaining the desired ambient water temperature for the samples. The period of incubation of the sample is programmable.

77.2 Potential users

All laboratories, research institutes, universities involved in marine & oceanographic research especially in the area of primary production by phytoplankton and fisheries.

77.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

78 Ground Penetrating Radar (GPR)

78.1 Salient Features

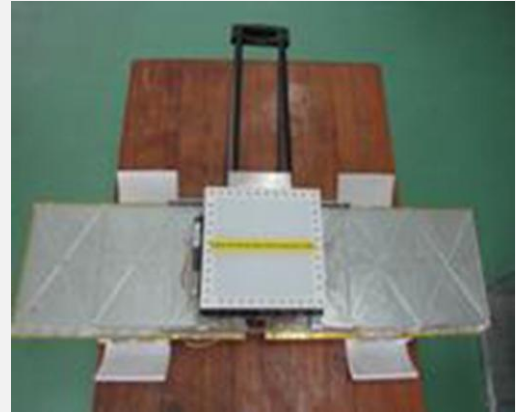
Based on stepped-frequency continuous wave (SFCW) approach, ultra-wideband (100%, i.e., bandwidth of 500MHz with centre-frequency of 500 MHz).

Depth Resolution better than 30 cm.

Integrated GPS for geo-tagging of the recorded data.

Built using commercial components readily available in the market, thus increasing the prospects of using indigenously developed GPR instruments at much lower cost (20 times lower compared to imported versions) for commercial and scientific use.

Total mass of the system is 10 kg out of which 5 kg is for electronics and antennas and the rest for the structure (can be further optimized). Power requirement of the instrument is 10 W.

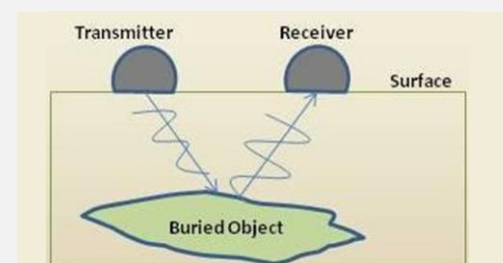
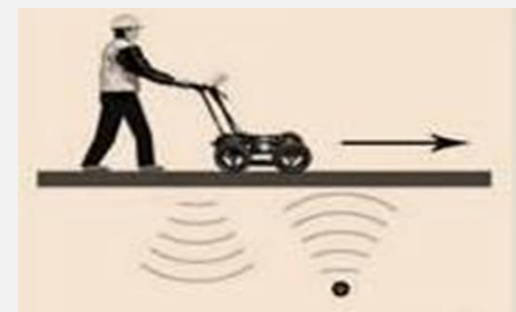


78.2 Potential Applications

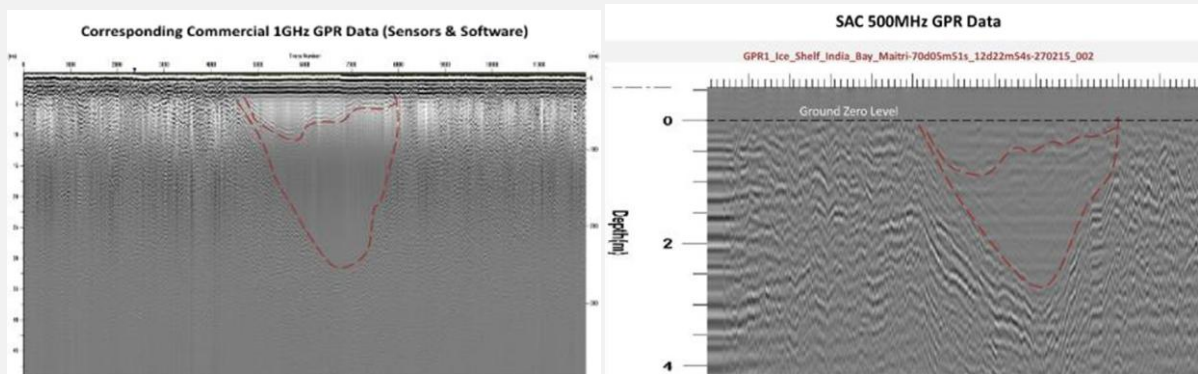
GPR is a high-resolution imaging radar that works on the principle of scattering of EM waves to locate buried objects. It operates by transmitting high frequency directly down into the ground via wideband antennas and detecting the reflected signals from targets (objects or materials with a dielectric contrast with the surrounding medium) buried beneath. It can be brought to use for the following applications:

Can be brought to use for both commercial as well as scientific applications.

GPR is an instrument that finds applications in environmental, engineering, archaeological, and other shallow investigations.



Different applications require subtle changes in the hardware (frequency selection) as well as the processing software. Therefore, once the exact application goal is defined the system can be tuned accordingly.



Benchmarking with respect to Commercial GPR

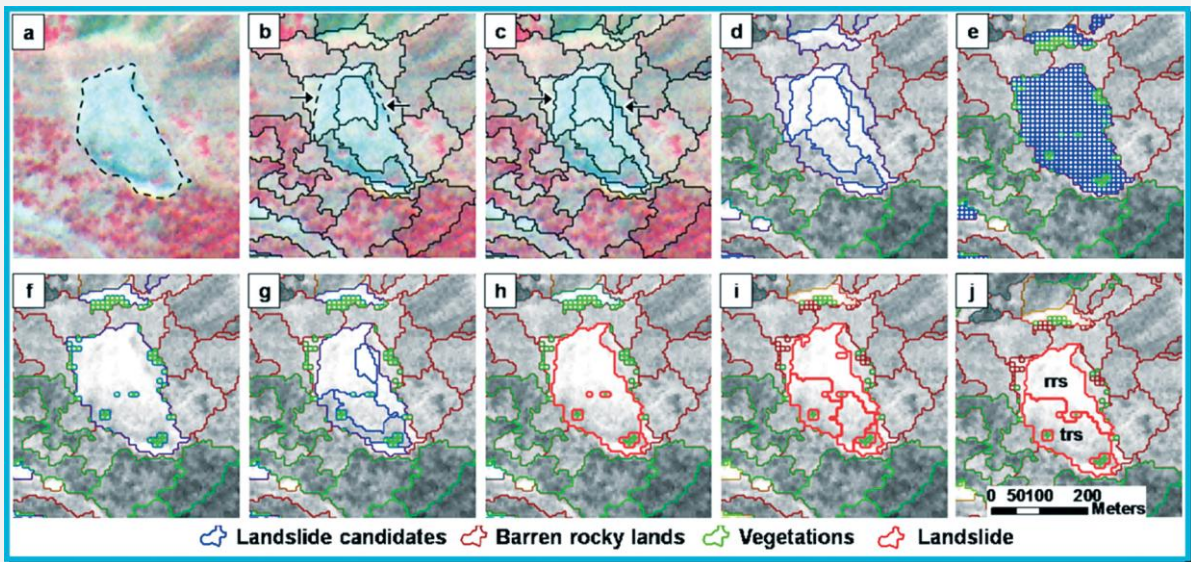
78.3 Technology Transfer from ISRO

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79 Detection of Landslides from High Resolution Optical Satellite Data

Landslide is a geomorphic phenomenon; therefore, its identification is difficult to address in spectral domain alone using satellite/aerial datasets. The common noticeable feature after occurrence of landslides is the loss of vegetation and exposure fresh rock and soil. This unique property of a landslide in combination with its relationship with slope related parameters is used to create a generic routine in a COTS s/w, and is implemented through the following four sub-modules.

All the characteristic features of landslides derived from satellite data (e.g., NDVI, brightness) and DEM (e.g., slope, relief, curvature) were fused together in a series of steps comprising of controlled segmentation, merging, classification, thresholding etc. To increase the robustness and transferability of the landslide, a data driven thresholding approach using K-means algorithm was employed. The knowledge-based approach was further strengthened by utilising change detection technique that increased the landslide detection accuracy from 76.4 % to 96.7%. The minimum size of the landslide that can be detected using this method depends upon the resolution of the satellite data. However, using 5.8 m resolution data, a landslide of 774 sq. m was detected. The object-based landslide detection technology developed to detect landslides from segmentation to classification.

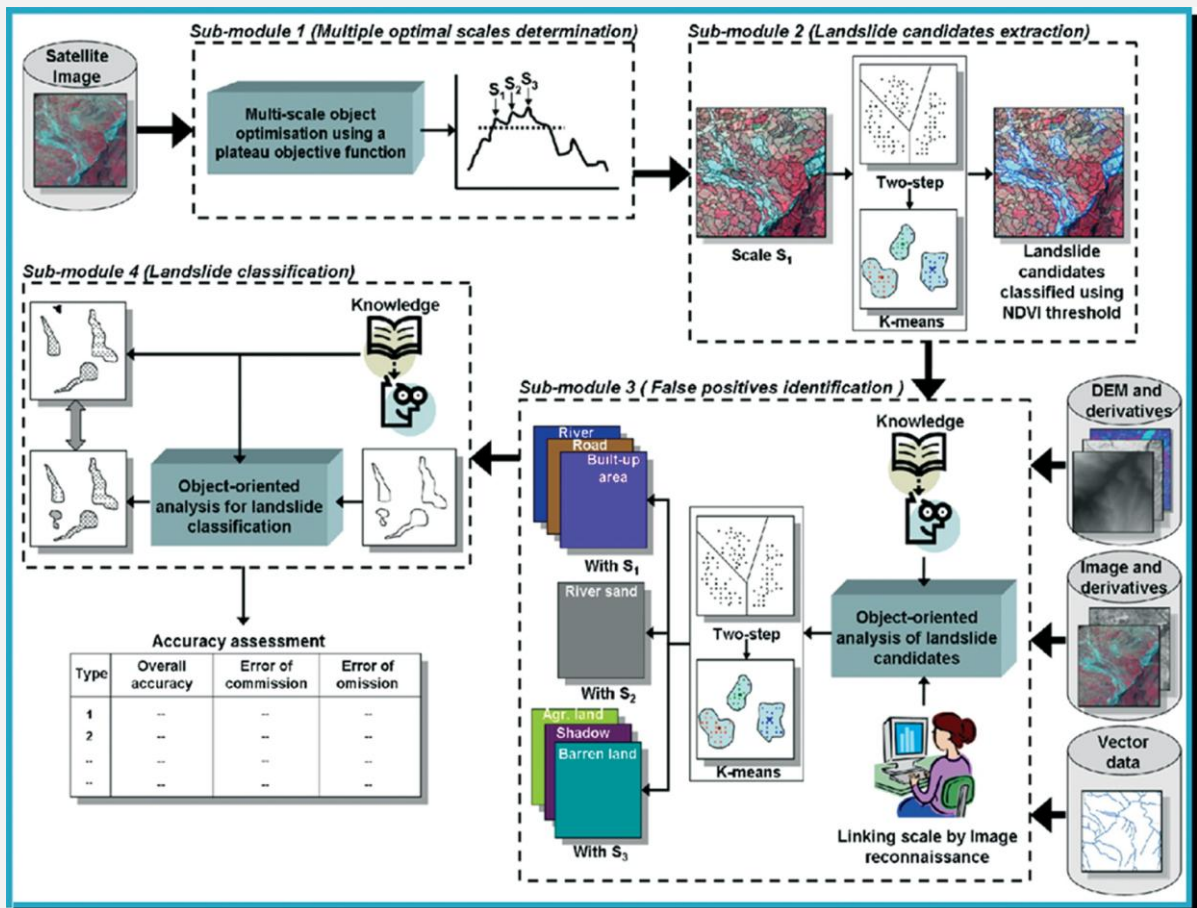


79.1 Salient features:

This technique requires only high-resolution optical satellite data. The technique combines spectral, shape, texture, morphometric and contextual information derived from high resolution Indian satellite data and DEM for the preparation of new as well as historical landslide inventories.

The main innovative aspect lies in the selection of landslide diagnostic parameters and their use in the comprehensive characterization of different types of landslides, a

concept which is addressed for the first time for detection of landslides in an object-based environment. Towards the development of a robust data driven methodology, a new POF was developed that was helpful in the multi-scale analysis of a terrain. Together with POF, and applying a change detection method using archived satellite data, a maximum landslide detection accuracy of 96.7% in Okhimath area of the Uttarakhand state could be achieved. The method has been validated in other mountainous terrains of India that has a different geological and geomorphological



setup.

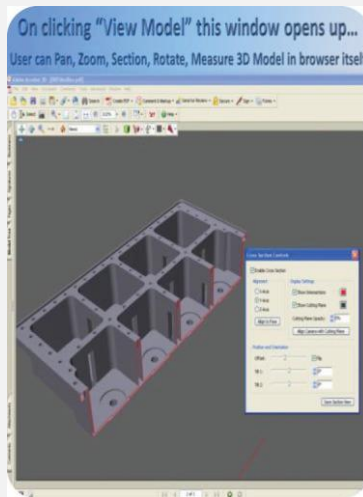
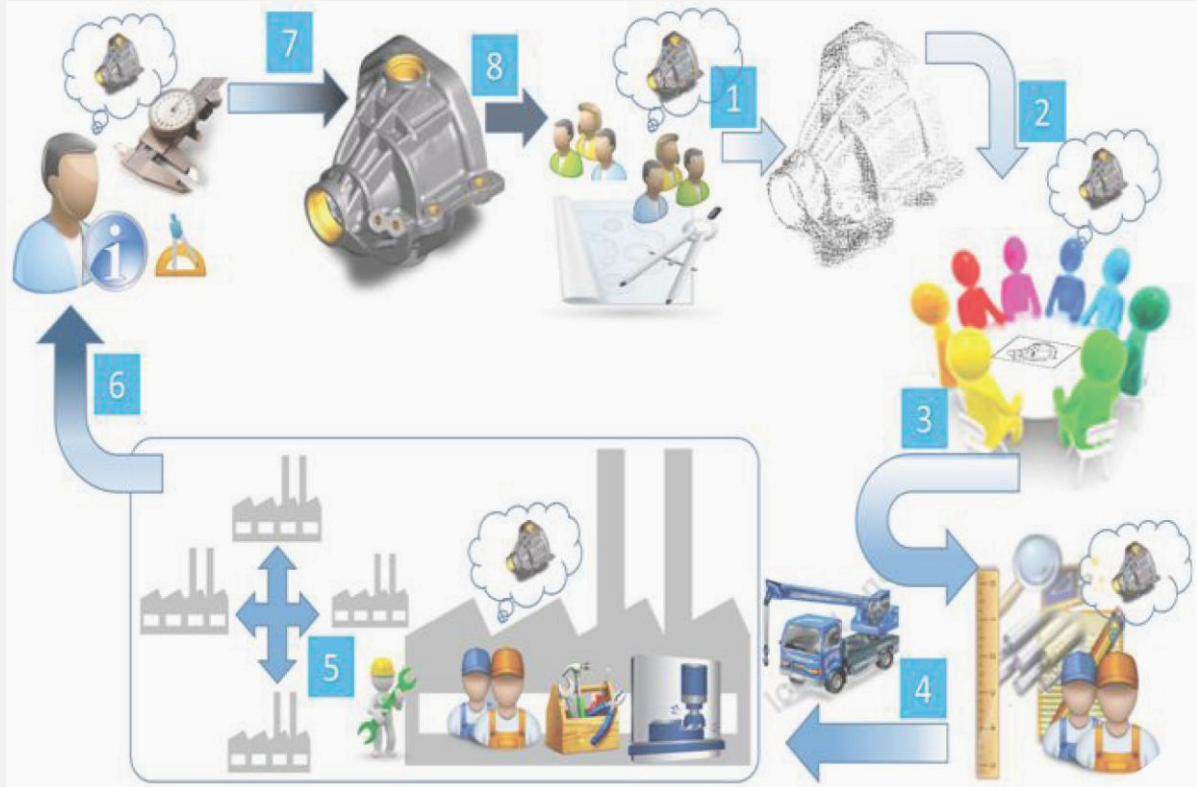
79.2 APPLICATIONS

This technology will be used to create routine landslide inventor i.e., e.g., on monthly or annual basis for large Himalayan region in India. This technology can also be used for land cover classification or vegetation change detection after suitable adaptation, since few land cover units such as barren land, agricultural land has already been identified as false positives to landslides.

80 e-smart

e-System for Mechanical Workflow-Management and Reporting Tool

e-SMART is an online software tool to automate and provide seamless end-to-end workflow management from designer to delivery



Feature	Benefits
End-to-end workflow management	All departments like Designers, Planning Engineers, Workshop Engineers, Cutting-Store Personnel, Inspection Engineers and Management Personnel work on same platform
Simple and intuitive interface.	Easy to train manpower
Web based Scalable architecture	Saves on infrastructure costs. Remote facilities can be connected

User-level Authorization and authentication	Responsibility and accountability
Provision for Data-warehousing and automated daily-backup	Data protection
3D Visualization of fabrication parts in web browser	No commercial/paid CAD/CAM software required
Thumbnails (small images) of fabrication parts facilitate in quick visualization and identification	Increases productivity
More than 60 online reports can be generated and exported in multiple formats like .rpt, .xls, .doc, .xml	Critical Information for decision-making can be obtained
Back traceability of a part	Complete history of a part can be obtained
Paperless operations	Saves on cost and delays due to movement of papers

ALL mechanical fabrication workflow activities of SAC are managed by e-SMART system.

e-SMART is in use and operations in SAC for more than 7 years.

Thus, it makes e-smart time tested and proven software.

80.1 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

81 Methods and System to Control the Data Processing Workflows in Distributed Environment with Asynchronous Message Driven Mechanism

A production workflow includes an ordered sequence of tasks to be executed that needs to be distributed on multiple computational nodes. Each task is assigned by a sender application to a receiver application running on a computational node through a message. On receiving the message, the receiver application sends and sends an acknowledgment to the message and schedules the sub tasks associated with the task. The sender application on receiving the acknowledgment removes the message from the queue otherwise the messages are stored in the database. On completion of the sub tasks the receiver application generates a message and the sender application on receipt of the message takes up the next task in the sequence and generates a message to another application. The sender application keeps on generating messages till all the tasks are completed in the sequence. The methods adopted in this invention provides persistence and guaranteed delivery of messages thereby improving the quality of service in transaction processing systems that are managing complex workflows.

81.1 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

82 Microwave Data Analysis Software (MIDAS)

Space Applications Centre (SAC) has developed in-house Microwave remote sensing data analysis software called Microwave Data Analysis Software (MIDAS). MIDAS is conceived and designed, to cater to various application driven analysis methods to analyses microwave remote sensing data. Currently it caters to SAR data analysis only, which includes different decomposition techniques for Full Polarimetry (FP) and Hybrid/Compact Polarimetry (CP). The software tool also has functional modules for doing radiometric quality analysis and impulse response



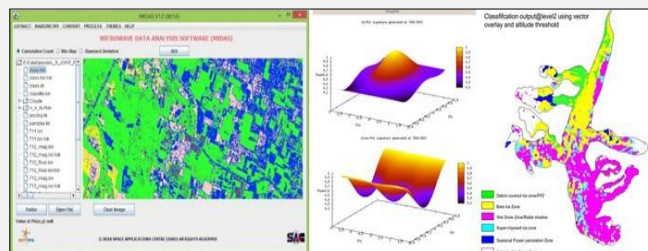
Main GUI of MIDAS software MIDAS is copyrighted with registration number 13609/2020

analysis.

It has different speckle filters for SAR specific noise removal. It also includes techniques for glacier classification and facies detection, oil spill detection, ship detection etc. This software has been designed in a modular fashion to support new sensor data interfaces and the required application algorithms. Besides supporting ISRO sensors, MIDAS additionally, supports various SAR missions of other space agencies such as ALOS-1, RADARSAT-2, NASA-JPL UAVSAR and Sentinel-1.

82.1 Main Capabilities:

1. Written in C/C++
2. Capable GUI in JAVA with Integrated image
3. viewer.
4. Polarimetric speckle filters integrated along with
5. 11 amplitude filters



3D Point Cloud Depth Map Using this Camera

6. Fast, modular and easily extensible
7. Support for full-pol decompositions include H-A- Alpha, Pauli, Yamaguchi, Freeman-Durden and Raney (CP decomposition) etc.
8. Full-pol Vanzyl type polarization response
9. (Polarimetric signature) generation module.
10. ROI handling along with Wishart supervised classifier.
11. Tools for Radiometric analysis & Impulse
12. Response analysis.
13. Sigma0, Gamma0 modules.

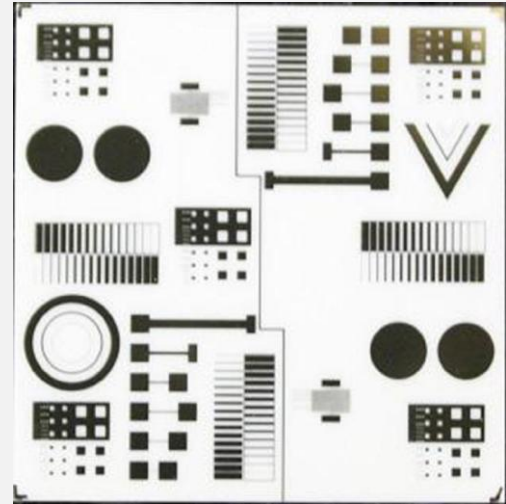
82.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

83 Lithography and Patterning on Thin Film for Hi-Rel MIC

83.1 Introduction:

Space Applications Centre (SAC) of ISRO has developed Lithography and patterning process on thin film for High-Reliability (Hi-Rel) Microwave Integrated Circuit (MIC) for space applications. This process fulfills RF/microwave properties like EM wave transmission/ radiation, electrical conductivity, interconnection, corrosion protection, solderability, bondability etc. and making them a good base for mechanical strength along with thermal conductivity and thermal coefficient of expansion (TCE) matching with carrier plate on which substrate needs to be assembled.



These processes are qualified up to critical dimension (CD) of 100 micron for space use with very tight tolerances after subjecting to various tests like visual inspection, metal adhesion test, environmental tests etc. confirming to ISRO PAX-305 and MIL standards.

The salient features of the technology include process repeatability, patterning accuracy, defect density control and adhesion as per ISRO PAX-305 to ensure better yield. Presently, the developed process is being utilized for fabrication of subsystems for communication and navigation projects.

83.2 Essential Infrastructure Requirements:

1. Yellow Room of Class 100
2. Clean room of Class 10000 and LAF for class 100 type
3. Stereo Zoom Microscope up to 100 X magnification
4. Wet processing work station
5. Ultrasonic/Mega sonic cleaner
6. Convection/Clean Air Oven/Hot plates

83.3 Consumables Required:

1. Cleaning solvents of electronic grade (EL): Trichloroethylene (TCE), Neutra-Clean 7, Dry IPA, Acetone and DI water (Resistivity > 5MΩ etc.)
2. Photoresist: LPR E-1020, All resist AR N-4300

3. Etchants: I2, KI, NaOH, K3Fe (CN)6
4. Lint free tissue paper, cotton, scraper etc.
5. Spinner for Photoresist coating
6. LASER direct write / UV Exposure system
7. Weighing Balance
8. DI Water system
9. Chemical etching room with Fume hood and exhaust arrangement
10. Nitrogen Purged, Temperature & Humidity controlled Storage Unit

83.4 Material Requirements:

Mask /Photo Film

Metalized Alumina substrates (Coostek make superstrate - 996 or equivalent).

Cr-Cu-Au Metallization on both sides of substrates.

Metallization thicknesses: Adhesion layer [Cr]: 200-250Å

- Conductor [Cu]: $4.5 \pm 0.5 \mu\text{m}$
- Passivation layer [Au]: $1.5 \pm 0.5 \mu\text{m}$,
- Total Metallization thickness: 5-7 μm

Sheet Resistivity: < 0.006 ohms/square or better.

83.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

84 Low Temperature Co-Fired Ceramics (LTCC)

(Circuit Fabrication for Satellite Payloads)

Space Applications Centre (SAC), Ahmedabad is a leading R&D Centre of Indian Space Research Organisation (ISRO) and is responsible for development and realisation of ground as well as satellite hardware required for various Communication, Navigation as well as Remote Sensing satellites.

SAC has well established and space qualified Low Temperature Co-Fired Ceramics (LTCC) facility for the fabrication of High-Rel circuit and packages for various satellite payloads. SAC is also involved in the development of 3D integration and packaging for new applications.

Salient features of LTCC technology includes multilayer integration, embedded passives, easy hermetic sealing. It provides excellent SiP technology for integration of many technologies and devices for space applications.

84.1 Essential Infrastructure Requirements:

1. Clean room of Class 10,000
2. Mechanical punching equipment
3. Stencil and screen printer Hot air convection oven
4. Stacker
5. Isostatic laminator
6. Sintering furnace
7. Dicing equipment
8. Microscope

Sr. no.	Specification	SAC Requirement
1	Conductor width	Minimum 4±0.5 mil
2	Via dimension	Minimum 4 mil ±10%
3	Via separation	Minimum 2.5 D (D - hole diameter)
4	Cavities	Step, blind and through cavities
5	Tape system	Ferro A6ME & DuPont 951
6	Maximum metal density	50% in all layer
7	Tape size	6.5" X 6.5", (8 "X 8")
8	Metal scheme	All gold
9	Number of layers	10 & more

84.2 Preferable Infrastructure Requirements:

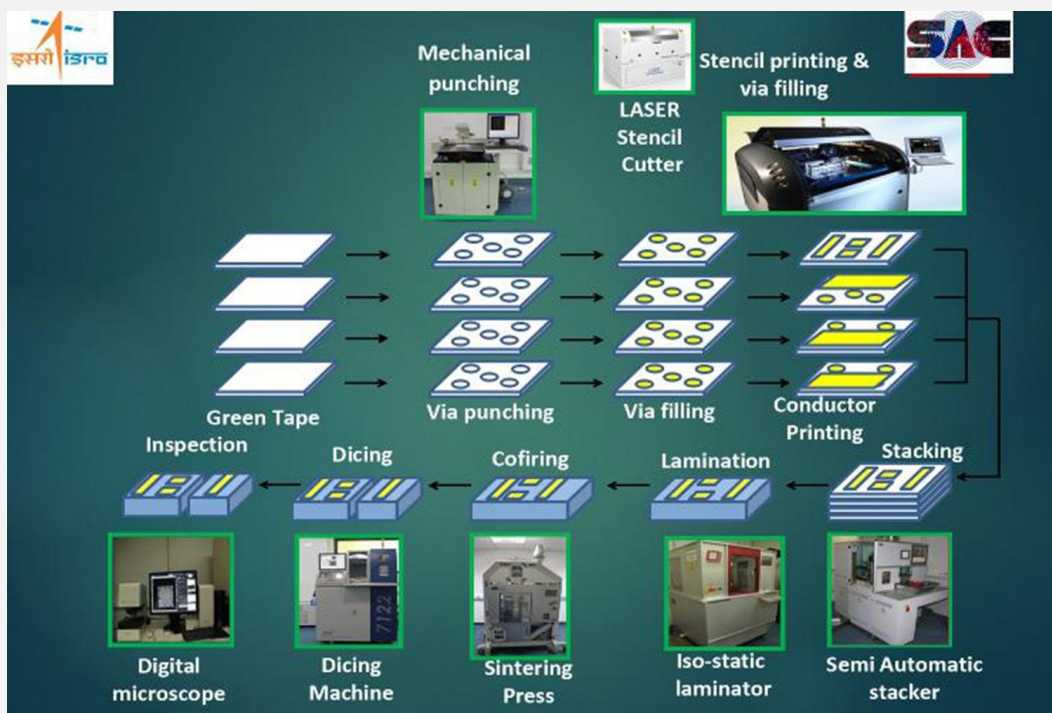
1. Stencil & screen manufacturing facility
2. Characterization tools
 - Tension meter

- Four probe Sheet Resistivity meter
- Density measurement tool
- Flatness measurement tool
- Stencil check system

84.3 Material Requirements:

DuPont 951 tape system: tape thickness 5/10 mil & compatible gold conductor and vias fill paste

Ferro A6ME tape system: tape thickness 5/10 mil & compatible gold conductor and vias fill paste



The developed product shall undergo extreme testing as per ISRO qualification standards and can be qualified for the space use only after successful completion of the testing. ISRO offers to transfer LTCC fabrication technology to industries in India with adequate experience and facilities. Enterprises interested in obtaining know-how may write giving details of their present activities, infrastructure and facilities to the following address

84.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

85 Black Anodizing on Aluminium 6061t6 & Chromatin Technology

Space Applications Centre (SAC) of ISRO has developed electroplating processes for space hardware to achieve required surface engineering properties like EMI/EMC, electrical conductivity, non-conductivity, corrosion protection, solderability, emissivity and making a good base for Thermal Control Coatings. These processes are qualified for space use with very tight tolerances and subjected to various tests like visual inspection, adhesion test, environmental tests, and engineering property specific tests confirming to ASTM and MIL standards.

SAC has developed Black anodizing on Aluminum 6061-T6 alloy process which will find commercial and industrial applications. The black anodizing on aluminum alloy components such as boxes, cavities, posts etc. are used for optical as well as communication payloads.

This coating is corrosion resistant has:

- emissivity > 0.9
- solar absorptance > 0.93
- optical reflectance < 1%

Electrolytic black anodizing is a two-step process where anodizing is carried out in step 1 and step 2 involves electrolytic coloring. It has very good color fastness and optical properties. It is regularly used on satellite.

Components for satellites, at times, require bare white anodizing for corrosion protection only and at times need yellow chromatin for basic protection of Aluminum with conductivity. There are instances where some part of the components need chromatin for conductivity and other need black anodizing for emissivity.

85.1 Plating Specifications

Black anodizing thickness: 25 ± 3 microns



85.2 Pre-requisites

1. Basic Electroplating know-how
2. Electroplating set up including electrolytic
3. chilling plants, power supplies etc.



85.3 Applications

Decorative

Engineering / Industrial

To enhance the emissivity and corrosion resistance of Aluminum alloy components.

85.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

86 Smart Fire-Retardant Coating

A Versatile Solution to Cater to Wide Gamut of External Stimuli

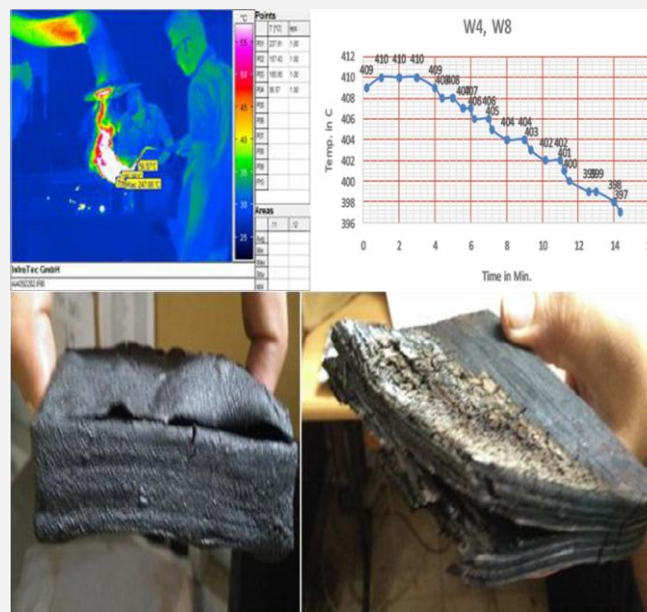
Space Applications Centre of Indian Space Research Organization at Ahmedabad has developed an omni-purpose thin coating which can be applied easily on any substrate to obtain benefits in terms of fire retardant. This coating overcomes many of the limitations of commercially available paints.

86.1 Potential Applications:

It can protect almost all type of materials. Hence, it may find applications in all type of finishing materials like wall paneling, false ceiling, doors, windows, walls. Its versatility makes it suitable for use in restaurants, hotels, hospitals, schools, Airports, shopping malls, metro stations, Bus hubs, Commercial buildings as well as personal residence.

86.2 Advantages

1. Provide two types of protections-fire resistance, flame retardant
2. Has good adhesion to all surfaces
3. Aesthetically appealing, can be mixed with any paint without loss of its fire-retardant property
4. Suitable for both indoor & outdoor use. Post curing will not wash off with rain water.
5. Superior fire, thermal protection benefits.



Coated v/s bare wood specimen at 400°C

86.3 Special features:

1. Can be applied as thin coating on any surface.
2. Can be applied over existing surfaces after fire exposure.
3. No surface preparation required except cleaning of dust and oil.
4. Can protect from any mode of fire. Sustains high temperatures
5. Saves substrates up to 50% after fire.
6. Reduces moisture absorption by 50%

86.4 Mode of application:

Can be applied like plaster by trowel. Any extensive training for application not required.

86.5 Other Features:

1. Good adhesion of the coating facilitates vertical and overhead application, minimizes clean up.
2. Virtually free of maintenance, doesn't crack or deteriorate significantly with time.
3. Dries to the touch approximately 2 to 4 hours after application and cures thoroughly in 48 hours in ambient temperature.

86.6 Technical Specifications

1. Total Solids : 40 - 50%
2. Color : Whitish
3. Grey. Specific Gravity : 1.29 gm/cc.

87 Gold Plating on Aluminum 6061 T6 and Kovar

Space Applications Centre (SAC) has developed and qualified a robust gold plating process on Aluminum 6061T6 and gold plating on Kovar for space use. These processes are qualified for space use with very tight tolerances on various process parameters after subjecting to various tests like visual inspection, adhesion test, and environment tests, and engineering property specific tests conforming ASTM and MIL standards.

Aluminum is gold plated for its unique combination of physical, chemical and electrical properties. The high electrical conductivity of gold, low contact resistance and good solderability combined with the consistency of these properties over wide range of environment conditions experienced by satellite makes gold plating the ideal choice for plating electronic hardware.

Kovar is used to fabricate carrier plates which act as support for MICs for use in communication payloads.

87.1 Specifications

Gold Plating on Aluminum 6061T6 Undercoat : (Electroless-Nickel)	Nickel-Phosphorous
Composition of undercoat (8-12%)	: Nickel - Phosphorous
Undercoat thickness	: 10-12 μ
Topcoat	: Gold (Electroplating)
Type of Gold Plating Cyanide	: Acidic Gold Potassium
Purity of Gold	: 99.99%
Thickness of Gold plating	: 2.5 \pm 0.5 μ
Gold Plating on Kovar Undercoat	: Nickel (Electroplating)
Undercoat thickness	: 3-4 μ
Topcoat	: Gold (Electroplating)
Type of Gold Plating	: Acidic Gold
Potassium	: Cyanide
Purity of Gold	: 99.99%
Thickness of Gold plating	: 2.5 \pm 0.5 μ

87.2 Salient Features

1. This process is developed after undergoing intense qualification plans and

tests to withstand harsh space-like conditions

2. Acidic gold potassium cyanide plating process
3. Easy to control and maintain
4. Optimized for uniform and dense thickness

87.3 Applications

Gold plating is used in space grade mechanical components (Electronics circuit housing boxes, carrier plate etc.). In electronics, gold plating is used to provide a corrosion-resistant electrically conductive surface. It is also used extensively in semiconductor industry e.g., in electrical switch contacts, connector pins and barrels and other applications where intermittent electrical contact occurs. Gold plating is generally practiced in aerospace applications.

88 Cr-Cu-Au Metallisation for Hi-Rel MIC Fabrication

Space Applications Centre (ISRO) is in the field of Microwave Integrated Circuits fabrication for communicational, remote sensing and navigational payloads. SAC has developed the process of Cr-Cu-Au (Chromium-Copper-Gold) metallisation on both sides (top and bottom side) of Alumina substrates using Magnetron sputtering techniques. The base material for MIC fabrication is dielectric ceramic viz. alumina on which the metallisation is to be carried out for MIC patterning.

The salient features of the technology include process repeatability, adhesion, uniformity, and compact structure of deposited thin film. The metallisation is expected to withstand environmental tests and demonstration of compatibility with further processes like pattern engraving and assembly and packaging. Presently, the developed process is utilised for fabrication of subsystems for ongoing IRNSS, GEOSAT and SCATSAT project activity.

88.1 Essential Infrastructure Requirements:

1. Clean room of Class 100 type
2. Magnetron sputtering system with three cathode/ sputter gun configuration
3. Ultrasonic cleaner
4. Vapour degreaser
5. Stereo Zoom Microscope up 100X magnification
6. DI water plant

88.2 Preferable Infrastructure Requirements:

1. Thin film characterisation tools like
2. High resolution Microscope up to 1000X
3. magnification
4. Four probe Sheet Resistivity meter
5. Muffle Furnace
6. Adhesion tester

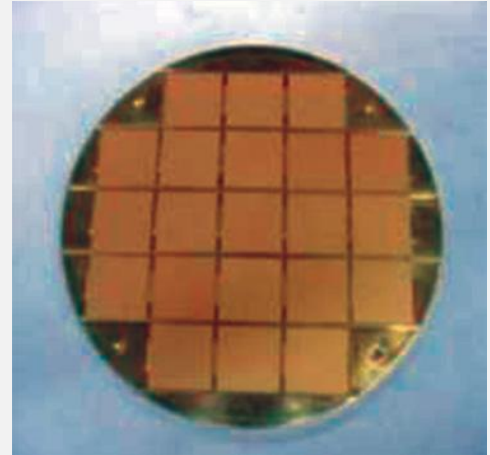
88.3 Material Requirements:

1. Alumina substrates (Coorstek make superstrate- 996 or equivalent)
2. High purity sputtering Targets of Cr, Cu & Au
3. High purity Argon gas
4. Cleaning solvents of electronic grade like Acetone, TCE, IPA, HCL, Ammonia,

DI water etc.

88.4 Technical Specifications:

1. Substrate: Alumina substrates
2. Metallisation scheme:
3. Cr: ~ 300 Angstrom
4. Cu: 4 to 4.5 micrometer
5. Au: 2 to 2.5 micrometer
6. Total thickness: 5 to 7 microns
7. Uniformity: $\pm 10\%$ on single substrates
8. $\pm 20\%$ batch to batch
9. Metallisation required on both sides of substrates
10. Sheet Resistivity: < 0.006 ohms/square



The developed product shall undergo extreme testing as per ISRO qualification standards and can be qualified for the space use only after successful completion of this testing.

ISRO offers to transfer this technology of Cr-Cu-Au metallisation on alumina substrates by Magnetron sputtering technics for MIC fabrications to industries in India with adequate experience Enterprises interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities to the following address.

88.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.]



89 Silver Plated Waveguides Technology

Space Applications Centre of Indian Space Research Organization at Ahmedabad has developed a method to carry out silver plating from inside in aluminum waveguides. It is a difficult task to plate due to the complexity and shape of the component. The purpose of this process is to get uniform deposition throughout the inside & outside surfaces of the component.

Silver plated waveguides are used in various communication payloads like GSAT, RISAT etc. Silver plating on Aluminum waveguides is required to obtain good RF performance, as silver gives the best-known electrical conductivity and also is solderable.

Most commonly used space qualified paints are available normally in two colors, Black and White. Thermo-Optical properties of Thermal Control Coatings usually carried out are as per details given below:

The plated parts should be free of pits, nodules, blisters & roughness on the components. It should pass environmental tests like heat resistance, humidity, thermal cycling, thermo vacuum etc.

89.1 Plating Specifications

Electro less Nickel-plating thickness: 6 to 8 microns
silver plating thickness: 5 to 8 microns



89.2 Pre-requisites

1. Basic Electroplating know-how
2. Electroplating set up including baths, anodes, supplies etc.

89.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

90 Thermal Control Coating Technology

Space Applications Centre of ISRO has qualified the process of thermal control coating for spacecraft subsystem component made of different materials such as Anodized Aluminum, Chromated Aluminum, Bare Aluminum, Electroless Nickel plated Invar, Bare Invar, Silver plated Aluminum, Chromated Magnesium, Black anodic coated Magnesium etc. for space use. Black paint is commonly utilized on the interior of the satellite, to facilitate radiant heat transfer among internal components.

Most commonly used space qualified paints are available normally in two colors, Black and White. Thermo-Optical properties of Thermal Control Coatings usually carried out are as per details given below:

90.1 Terminal Specifications

1. Total Mass Loss (TML) : $\leq 1.0\%$
2. Color : Black and White
3. Appearance : Flat / Matt finish
4. Dry Film Thickness (OFT) : 50 Micron to 70 Micron Collected Volatile Condensable
5. Material (CVCM) : $\leq 0.1\%$

Coating type	emissivity (ϵ)	Solar Absorptive (α)	α/ϵ
Black	0.90	0.90	1.00
White	0.85	0.20	0.23

90.2 Pre-requisites

1. Painting know-how
2. Conditioned Thermal painting booth
3. Qualified paints, guns etc.

90.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

91 Flameproofing Coating-Caspol

91.1 Introduction

CASPOL (Ceramic-Polymer hybrid) is a water based, ready-to-coat and easy-to-use flame proof coating having both societal and advanced end-use applications. It confers excellent flame retardant, waterproofing and thermal control properties to substrates ranging from masonry surfaces, textiles, paper, thatched leaves, wood etc. to advanced materials like polyurethane and phenolic based thermal insulation foam pads.

91.2 Salient features of CASPOL are:

- No liquid or vaporizable material (except water)
- Human and eco-friendly
- Brushable and sprayable
- Low cost

91.3 Description

CASPOL is a room temperature curable, water-based formulation having self-extinguishing properties, good adhesion and water repellency characteristics. It is based on ceramic composition dispersed in an aqueous polymeric emulsion containing flame retardant components. All the ingredients are dispersed in water to get a suspension of the required viscosity for application by brushing or spraying. It is having limiting oxygen index (LOI) above 40. The material coated with CASPOL will be self-extinguished within 4 seconds after removal of flame. It is also having good adhesion to the substrate surface both in the dry condition and after exposing the coated forms in water shower. Foam materials can be impregnated with CASPOL by dip coating.



Fig. 1 Model huts made of thatched coconut leaves set to fire. (Left)-Hut without CASPOL coating gutted completely in fire within a few seconds whereas CASPOL coated hut remained intact even in fire.



Fig. 2 Images of commercial polyurethane foams set to fire. (Left)-foam without CASPOL impregnation burned completely in fire within a few seconds whereas CASPOL impregnated foam (right) remained intact even in fire.

91.4 Applications of CASPOL

1. **Launch vehicle:** CASPOL is a flame proof coating, giving the required flame retardant properties to thermal protection foam pads used in Launch Vehicles.
2. **House hold:** CASPOL can be applied over thatched leaves of the cottage roof to flameproof it in addition to increasing the life of such roofing of households, so that periodicity of the maintenance and replacement can be reduced significantly. Application of CASPOL reduces the temperature inside the room and prevents water leakage. The low solar absorptivity (0.20%-0.40%) and high emissivity make it a good temperature controller in sunny weather
3. **Waterproofing/thermal control of concrete:** CASPOL can be applied over the concrete surface of a building to prevent water seeping. The high emissivity keeps the building cool by at least 5 to 6°C less. After the application of CASPOL, water seepage problems will not be felt as CASPOL pots micro cracks and holes.
4. **Railways and automobiles:** CASPOL can be used as a flame retardant material in railways and automobiles where the seat cushions can be made flameproof using this material, without affecting the cushioning characteristics significantly.
5. **Foams In Public Transport:** If the foam materials used in passenger seats are rendered flameproof, fire accidents can be reduced to a large extend. Since flame proofing of foam materials using CASPOL can be achieved through less expensive processes, there is considerable market potential for CASPOL in Indian foam market.

Properties	CASPOL- alone	CASPOL coated PIPhenotherm/ Polyurethane
LOI, %	32-42	32-42
Solar absorptance	0.20-0.40	0.20-0.40
Adhesion tape test at RT	N/A	pass

Oxyacetylene flame test, time for extinction, sec	N/A	≤ 4 sec
Ignitability	N/A	Not easily ignitable
Surface spread of flame	N/A	Class 3
Heat release rate	N/A	53.83 kW/m ²
Fire propagation index	N/A	17.97
Sensitization to skin	No sensitization	N/A
Irritation to skin	Non-irritant	N/A
Toxicity	Cytotoxic	



Fig. 3 Two images of commercial seat cushion set to fire. In each image: (Left)-cushion with CASPOL impregnation remain intact even after fire whereas cushion without CASPOL impregnation (Right) is burned completely in fire within a few seconds

CASPOL can also be used for flame proofing foam materials used in auditoriums and cinema halls where chances of fire related accidents are high.

VSSC is willing to offer the technology of CASPOL to capable and interested parties who are in the field of manufacturing similar items.

Interested entrepreneurs are requested to contact the address given below with all relevant particulars regarding their line of current activity, infrastructure available, market assessment of the product, financial arrangements strength of the company, turn over and sales of their products for the past few years and a copy of their latest annual report.

91.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

92 Corrosion Resistant Coating NRCM-204

NRCM-204 is a corrosion resistant coating material for metals and composites to protect from various environments like nitric oxide, dinitrogen tetroxide (N₂O₄), mixed oxides of nitrogen, concentrated nitric acid (Conc.HNO₃) etc. The system is comprised of inorganic-organic hybrid network consisting of hydroxy siloxane, epoxy-amine based alkoxy silanes, crystoballite silica. Complete curing of the system is achieved by simultaneous curing of epoxy-amine and hydroxy siloxane-alkoxy silane in presence of tin based catalyst.

92.1 Salient Features

Ambient temperature curing

Corrosion resistant material to protect from harsh oxidizing environment

92.2 Properties

LSS (Al/Al) at RT, ksc	: ≤ 10
Tensile strength, ksc	: ≤ 5
Tensile Modulus, ksc	: 5 to 15
Elongation (%)	: 70 to 120 Dip test of coating in Conc.
HNO ₃ for 3 days	: No Peel off

92.3 Applications

NRCM-204 offers a highly corrosive resistant coating which can be coated over metals and composites for almost all type of corrosion which includes various acids. Conventional polymeric materials will not withstand such a highly corrosive environment.

92.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

93 Silicone Polymer based Thermal Protection System: PC-10 TPS (Red) and (White)

Pc-10 thermal protection systems are silicone polymer based filled compounds, which are good ablative thermal insulators. These compounds are room temperature curing systems which can be applied by brushing, spraying and putty blade. The remarkable features of the system include good thermal, chemical and ageing resistance and compatibility with wide variety of substrates. Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed a technology for processing and application of different types of silicone polymer based thermal protection systems with tailored properties to meet various mission/ application requirements.

The processing involves incorporation of selected quality fillers and ingredients in specific type of silicone polymer resin and use of suitable curatives to achieve desired thermo-physical properties.

93.1 Salient Features

1. Simplified and cost-effective technology for processing premium quality ablative thermal protection systems
2. Overnight, room temperature curing system.
3. Flexibility with respect to application procedure such as spraying, brushing or putty application.
4. Compatibility with wide variety of substrates including metals, composites, glass etc.
5. Excellent ageing behavior and hydrophobicity, making it suitable for long term application with no deterioration of properties for more than 5 years.

93.2 Applications

1. Useful for high quality ablative thermal protection system for temperatures up to 3500C direct exposure with reasonable stability and capability to retain properties. The system also has good moisture resistance and good age resistance. The system can be applied to desired thickness depending upon the thermal environment envisaged. Reasonable mechanical strength and adhesive properties with large number of substrates has been demonstrated by the system. Ability to retain properties at temperatures up to 1500C and low temperature flexibility are other highlights of the system owing to the low glass transition characteristics associated with silicone polymers.
2. The products can be used for thermal protection application for protecting rocket hardware from aerodynamic heating and launch pad components from flame impingement and also as moisture / water impermeable coating etc.

3. The system can be tailored for use as corrosion protection coating on metal substrates for outdoor use.

93.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below.

94 High Emissive Silicone Coating, HESC/CSNM-29

Vikram Sarabhai Space Centre has developed a good number of specialty coatings to meet the specific requirements in Launch Vehicles and Satellites. These coatings may also find various industrial applications.

HESC/CSNM-29 is one such special coating system developed as a high temperature resistant enamel coating. This coating finds application as a high emissive topcoat on ablative surfaces. It is also used as a high emissive and thermal insulative coating on the PCB sensor cards for GPS Radiosonde studies. This room temperature curable silicone-based coating system contains special inorganic fillers, which imparts high emissivity to the system. Other applications could include anticorrosion and weather/ rain proof coating on metallic substrates. The coating is weather and high temperature resistant and lasts for long.

94.1 Typical Properties / characteristics:

	Property
Part A	White, viscous
Part B	Transparent liquid
Ford cup viscosity (Ford cup No. B 4)	20-40 sec. after diluting with 200 ml toluene
Adhesion tape test	No peeling from substrate

94.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

95 FB-CVI for Realisation of C-C Composite

Indian Space Research Organisation (ISRO) at Vikram Sarabhai Space Centre has developed Film Boiling Chemical Vapour Infiltration (FB-CVI) technology for realisation of Carbon-Carbon Composite products. Carbon-Carbon composites materials possess excellent thermo-mechanical properties apart from excellent ablation and erosion properties, which are prerequisite for numerous high temperature applications. In addition, Carbon-Carbon Composites possesses ideal characteristics of low density, tailorable thermal conductivity, high heat absorption capacity, dimensional stability at high temperature, tribological properties and biocompatible characteristics making it suitable for a wide spectrum of applications. The process of FB-CVI enables realization of Carbon-Carbon Composite products through a faster process methodology and is adaptable for manufacturing of C-C Composites products for diverse applications.

95.1 Salient Features of Film Boiling CVI process Technology

1. Simplified and Cost-Effective technology for manufacturing Carbon-Carbon Composite products.
2. Faster densification process (2-3 mm/hr.) for realization of Carbon-Carbon Composite products.
3. Less parametric sensitive making the process robust and reliable.
4. Flexibility for realization of 2D, 2.5D & 4D C-C composite-based products.
5. Realisation of Carbon-Carbon Composite products through a single process cycle.
6. Closed loop circulation of precursor thereby minimizing pollution aspects.

95.2 Applications

Carbon-Carbon Products realized through Film Boiling CVI process can have wide spectrum of applications, considering high thermal shock resistance, capability of retaining mechanical strength at elevated temperatures and other characteristics of the material.

95.3 Technology transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs/industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below.

96 Pulse Hard Anodization Process

Hard anodizing process produces a thick ceramic like coatings on Aluminum and its alloys. The micro hardness of the coating is more than 250 HV. These dense anodic coatings are usually thick by normal anodizing standards, and they are produced using special anodizing conditions. The thickness range is usually between 25 and 250 μm . The hard anodic oxide coatings produced under special conditions have high hardness values and very good abrasion resistance compared to normal anodic coating.

96.1 Features

Pulse hard anodizing process is carried out at

+10oC compared to conventional hard anodizing process, which is carried out at -5oC, thus saving a considerable cooling load.

The burning and powdering problems associated with conventional hard anodizing process are eliminated

Processing Parameters	Conventional Hard Anodizing	Pulse Hard Anodizing	Advantages
temperature ($^{\circ}\text{C}$)	-5 \pm 2	10 \pm 2	Considerable saving in cooling load and cost. Solution conductivity is better and permits higher current density processing.
Current Density (A. ft-2)	35 \pm 5	45 \pm 5	Faster, better and harder coating
Voltage (V)	24 -90	16 – 32	Heating at the interface of Component & electrolyte is eliminated. Burning problem is eliminated
time (min)	80 -120	40-60	The time taken to build up a thickness of 50-70 microns is halved. Results in harder coating without powdering.
Properties of the Coating			
Thickness (micron)	60 \pm 10		
Microhardness (HV)	250-350	250 – 500	Better and harder coating
Insulation value	30-2.5 G Ω	30-1.5 G Ω	comparable
Coff. Of friction	0.3 to 0.5	0.3 to 0.4	Comparable
Corrosion resistance (Rp in Ω .cm2)	18.7 X 106	11.1 X 106	Comparable

96.2 Applications

1. Hard anodic oxide coatings find application in the engineering industry for components where abrasion resistance is the required primary characteristic of the coating. For Ex:
2. Automobile Industry (Pistons, Cy, inders, Hydraulic gears)
3. Aerospace Industries (Variety of components like sliding / rotating

mechanisms with solid lubricants, Thermal barrier coating, Thermal control coating etc.,)

4. Chemical and flame-resistant surfaces
5. Cooking utensils
6. Highly insulating (electrical) dielectric coating

96.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

97 Anodising on Titanium Alloys

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed anodizing process for Titanium and its alloys to impart corrosion resistance and multicolored aesthetic appearances used for color coding applications.

97.1 Salient Features

Anodizing on Titanium alloys imparts a colored aesthetic appearance to the base alloys. It is used as corrosion resistance coating as well as aesthetic architectural material in construction industries.

97.2 Typical Properties / characteristics:

Appearance	Uniform Coating
Thickness	~ 500 Ao
IR Emittance (~ IR)	~ 0.25 ± 0.05
Solar Absorptance (~ S)	~ 0.70 ± 0.05

97.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

98 Pulse Hard Anodising

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed pulse hard anodizing process on Aluminum alloys. The hard anodic oxide coatings produced under special conditions have high hardness values and very good abrasion resistance compared to normal anodic coating. Hard anodic oxide coatings find application in the engineering industry for components where abrasion resistance is the required primary characteristic of the coating.



98.1 Salient Features

Pulse hard anodizing process is carried out at +10 oC compared to conventional hard anodizing process, which is carried out at -5 oC, thus saving a considerable cooling load. The burning and powdering problems associated with conventional hard anodizing process are eliminated.

98.2 Major Specifications

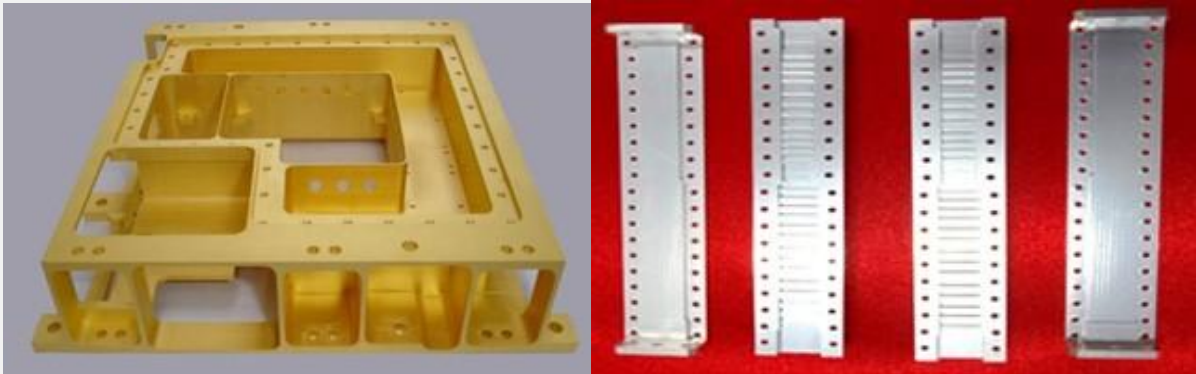
Thickness (microns)	ASTM-B-244 Eddy Current Method	60±10 Micron
Microhardness (HV)	ASTM-E 384, Diamond Indenter	250 - 500
Insulation Value (Electrical)	10-100 V Range, DC	30 - 1.5 GΩ

98.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

99 Nanoparticle (Silver & Gold) coating on Aluminum

Space Applications Centre (SAC) has developed and qualified a robust Nanoparticle (Silver & Gold) coating on Aluminum 6061T6. The high electrical conductivity of gold, low contact resistance and good solderability combined with the consistency of these properties over wide range of environment conditions experienced by satellite makes gold plating the ideal choice for plating electronic hardware. Nano particle size is in the range of 25-50 nm. The nano silver plating on aluminum alloy components such as RF filters improves surface conductivity and hence reduces the insertion losses. The process is used for components like waveguides, adaptors, HRFs, filters etc. Silver plated waveguides are used in communication payloads of satellites. Nano Silver plating on Aluminum is optimized to give better RF performance as compared to traditional silver plating. Nano Silver coating provides high luster, electrical conductivity near to pure silver and is solderable. Indoor humid environment tarnish resistance is achieved by nano deposition.



99.1 Applications area

1. Engineering / Industrial
2. To enhance the electrical conductivity of the surface

99.2 Specifications:

Gold nano Plating on Aluminum 6061t6	
Undercoat	Nickel-Phosphorous (Electroless Nickel)
Composition of undercoat	Nickel – Phosphorous (8-12%)
Undercoat thickness	10-12 μ
Topcoat	Gold (Electroplating)
Type of Gold Plating	Acidic Gold Potassium Cyanide
Purity of Gold	99.99%
Thickness of Gold plating	2.0±0.5μ or 1.0±0.2μ

Silver nano Plating on Aluminum 6061t6	
Undercoat	Nickel-Phosphorous (Electroless Nickel)
Composition of undercoat	Nickel – Phosphorous (8-12%)
Undercoat thickness	8-12 μ
Topcoat	Silver (Electroplating)
Type of Silver Plating	Basic Silver Potassium Cyanide
Thickness of Silver plating	7.0±2.0μ

99.3 Salient Features

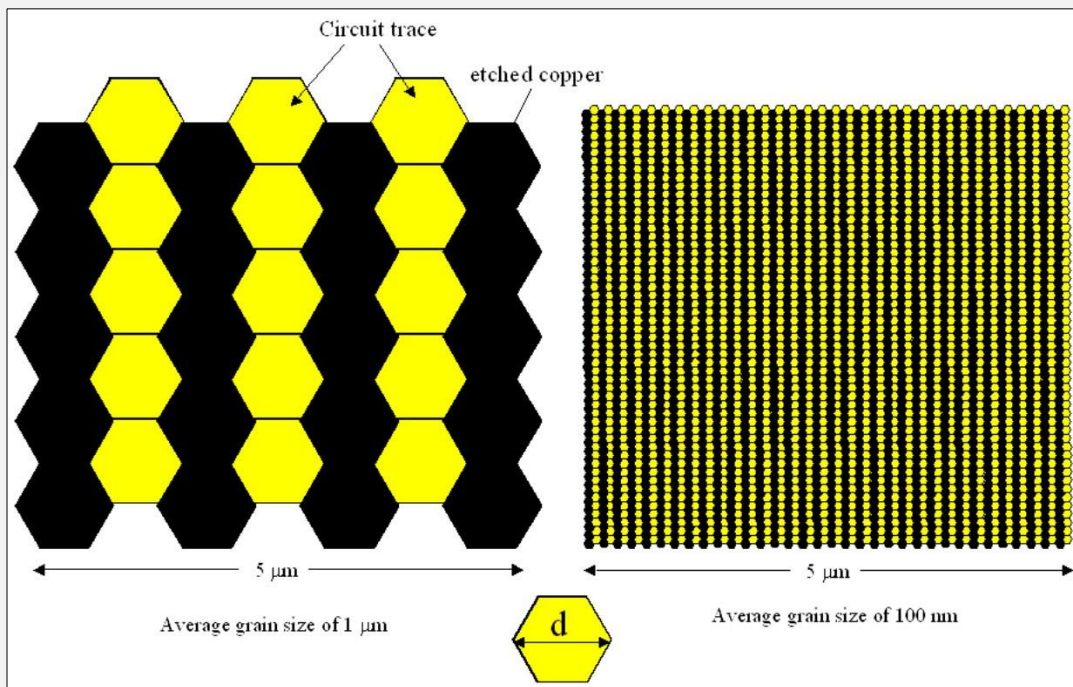
1. Processed developed after undergoing intense qualification plans and tests to withstand harsh space-like conditions.
2. Highly stable cyanide-based chemistry.
3. Easy to control and maintain.
4. Optimized for uniform and dense thickness with liberal process parameters range.
5. Undercoat of electroless nickel for better corrosion protection of aluminum.
6. Silver nano particle coating resistant to indoor humid environment tarnish effects tested as per ASTM B809.

99.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

100 Nano-Structured Metal Deposition by Electroplating Method for PCB required for Space application

Space Applications Centre (SAC) has developed Nano-Structured Metal Deposition by electroplating method for PCB. This technology ensures the deposition of <100 nm copper and gold metal deposition by electroplating method for RF/Microwave PCB circuits fabrication. Nano crystalline and ultra-fine grain deposited copper by this technology can potentially offer improved reliability and functionality to the PWB. Secondly Nanocrystalline deposition significantly contribute for the isotropic etching characteristics of copper during the lithographic etching process, hence wiring density can be increased through grain size reduction. Nano soft gold plating deposit provides an extremely pure deposit of gold and non-porous coating.



100.1 Applications area

PTH Gold plated PCBs for RF/Microwave applications.

MLBs with high aspect ratio boards.

100.2 Salient features

With this technology it is possible to etch 100-micron track width and spacing. Moreover, fabrication process passes through all qualification tests including following environmental and functional tests.

Salient features	
Hot Storage	125 °C – 168 Hours
Thermal Cycling	- 65 °C – 10 min., +125 °C – 10 min., No. of Cycles: 200 (100 + 100)
Humidity	- 40°C ± 2°C 90 – 95 % RH for 21 days

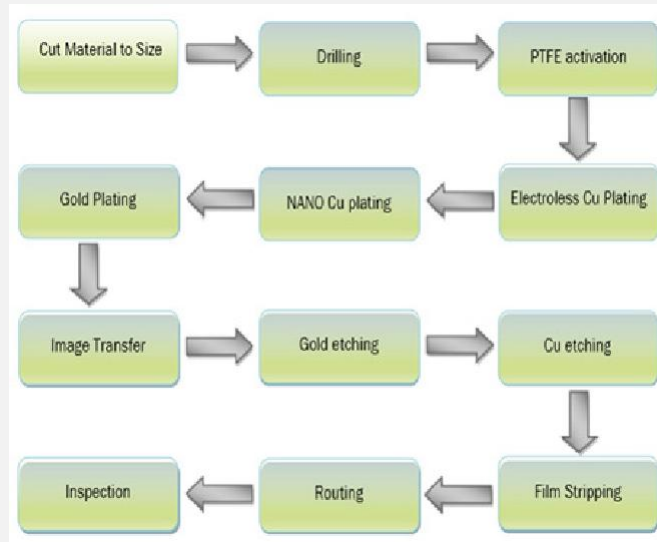
1mil Wire, 5/10/20mil Ribbon Bonding (5 bonds of each) using parallel gap method

100.3 Broad Specifications

Copper nano deposition < 100 nm

Gold nano deposition < 100 nm

100.4 Process Schematic diagram

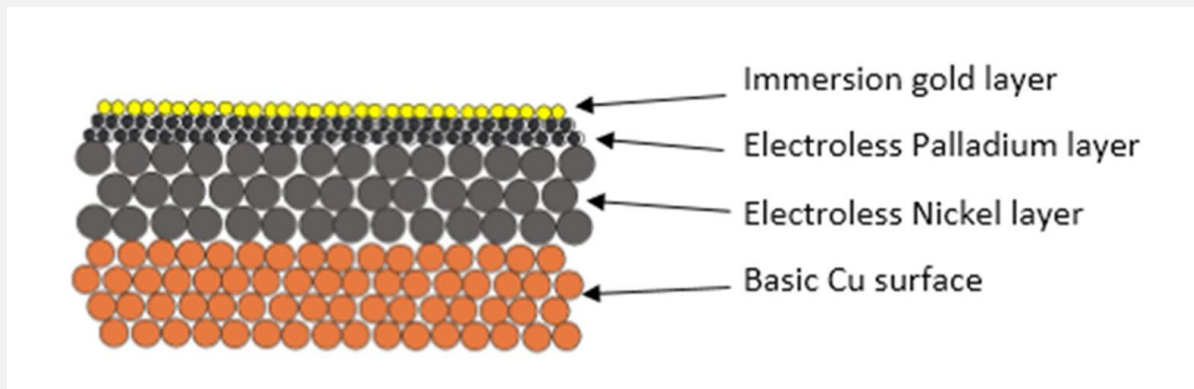


100.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

101 Electroless Nickel Electroless Palladium Immersion Gold (ENEPIG) Process for Printed Circuit Boards

Space Applications Centre (SAC) has developed Electroless Nickel Electroless Palladium Immersion Gold (ENEPIG) surface finish is most suitable surface finish. Here palladium is added between electroless nickel and immersion gold as shown in fig. Palladium layer plays a role in stopping immersion gold technology from corroding nickel layer. As a result, ENEPIG is capable of defeating the defect of black pad held by ENIG. Moreover, ENEPIG provides planner solderable finish, Al and gold wire bondable, nickel strengthen the PTH, Nickel barrier prevent the copper dissolution during thermal exposure, it has good shelf life and does not tarnish. This process overcomes some of the limitations of Hot Air Solder levelling and electrolytic gold types of surface finish, being used for digital/ analog and RF/Microwave applications



Electroless Nickel Electroless Palladium Immersion Gold (ENEPIG) surface finish

101.1 Applications area

PPTH Gold plated PCBs for RF/Microwave applications.

MLBs with high aspect ratio boards.

101.2 Salient features

Optimised fabrication process is passes through all qualification tests including following environmental and functional tests.

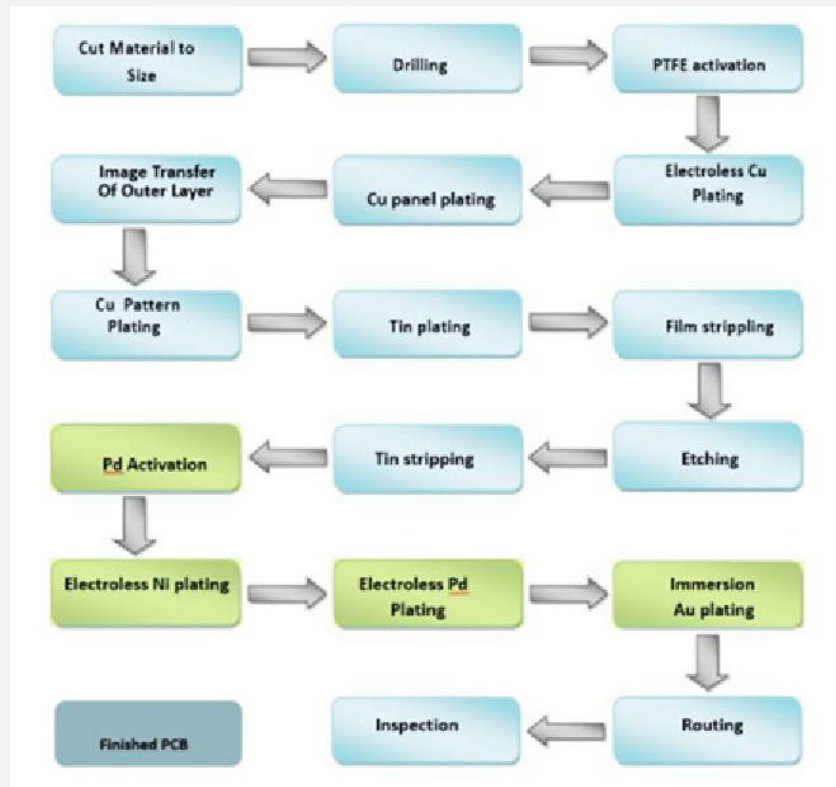
1. Hot Storage: 125 °C - 168 Hours
2. Thermal Cycling: - 65 °C - 10 min., +125 °C - 10 min., No. of Cycles: 200 (100 + 100)
3. Humidity: - 40°C ± 2°C 90 - 95 % RH for 21 days
4. 1mil Wire, 5/10/20mil Ribbon Bonding (5 bonds of each) using parallel gap method.

101.3 Broad Specifications

Immersion Gold layer thickness: 0.07 to 0.15 μm

Electroless Pd layer thickness: 0.1 to 0.30

Electroless Ni layer thickness: 3 to 5 μm



101.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

102 Gold Plated PTH / non PTH PCBS

on PTFE Based Substrates For RF/ MM Wave applications for Space and Ground use

102.1 Product specifications

1. Minimum hole dia 0.3 mm for serial no. 1,2, and 5
2. Minimum hole dia 0.5 mm for serial no. 3 and 4
3. Surface activation of PTFE based laminates.
4. Soft gold plating
5. Gold Overhang \leq 10 micron
6. Track width and spacing 130 microns
7. Slot dimension 0.8 mm to 1.5 mm

102.2 Salient Features

Laminate types: Process is capable to fabricate space qualified PCBs on following types of substrates, with thickness varies from 10 mil to 25 mil.

1. RT Duroid 6002 ½ / ½ Cu
2. RT Duroid 6010 ½ / ½ Cu
3. RT Duroid 6002 ½ / 1mm Cu
4. RT Duroid 6010 ½ / 1 mm Cu
5. TMM10i

102.3 Approximate Work Load Per Year

1. 800 to 1000 PCBs for on-board
2. 1000 to 1200 PCBs for ground applications

102.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

103 Precision Tapping Attachment

Space Applications Centre of Indian Space Research Organization at Ahmedabad has developed a Precision Tapping Attachment which is much useful for precision tapping in mechanical packages. This attachment is useful for tapping of highly precise M1.2 screws and onwards with accuracy.

103.1 Salient Features

1. Useful for highly precise M1.2 screws and onwards with accuracy.
2. To ensure for perfect and precise tapping with perpendicularity.
3. Ensuring tapping up to proper depth.
4. No jamming or breaking of tapping tool.
5. Even unskilled worker can also use it.
6. Increasing in productivity.

103.2 Technical Specifications

1. Tapping Capacity : Starting form highly precise M1.2
2. Overall Size : 345 mm x 300mm x 330 mm height
3. Swiveling of arm : 360°
4. Vertical Adjustment : Easily possible up to 300 mm
5. Horizontal Adjustment : In range of 50 mm, Maximum Distance 215 mm
6. Tapping Operation : Manually
7. Overall Weight : 9 kg
8. Tools : Standard tools can be used
9. Extension : Extendable for Helicoil insertion and semi-automation for vertical feed and lubrication

103.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

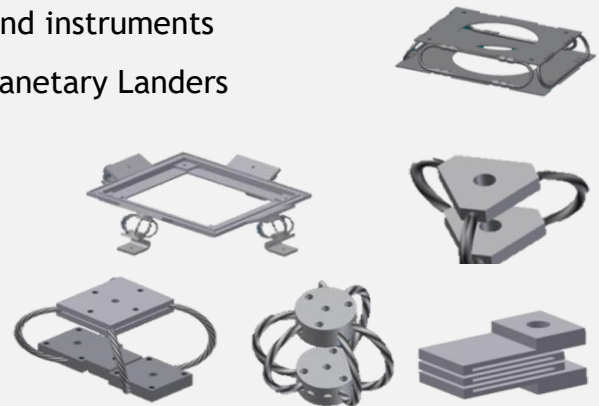
104 Vibration Management Solutions

Manages motion-Minimizes vibration, shock and noise

1. Developed by Space Applications Centre, ISRO, Ahmedabad.
2. Delicate electronic and optical systems which are vulnerable to vibration and shock can be protected from these.
3. This Vibration Management Solutions (SVMS) solves vibration and shock difficulties during transportation on ground and space.
4. SVMS systems are based on wire rope mounts that provide inherent damping by virtue of relative motion between wire strands.
5. Wire rope isolators usually can accommodate large deflections without the danger of bottoming and plastically deforming, hence offers a wide range of isolation to a variety of applications.

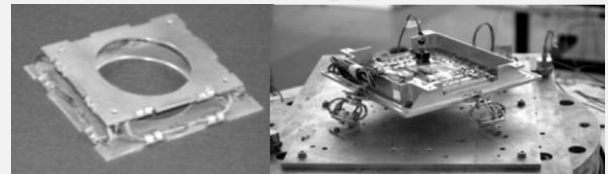
104.1 Potential Application Areas

1. Space Missions Payload Systems and instruments
2. Delicate systems Suspension in planetary Landers
3. Air / Road / Sea Transportation
4. Foundation of Equipment
5. Chemical Processing Equipment



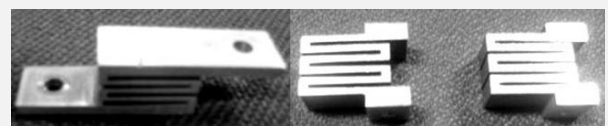
104.2 SVMS Types:

1. SVMS Quad-Fed
2. SVMS Tri-Fed
3. SVMS Hex-Fed
4. SVMS Platform



104.3 Salient features

1. All metal construction
2. High inherent damping
3. Wide Temperature Range - 100-200° C
4. Maintenance Free
5. Corrosion Resistant
6. Multidofs
7. Seismic isolation



104.4 TECHNICAL SPECIFICATIONS

Type	Supported Mass (Gm)	Frequency Range (Hz)
SVMS Quad-Fed	400-3000	5-2000*
SVMS Tri-Fed	<18	
SVMS Hex-Fed	<65	20-2000
SVMS Platform	<240	

105 Fabrication of Waveguide Runs

Space Applications Centre (SAC) of Indian Space Research Organisation (ISRO) has developed an Innovative Process technology to fabricate Waveguide run from Thin-Walled Rectangular Tubes having various cross-sectional dimensions.

These waveguide runs are of various shapes & different lengths and are being used for making total waveguide plumbing line, by assembling the said waveguide runs through flanges welded at each end. The different shapes are being made by variety of bends & twists generated through forming process by working on straight tubes.

105.1 Technical Specification

Raw Material details

Form	Rectangular rolled tubes
Material	Al. Alloy 6061-T6
Internal Surface Finish	1.6 Micron

105.2 Type of Cross Section & Joining of End Flanges Raw Material Details

Waveguide	Internal imension (L x B) in mm	Wall thickness in mm
WR-75	19.05 x 9.525	0.635
WR-51	12.95 x 6.47	0.635
WR-28	7.11 x 3.55	0.635

105.3 Applications

1. Ground as well as Airborne Radar
2. Transmission & Reception in range of Microwave frequencies
3. Satellite based Communication System
4. In the devices of Navigation Aids
5. High power testing of Microwave system

Waveguide	Bends	Bend Angles (Degrees)	e Plane mean Bend Radius (mm)	H Plane mean Bend Radius (mm)	Twist Angles (Degree)
WR-75	E-Plane, H Plane	0 to 180	30	35	0 to 90
WR-51	E-Plane, H Plane	0 to 180	20	25	0 to 90
WR-28	E-Plane, H Plane	0 to 180	20	20	0 to 90

Process of Joining of flanges with waveguide	Space Qualified tungsten Inert Gas(tIG) Welding
Material	Al. Alloy 6061-T6
Internal Surface Finish	1.6 Micron
Thickness	1.2 mm to 0.635 mm
Quality*	RF Leak Proof

105.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

106 Sit on Umbilicals for Remote Fluid Servicing of Launch

Umbilicals are extensively used in the fields of aviation, space technology as well as automotive. Indian Space Research Organisation (ISRO) at its Liquid Propulsion Systems Centre has developed a compact and reliable sit on Umbilical which can be used for remote fluid servicing of Launch Vehicles.

106.1 Principle of operation

This innovation though is developed for a specified requirement (servicing the lower stage of launch vehicle) can be extended to various other applications. This system has a flight segment (part of vehicle) which sits over the ground segment (assembled to launch pedestal). The flight segment gets lifted off along with vehicle upward movement.

The system has got a pack of Belleville disc springs to take up longitudinal deflections and a twin spherical ball mechanism to transfer disc spring load to ground segment and also accommodate vehicle sway. Moreover, the system employs push open type check valves for fluid transfer in mated condition.



106.2 Specification

1. Accommodate vehicle sway of +10mm
2. Accommodate vehicle longitudinal deflection of 10mm in downward direction
3. The ground segment & flight segment has to separate within 20mm of vehicle lift off.
 - Automatic sealing devices should automatically close after vehicle lift off ensuring leak tightness both in mated and separated condition.
4. External leak of SOU in mated condition $\leq 1 \times 10^{-3}$ sccm/sec of GN₂ at Room

106.3 Temperature

Envelope of SOU should be minimum.

Flight segment to have minimum aerodynamic load during flight.

106.4 Advantages and salient features

1. Minimum assembly and test time required at launch pad.
2. Provides completed testability & serviceability at launch pad.
3. Simple concept of self-sealing connectors
4. Easy fabrication and testing
5. Compact design
6. Design allows easy de-mating when flight segment gets lifted off along with vehicle upward movement. No complex locking and separating mechanism.

106.5 Applications

1. Servicing of military and commercial aircrafts
2. Remote fluid servicing of missiles
3. Oil rigging operations
4. Automobile industry
5. Chemicals and fertilizer industry handling toxic chemicals
6. Locomotives Commercial gas (LPG) filling center

107 Tool for Connector Pin & Teflon Trimming

107.1 Tool Features

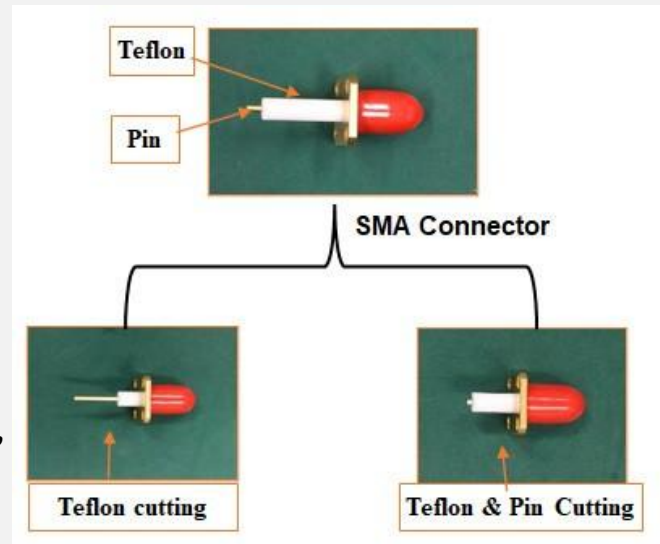
Teflon & pin trimming with $\pm 50 \mu\text{m}$ accuracy.

No cut marks (Nicks) on pins

Zero defect process output

High throughput

Motorized & simple tool, hence,
person independent process



107.2 Application Area

Patch Antenna, waveguide adaptor,

Large numbers required in SAC.

Probable co.: Astra AMPL

Escq qualified fm grade

107.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

108 SAC Video Imaging System (SVIS)

Space Applications Centre of Indian Space Research Organisation has designed and developed a state-of-the-art Video Imaging System called as “SVIS”. It is a space grade certified system that provides high resolution color images with higher frame rates.

SVIS consists of a CMOS based sensor, Camera, Digital card, DC-DC card along with Solid State Recorder. Solid State Recorder (SSR) is NAND flash based which is used to process high resolution image data transfer with higher frame rates. At present, this system is being used in the launch vehicles for capturing high resolution images with higher frame rates as and when required.



108.1 Applications

1. High resolution image data capture
2. High frame rate data capture

108.2 Salient Features

S/n	Parameters	Description
1.	Detector	1600 x 1200 (2M) CMOS sensor
2.	FOV & depth of field	50 deg; 600 mm minimum
3.	Frame Size/ resolution	1600 x 1200 (Maximum)
4.	Frame Size	~30 Mb (Before compression) ~1.5 Mb (After compression)
5.	On-board Storage capacity	~ 2 – 4 Gb
6.	Output data rate	Commensurate with DROPS Protocol (400-500 Kbps)
7.	Power	< 7 W
8.	Frame Rate	

108.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

109 Optical Imaging System

109.1 An Advanced Technology from ISRO

Useful under twilight and mid-day lighting conditions

Sampling Resolution: 2cm at 5000 m

FOV: $0.46^\circ \times 0.46^\circ$

200 mm RC Telescope

Operating Wavelength range: Vis-VNIR

Frame rate: 30 Hz (Rolling shutter)

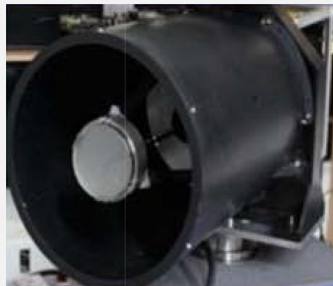
Programmable Exposure period

Includes Focusing Mechanism

Camera Head control, video data acquisition, NUC correction, and image visualization s/w with intra-scene dynamic range adjustment for 2kx2k Si based focal plane array

Sturdy Mechanical Structure

Weight: <10 kg



Avg: 5000 photons Avg: 50 photons

109.2 Potential Applications

1. Imaging during day time and twilight condition
2. Scientific Studies, Astronomy
3. Applications requiring high intra-scene dynamic range up to 80 dB

109.3 Possible Customizations

1. Multi-band (with frequency selective beam splitter or filter wheel), including Infrared spectrum, target imaging using suitable focal plane array
2. Frame rate enhancement up to 100 frames/s
3. Temperature compensated automatic focus adjustment
4. RGB Color imagery with incorporation of color data processing pipe
5. Nighttime imaging with external illuminator



Avg: 5000 photons

Avg: 15 photons

(Locally processed with digital filter)

110 Film Adhesives EFA 1753 and EFA-1752

(Structural Adhesives for Honeycomb Sandwich Fabrication)

Vikram Sarabhai Space Centre of Indian Space Research Organization has developed an epoxy film adhesive; EFA-1753 (300 GSM) and EFA-1752 (200 GSM) (in the form of continuous film) that cures at elevated temperature 175 °C for 1 h and they possess good adhesive strength and filleting properties. Light-weight honeycomb sandwich structures are extensively made using epoxy film adhesives with precisely controlled glue line thickness. Film adhesive can also be used by shipping and boat manufacturing industries also, for fabrication of sandwich structures and other composite assemblies.

110.1 Salient Features

1. One-component, heat curable, toughened, high strength polymeric film adhesive.
2. Heat curable (175°C for 1 h).
3. Ensures filleting during curing, leading to very high bond strength in honeycomb sandwich.
4. Space qualified.

Properties	Values
Areal density, GSM [Two types]	300±20 (EFA 1753) and 200±20 (EFA 1752)
Lap shear strength at 25°C (Al/Al), MPa	≥ 25
LSS at 130°C (Al/Al), MPa	≥ 12
LSS at -196°C(Al/Al), MPa	≥ 25
Honeycomb Flat wise tensile strength at 25°C, MPa	≥ 4
TML, %	≤ 1.0
CVCM, %	≤ 0.1

110.2 Technology transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs/industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

111 EPG 2601[M]

ADBOND EPG 2601M is formulated for bonding of honeycomb structures and capable of working under harsh space environments such as thermo-vacuum, thermal cycling, radiation etc. The main feature of this material is that it is thermally conducting and can retain its property at very low temperatures.

ADBOND EPG 2601M is two parts chemically reactive epoxy structural adhesive system consists of polyether modified epoxide resin, filler, rheological additive and colorant in the resin part, curing agent and accelerator in the hardener part. Cure is achieved by mixing the hardener part with resin part packed separately.

Some of the specialties of this material are minimum cure shrinkage combined with excellent adhesion, superior strength & toughness and low out gassing Typical properties/ characteristics

1	Color & consistency	Part A: Black, viscous resin, Part B: Brownish yellow
2	Viscosity (ps)	1000 to 4000
3	Sp. Gravity	1.65
4	Hardness (Shore D)	≥70
5	Lap shear strength (ksc) on Alumina at RT	120
6	Thermal conductivity (cal/cm/C/s)	8* 10 ⁻⁴
7	Coef. of thermal expansion (/ oC)	3.5 x 10 ⁻⁵ – 10 x 10 ⁻⁵
8	Volume Resistivity (ohm-cm)	6* 10 ¹²
9	Out gassing	
10	- TML (%)	1
11	- CVCM (%)	0.05
12	Service temperature	93 K to 373 K

111.1 Technology transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

112 Rocasin

Rocket case insulation (ROCASIN) is a rubber compound based on the copolymer of acrylonitrile and polybutadiene known as NBR as per ASTM code. It is specially formulated to serve as a rocket motor case insulation having compatibility to propellant grain system. This has, high strength and strain capability and excellent thermal erosion resistance properties as would be desirable in any rocket motor insulation compound. Due to its low coefficient of gas diffusion, ROCASIN finds application as impermeable liners for FRP vessels holding nitrogen at high pressures. Other than sheet form, it finds use as molded elastomeric flight components like igniter head end insulation, igniter nozzle liners, convergent liners, insulation boot, thermal boot, head end domes etc.

112.1 Applications

Can be used as a thermal insulation barrier layer for various equipment and systems wherever required.

112.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

113 5-Aminotetrazole Nitrate

5-Aminotetrazole Nitrate (ATN) is a nitrogen rich oxidizer having the empirical formula $CH_4N_6O_3$. An ingredient in gas generating solid propellant/charge composition. Burns faster and yields only non-corrosive gases free from HCl upon combustion. Thus, making it ideal ingredient for Green Propellant.

113.1 Salient Features

Nitrogen rich energetic oxidizer.

Non hygroscopic in nature, hence alternate to Ammonium nitrate. Non HCl producing, good alternate to Ammonium Perchlorate.

Acts as monopropellant.

Compositions made out of ATN are fast burning.

113.2 Applications

Can be used as energetic material in power cartridges.

Can be used as oxidizer for making cool gas generating propellant.

113.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

113.4 Properties

Sl. no.	Properties of Atn	
1.	Color	Colorless
2.	State	Crystalline powder
3.	Molecular Weight	148
4.	N-content (%)	56.7
5.	O-content (%)	32.4
6.	Heat output (cal/g)	1000±50
7.	Friction sensitivity (kgf)	36
8.	Impact sensitivity (kg.cm)	50
9.	Decomposition Temperature (oC)	175

114 BMT- Ceramics

Dielectric ceramics find application as resonators (DR), substrates, antennas etc. in terrestrial as well as space communications systems ranging from UHF to mm-band frequencies. Their advantages are small size, light weight, temperature stability etc. Globally, a few materials have been manufactured for use in specific range of microwave spectrum.

Barium Magnesium Tantalite (BMT) is a typical perovskite ceramic, which is widely used in oscillators, multiplexers, filters etc. above 10GHz in satellite and terrestrial microwave communication system. The technology has been developed in collaboration with

CMET, Thrissur. This dielectric, coming in the medium permittivity materials, possesses extremely low dielectric loss ($\tan\delta \sim 10^{-5}$) in microwave and millimeter wave frequency ranges.

This indigenously developed BMT is equivalent to 8700 series of Trans-Tech and D series of Murata that are used in 10-25 GHz range.

114.1 Typical properties

Bulk density (Target)	< 8 g/cm ³
(Achieved)	7.45 ±0.1 g/cm ³
Dielectric constant (ϵ_r)(Target)	25±3
(Achieved)	24±1
Unloaded Q-factor (Q_u)(Target)	15,000 @ 5.6 GHz
(Achieved)	28,000 @ 5.6 GHz
(Achieved)	22,000 @ 7.5 GHz
Unloaded Q-factor (Q_u)(Target)	8,000 @ 10 GHz
(Achieved)	20,000 @ 10 GHz
Temp. coeff. of freq. (πf) (Target)	< 7 ppm/K
(Achieved)	6 ±1.0 ppm/K

VSSC is willing to offer the technology of BMT ceramics to eligible interested parties who are in the field of manufacturing similar items Interested entrepreneurs are requested to contact the address given below with all relevant particulars regarding their line of current activity, infrastructure available, market assessment of the product, financial arrangements made, turn over and sales of their products for the past years and a copy of their latest annual report.

114.2 Technology Transfer from ISRO



ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

115 DK 18- Ceramics

DK-18 is a MgTiO₃ based ceramic, which is widely used as Patch Antenna substrates in Satellite and GPS communication systems. This dielectric, coming in the medium permittivity materials, possesses extremely low dielectric loss ($\tan\delta \sim 10^{-5}$) in microwave frequency ranges.

Electronic ceramics with high permittivity ($\epsilon_r > 20$) and low dielectric loss ($\tan\delta < 10^{-3}$) have a number of applications in microwave devices like filters, oscillators, multiplexers etc. in terrestrial as well as Space communications systems ranging from UHF to mm- band frequencies. In such devices, it is desirable that the ceramics have high ϵ_r to confine the electromagnetic waves near them. However, when applications like antennas and substrates are considered, $10 < \epsilon_r < 20$ is desirable for better radiation field outside the ceramic and size reduction. Their advantages are small size, light weight, temperature stability etc. Globally, a few materials have been manufactured for use in specific range of microwave spectrum. This indigenously developed DK18 is equivalent to Kyocera SM200 and P series of Murata that are used as substrates for GPS antennas.

Since the process temperatures are much lower than the tantalates and raw material cost is also low, the production cost of this ceramics is much lower compared to other similar products in the market. This ceramic also has the added advantage of having a low ρ , only about a half that of tantalates.

115.1 Typical properties:

Appearance	Light cream
Bulk density (g/cc)	3.7±0.15
Open Porosity	Nil
Closed Porosity	<2%
Resistivity ($\Omega \cdot \text{cm}$)	10 ¹³
Coeff. of Thermal Expansion (10 ⁻⁶ /K)	9.2
Dielectric constant (ϵ_r)	19±1.5
Quality factor (Qu @ GHz)	12,000 (6.5)
Loss factor ($\tan\delta$, 10 ⁻⁵)	8.4
Temp. coeff. of frequency (Δf , ppm/K)	0 ± 5
TE01 ₂ resonator size at 5 GHz (D=2L, mm)	14

VSSC is willing to offer the technology of DK18 ceramics to eligible interested parties who are in the field of manufacturing similar items

Interested entrepreneurs are requested to contact the address given below with all relevant particulars regarding their line of current activity, infrastructure available, market assessment of the product, financial arrangements made, turn over and sales of their products for the past years and a copy of their latest annual report.

116 High-Permittivity Ceramic (DK36) For R F Applications

Dielectric ceramics with high permittivity ($\epsilon_r > 10$) and low dielectric loss ($\tan \delta < 10^{-3}$) have a number of applications in microwave devices. The process technology for realizing DK36 ceramics with dielectric constant ϵ_r 36-39 has been established. This is similar to imported ceramics like TE36, MDR36, SB350 and 8300 and useful for microwave filters, oscillators etc. The process technology adopted is advanced solid state ceramic route. The ceramics can be fired to full density below 1350°C . DK36 ceramics can find use in devices like filters, oscillators, diplexers, patch antennas etc. The nominal properties of DK36 ceramic are given below.

Bulk density (g/cc)	4.35 – 4.55
Coeff. of thermal expansion ($10^{-6}/\text{K}$)	8.8 – 9.2
Dielectric constant (ϵ_r)	36 – 38
Unloaded Quality factor (Q_u @ 4 GHz)	6,000 – 8,000
Loss factor ($\tan \delta, 10^{-4}$) @ 4 GHz	1.25 – 1.5
Temp. coeff. Of frequency (τ_f , ppm/K)	2 – 7

DK36 ceramics can find use as resonators in filters, oscillators etc. and substrates for patch antennas.

116.1 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

117 Cryo Adhesive EPIFIL-9661

(Used As an Adhesive for The End Fitting Reinforcement of Polyimide Pipelines & As

A Matrix Resin for The Kevlar Composite Over Wrap on Lox Feed Polyimide Pipelines)

Adhesive EPIFIL-9661 is three-part room temperature curing adhesive. Part A is a urethane modified epoxy resin, prepared by the co-reaction of epoxy, polyol and isocyanate. Part-B is a mixture of amine hardeners and Part-C is a Silane Coupling agent. This adhesive system presently finds different applications such as matrix resin for Aramid (Kevlar) composite over-wrap

on Liquid Oxygen (LOX) feed polyimide pipelines, for reinforcing the metallic end fittings made of SS-321 and the fiber glass tape to the LOX and LH2 polyimide pipe lines and as a coating material for glass phenolic composite which perform as a thermal isolator between the mix ratio controller and (MRC)/apparent velocity regulator (AVR) valve and the motor in the cryogenic stages of GSLV.

Properties	Values
Epoxy value (equivalents/kg) of Part-A	3.5 – 4.5
Viscosity at 30 OC (cps) of Part-A	450 –700
Amine Value (mg KOH/g) of Part-B	340-400
Viscosity at 30 OC (cps) of Part-B	350-500
Pot life at 25 OC (minutes)	180 (Minimum)
Hardness Shore D (after 7 days cure at RT (30±5 OC)	65 (minimum)
Lap Shear Strength (PI-PI on Aluminum alloy back up) at RT (at 25 OC), (in kg/cm ²)	40 (minimum)
Lap Shear Strength (PI-Fiber glass tape on SS-321 bac up) at RT (air-conditioned room, at 25OC), (in kg/cm ²)	40 (minimum)

117.1 Salient Features

1. Three-component, RT curable, toughened, low viscous polymer liquid adhesive
2. Increased pot life [up to approx. 3hrs.]
3. Good bond ability with PI film as well as SS materials
4. Flight qualified

117.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this



knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below.

118 Matrix resin for composite application EPY PEEKTOH

Indian Space Research Organization at its Vikram Sarabhai Space Centre (VSSC) has developed EPY PEEKTOH resin which is an elevated temperature curing high performance epoxy resin matrix suitable for composite applications. The specialty of the formulation is good mechanical properties, high glass transition temperature and low outgassing properties. This is an ideal matrix resin for processing thick carbon fabric laminates (≥ 30 mm) without any micro cracks and delamination.

Properties	
Volatile matter at 65°C for 5 hours :	0.04
maximum Viscosity at 65°C (poise) :	60-80
Shore D hardness at 30°C :	85
Specific gravity at 30°C :	1.1 –1.4
Flexural strength at 25°C(MPa) :	110 –120
TML-WVR (%) :	≤ 1.0
CVCM (%) :	≤ 0.1
Glass transition temperature (°C) :	210

118.1 Salient Features

1. Elevated temperature curing
2. Very good mechanical properties
3. High glass transition temperature
4. Low outgassing properties
5. Suitable viscosity at 60-70°C for processing two-dimensional fabric laminates

118.2 Applications

EPY PEEKTOH resin is mainly used for fabrication of composite YOKE panel hinge insert for satellites.

118.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

119 Guanidinium Azotetrazolate (GZT)

Guanidinium Azotetrazolate (GZT) is a nitrogen rich, carbon poor stable organic compound having the empirical formula (C₄H₁₂N₁₆). The decomposition products of GZT are mostly gases consisting of element alnitrogenas the major product. Since the heat of formation of nitrogen is zero, the decomposition products of GZT are inherently cool and inert. GZT is highly insensitive to mechanical and thermal stimuli and is found as a good fuel additive for gas generator compositions and a good alternate to sodium azide, which is more hazardous to environment.

119.1 Salient Features

1. Nitrogen rich organic energetic fuel.
2. Produces cool nitrogen gases on decomposition. Insensitive to mechanical and thermal stimuli.
3. Good alternate to sodium azide used in gas generators.
4. Versatile energetic compositions can be made by adjusting oxygen balance.

119.2 Applications

Sl. no.	Properties of GZt	
1.	Color	Yellow
2.	State	Amorphous solid
3.	Molecular Weight	284
4.	N-content (%)	78.9
5.	C-content (%)	16.9
6.	Heat output (cal/g)	360 ± 60
7.	Friction sensitivity (kgf)	> 36
8.	Impact sensitivity (kg.cm)	> 320
9.	Decomposition Temperature (oC)	252 ± 6

119.3 Properties

Fuel for making cool composite gas generators.

Fuel for making pyrotechnic charges for power cartridges.

119.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

120 Polydimethylsilane (PDMS)

(Raw material for polycarbosilane, a precursor of silicon carbide)

Polydimethylsilane (PDMS) is a pre-ceramic polymer precursor developed by Indian Space Research Organisation at its Vikram Sarabhai Space Centre. PDMS finds use in the synthesis of polycarbosilane (PCS) - a well-known polymeric precursor for silicon carbide (SiC). PCS is prepared from PDMS by heating PDMS in an autoclave, or at normal pressure with a catalyst. PCS is a ceramic precursor useful in realizing C/SiC, C/C-SiC and SiC/SiC based thermo-structural components for re-usable launch vehicles, C/SiC turbine blades, and SiC fibers.

120.1 Salient Features

1. Fine free flowing powder at room temperature.
2. It can be stored in sealed polyethylene bags at room temperature, away from direct sunlight, and has long shelf life.
3. PDMS is insoluble in water and other organic solvents such as Acetone, Cyclohexane, Ethyl Acetate, Toluene, Xylene.

Properties	Range
Appearance	White powder
Moisture content (by KF)	<1%
Silicon content (wt%)	42 – 48
Carbon content (wt%)	34 – 41
Hydrogen content (wt%)	9 – 12
Oxygen content (wt%)	<5

120.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

121 Phenolic Resin (PF-106)

Phenolic resin (PF-106) is a resol type thermosetting phenol- formaldehyde polymer used for processing high temperature resistant ablative materials such as carbon phenolic and silica phenolic composites. PF 106 is a high temperature curing resin which has excellent ablative properties and char strength.

The production of PF-106 involves the following steps:

1. Melting of Phenol.
2. Charging of formalin and molten phenol into the reactor in the desired mole ratio.
3. Addition of catalyst.
4. Condensation polymerization of phenol and formalin.
5. Neutralization of reaction mixture with acid.
6. Settling of reaction mixture.
7. Removal of water of reaction and salt.
8. Drying of resin to remove traces of water and other volatiles.
9. Addition of required quantity of alcohol
10. Filtration and product packing.
11. Storage

121.1 Salient Features

- | | |
|------------------------------------|--|
| 1. Appearance | : Yellowish brown to dark brown liquid |
| 2. Viscosity | : 150 -250 |
| 3. Specific gravity | : 1.12 -1.16 |
| 4. Total solid content | : 60-65 for ½ hr. (%) |
| 5. Free phenol (%) | : 6 max. |
| 6. Free formalin (%) | : 3 max. |
| 7. Point of trouble | : 6-10 ml of water of resin |
| 8. Storage conditions Temperature: | 10-20 °C |
| 9. Shelf Life | : 3 months |

121.2 Applications

The resin finds application as binder for high temperature resistant ablative composites materials such as carbon phenolic, silica phenolic and epoxy phenolic

systems.

121.3 Technology Transfer from ISRO

ISRO is willing to offer the know-how of this technology to suitable entrepreneurs/industries in India. Capable manufacturing industries interested in acquiring this know-how may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

122 Phenolic Matrix Resin (PF-108)

Vikram Sarabhai Space Centre has developed different types of resins catering to specific applications in Launch Vehicles and Satellites. These materials may also find various industrial applications such as bonding, sealing, coating, potting, laminating, molding etc.

PF-108 is a special grade liquid phenolic matrix resin which is used as a precursor for production of silica phenolic throat inserts for the liquid engines of ISRO launch vehicles.

122.1 Operational steps for synthesising PF 108

1. Melting of Phenol.
2. Charging of formalin and molten phenol into the reactor in the desired mole ratio.
3. Addition of catalyst.
4. Condensation polymerization of phenol and formalin.
5. Neutralization of reaction mixture with acid to desired ph.
6. Settling of reaction mixture
7. Removal of water of reaction and sodium salt by decantation.
8. Vacuum drying of resin to remove the final traces of water and other volatiles.

Major equipment needed are phenol melting vessel and reaction vessel.

1. Melting vessel for phenol melting.
2. Jacketed SS reactor fitted with cooling coils, stirrer, motor, condenser and receiver for polymerisation and drying. The reactor is suitably linked with the utility system during operation. It is also equipped with load cell, vacuum systems, temp controllers, cooling systems pressure/vacuum gauges, etc.
3. Decanter vessel for removal of water.
4. Water jet ejector for vacuum.

122.2 PF 108 Product Specifications

Appearance	: Yellowish brown to dark brown liquid
Viscosity at 30 DC	: 400 - 600
cps Specific gravity at 30 DC	: 1.18 - 1.20
Refractive Index at 30 DC	: 1.570 - 1.575

Total solids	: 72 -75%
Free phenol (%)	: 18 -22%
Free formalin (%)	: 0.5% (max.)
Ash Content	: 0.5% (max.)
Point of trouble	: 13 - 15.5 ml of water/10 ml solution
pH (5%solution)	: 7.3 -7.8
Sodium Content	: 0.4% (max.)
Water Content	: 14% (max.) Storage conditions
Temperature	: <15 °C
Shelf Life	: 3 months (in above condition)

122.3 Technology Transfer from ISRO

ISRO is willing to offer the know-how of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

123 RTV Silicone Single Part Adhesive, Silcem R9

Indian Space Research Organisation at its Vikram Sarabhai Space Centre (VSSC) has developed a room temperature curable single part adhesive, SILCEM R9 based on polysiloxane for multipurpose bonding applications. This system contains polysiloxane, fillers and curing components mixed under dehumidified conditions and filled inside squeeze tubes for ready - to - use condition. The adhesive can be squeezed out from the tube and very conveniently applied directly on the substrates and bonded. On exposure to humid air, it hardens by itself to a solid rubbery mass.

123.1 Salient Features

1. Single part siloxane-based system containing fillers and special curing components.
2. Room temperature curable on exposure to humid air. Safe inside the tube
3. Easy to apply. Simply squeeze and apply
4. Supplied in ready-to -use squeeze tubes of 100-150 g capacity
5. Meets the aerospace quality standards

Typical Properties	
Density (cured product) g/cc :	1.25 - 1.35
Tensile strength @RTksc :	22 - 42
Tensile strength@120°Cksc :	18 - 35
Elongation@RT% :	225 - 350
Elongation@120°C% :	110 - 300
Lap shear strength (Al-Al) @RTksc :	13 - 30
Lap shear strength (Al-Al) @120°Cksc:	13 - 28
Thermal conductivity at 100°CW/m. K:	0.25 - 0.50
Specific heat at 100°C, J/g/°C :	1.0 - 2.0
Hardness, ShoreA :	40 - 55

123.2 Applications

This adhesive finds large societal applications for use as sealants to provide leak proof joints. This material can also be used as a gap filler material where high temperatures are experienced. Being a water repellent adhesive material, the bonded substrates maintain good strength even under wet conditions. It finds applications as a general-purpose adhesive for bonding / sealing materials like wood, metals, leathers, foams etc.

123.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs /industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

124 Silica Fibres

Indian Space Research Organisation at its Vikram Sarabhai Space Centre (VSSC) has developed a new technology for developing silica fibers by sol-gel process. The fibers can be used for high temperature insulation up to 1500oC.

The low temperature process (400oC) adopted for developing silica fibers is more economical than the conventional technologies and can give high purity fine fibers. In addition, the fibers are hollow as well, thereby improving the insulation property further.

124.1 Fiber Specifications:

- | | |
|-------------------|-----------------------|
| 1. Composition | : Silica (99.5%) |
| 2. Diameter | : 1 - 20 μ |
| 3. Length | : 5 - 20 mm |
| 4. Aspect ratio | : 500 - 20,000 |
| 5. Morphology | : Amorphous (1400 oC) |
| 6. Heat Treatment | : Up to 1400 oC |

The technology of developing silica fibers is available for transfer to entrepreneurs working in a similar field. Interested entrepreneurs are requested to contact the address given below with relevant particulars regarding their line of current activity, infrastructure available, market assessment of the product, financial arrangements made and turn over and sales of their products for the past years.

124.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

125 Silica Granules

Indian Space Research Organisation at its Vikram Sarabhai Space Centre (VSSC) has developed a new technology for developing silica granules of fine sizes. The granules are produced from aero-gel chips and subsequently firing using microwaves. They can be used for high temperature insulation up to 1250oC. Since they are hollow and weigh very less, they can also be used as filler materials for paints, polymer/ metal and ceramic matrices to reduce density and improve thermal properties.

125.1 Product specifications:

1. Product Composition : SiO₂ (99.5%)
2. Diameter : <2 mm
3. Bulk Density : <0.35 g/cc
4. Morphology : Hollow, fibrous & Amorphous

The technology of developing silica granules is available for transfer to entrepreneurs working in a similar field. Interested entrepreneurs are requested to contact the address given below with relevant particulars regarding their line of current activity, infrastructure available, market assessment of the product, financial arrangements made and turn over and sales of their products for the past years.

125.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

126 Silica Aerogel by Ambient Pressure Drying Method

Indian Space Research Organization at its Vikram Sarabhai Space Centre (VSSC) has developed hydrophobic silica aerogel in granular/powder form by a simple and cost-effective ambient pressure drying process.

126.1 SALIENT FEATURES

Silica aerogels are exotic materials with a unique combination of properties.

As a virtue of high porosity and extremely small pores, aerogels exhibit extremely low thermal conductivity, making them a ‘super-insulator’. In addition to thermal insulation, aerogels are also superior sound insulators and they possess very low refractive index and an excellent dielectric medium which finds numerous applications.

VSSC has developed a conventional drying technology at ambient pressure to get rid of the solvents within the gel. This makes the process amenable to bulk-production in a cost-effective manner. The solvents used in the production can be recycled using this technology, thus making the process environmentally friendly.

Property	Value Achieved
Bulk density, g/cm ³	0.06 – 0.20
BET surface area, m ² /g	400 – 1000
Mean pore size, nm	10 – 40
Percentage porosity	>90 %
Contact Angle	>130°
Thermal conductivity, W/mK (RT, 1 atm)	<0.05
Dielectric constant (@ 1 MHz)	1 – 1.4

126.2 APPLICATIONS

1. Bulk-fill insulation (thermal and acoustic).
2. As fillers in concrete, cement, paints, adhesives, foams, ablatives, rubber, coatingsetc. for decreasing density, thermal conductivity & flammability, and increasing the heat resistance of the material.
3. As precursors to produce aerogel-based sheets that can be used as foot-insoles, boot / jacket insulation or as winter / Arctic apparel at areas having extremely cold climate.
4. In window glazing as insulator between glass/ polyacrylate panels, which allow natural light but not heat (for hot places-where A/C is used), and in trapping heat (in cold places), which allow in significant electricity and money saving.

5. As fillers in cosmetic items such as sunscreen creams, foundation, toothpastes etc.
6. Carrier for drug delivery.
7. Vibration/acoustic damping materials.

126.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

127 Silica Aerogel Based Composite Sheet

Indian Space Research Organization at its Vikram Sarabhai Space Centre (VSSC) has developed hydrophobic silica aerogel by a simple and cost-effective ambient pressure drying process. Using the developed aerogel powders, flexible, hydrophobic aerogel sheets have also been developed.

127.1 Salient Features

The composite sheets are made from Silica aerogel which is an exotic material with a unique combination of properties. Low density and thermal conductivity coupled with high porosity and surface area make aerogel a 'super-insulator'. However, their cost, brittle and friable nature has limited its use to specialized applications.

VSSC/ISRO has developed the technology to develop flexible and hydrophobic sheets from the aerogel powder which expands a gamut of applications, making it suitable to be used as an ideal replacement for conventional insulation. The lab scale technology developed has been demonstrated in thermal protection system since PSLV C39.

Aerogel sheets are ideal to be used as wrap around insulation, which can be cut to desired size and integrated. Aerogel sheets developed in ISRO on the other hand is non-dusting and are easy to handle.

127.2 Properties

Property	Value Achieved
Areal density, g/m ² (gsm)	150 – 500
Thickness, mm	0.6 – 10
Thermal Conductivity (@ RT), W/mK	~0.03 (TPS method)
Dielectric Constant (@ 10 GHz)	1.3 – 1.6

127.3 Applications

1. Wrap around insulation for use in pipelines/feed-lines etc.
2. For use as insulating layer in foot- insoles, boot / jacket insulation or as winter / Arctic apparel at areas having extremely cold climate.
3. As low dielectric constant substrates over which circuits can be printed.
4. Cryogenic thermal insulation.
5. In multi-layer insulation.

127.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

128 Waterproofing Compound RWPC-03

RWPC-03 is a waterproofing compound developed by VSSC for the waterproofing of silica tiles and silica felt/ fabric based flexible insulations. It is an alkoxy silane based system, processed by controlled hydrolysis of siloxanes. This is an environment friendly method and imparts efficient waterproofing of the system. The treatment involves spraying the aqueous solution of an organo-polysiloxane waterproofing compound on the substrate (preferably glass and silica based) and heating them to form a waterproofed article. In the case of silica tiles and silica felt/fabrics, water absorption could be brought down from 350% to <5% and <10% respectively using this compound. It is not a conventional surface coating method and makes both surface as well as bulk of the material water resistant.

128.1 Typical properties / characteristics:

1. Color and consistency : Transparent liquid
proofing compound : <5cP
2. Weight increases due to water proofing : 3% max by weight
3. Water absorption of water proofed silica tile : <5 % by weight
4. Water absorption of water proofed flexible insulation: <10% by weight

128.2 Applications

RWPC-03 can potentially be used as general-purpose water proofing compound for silica-based components including composites.

128.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below.

129 Sealant EPY 2121N

EPY 2121N is a two-part epoxy-amine-based sealant containing mica filler which impart high insulation resistance. This castable compound is designed to have pourable consistency and long work life, which result in void free filling of the cavities. Cure is achieved by the application of heat and the sealant exhibits good high and low temperature service capability.

129.1 Typical Properties / characteristics:

Property	
Color and consistency	Grey viscous liquid
Viscosity at 30°C (ps)	5000 – 10000
Pot life	>3 hours.
Epoxy value (eq./kg)	3 – 4.5
Cure	Ambient (25-35°C) / 18-24hrs followed by 60-65°C/5hrs
Lap shear strength on A1-A1 at RT	>100 ksc.

129.2 Technology Transfer From ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

130 Adbond EPP-3521

ADBOND EPP 3521 is a rubber based adhesive system developed for mounting various electronic systems to the structural elements. It is having very good thermal conductivity with good electrical insulation property and also possess very low out gassing characteristics.

This is an elastomer modified epoxy system consisting of insulative oxide filler in high concentration with silane coupling agent to provide electrical insulation and thermal conductivity.

ADBOND EPP 3521 will find usage in electric/ electronic gadgets manufacturing areas where potting/ bonding with good thermal dissipation and electrical insulation are warranted.

130.1 Typical Properties / Characteristics:

Property	
Color & consistency	Black & pasty
Viscosity of the resin (ps)	700 to 8000
Sp. Gravity	1.8
Hardness (Shore D)	
Lap shear strength (ksc) on Alumina at RT	80
Thermal conductivity (cal/cm/C/s)	1.04* 10 ⁻³
Volume Resistivity (ohm-cm)	1.5* 10 ¹³
Out gassing TML (%) CVCM (%)	< 1 ≤ 0.1
Cure	Ambient
Pot Life (min.)	45
Service temperature	223 K to 338 K

130.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

131 Umbilical Pads

Umbilical pads are semi-rigid foams which are developed based on polyurethane (PU) polymeric systems having energy absorbing capabilities. These are integral skin foams that can be used for absorbing shock and impact energy hence they are used for controlling vibration and for acoustic insulation. These pads are semi flexible water blown foam system produced by the polymerization reaction between hydroxyl bearing polymeric compounds called polyols and di or polyisocyanates in the presence of catalysts.

Umbilical pads are designed to absorb impact energy of the separating umbilical lines used in launch vehicles. These foam pads of required size and dimensions are moulded with clamps at the corners for assembling the pads at required locations in the launch pad. These shock absorbing pads can also be utilized for transportation of electronic packages.

131.1 Technological Highlights of the product if any

1. Semi flexible and shock absorbing foam
2. RT curable
3. Can be moulded to the required shape and size

131.2 Typical Properties

Nature of foam	Semi-flexible PU foam with blue colored fire-retardant coating
Dimensions	1200 mm x 1200 mm x 100 mm
Density (uncoated)	55 - 80 kg/m ³
Flame test with coating	Self-extinguishing within 5-6 sec
% Ball rebound with coating	20 - 30
Shelf life	5 years

131.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

132 Low Density Epdm Based Thermal Insulation

The technology offered is for a light weight/low density solid rocket motor thermal insulation material based on EPDM rubber. The rubber compound shall be processed in the form of sheets of required thicknesses by calendaring or extrusion. The sheets shall be used of insulation laying process following the same processing temperature and conditions as followed during NBR based systems. The material interface properties: rubber-to-metal and rubber- to-propellant match with conventional NBR based systems.

The advantage over the conventional NBR system is its 15% lower density values, resulting in lesser inert mass. Also, the thermal insulation capability is 10-15% better than elsewhere similar insulations.

The material also exhibits better aging resistance and low temperature characteristics. Other than in sheet form use, it finds utility as moulded elastomeric flight components like igniter head end insulation, igniter nozzle liners, convergent liners, insulation boot, thermal boot, head end domes etc.

132.1 Applications

Can be used as a thermal insulation barrier layer for various equipment and systems wherever required.

132.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below.

133 Coating Compound EPY 1061

Vikram Sarabhai Space Centre has developed different types of adhesive compounds catering to specific applications in Launch Vehicles and Satellites. These materials may also find various industrial applications such as bonding, sealing, coating, potting, laminating, molding etc. The following are some of the new formulations tailored to meet specific requirements as adhesive, sealant, coating and potting compounds. These are derived from resins and different curing agent combinations, modified with various classes of materials such as flexibilizer, toughening agent, fillers, pigments, cure accelerators etc.

EPY1061 is an amidoamine modified epoxy-based system specially developed to protect the metal surfaces from corrosion in aqueous strontium perchlorate medium. This coating and sealing system consist of two main components Part A (resin) and Part B (hardener) and a third component Part C which is a solvent. Parts A, B and C are mixed in a specified ratio and sprayed into the metal surface using spray gun to get corrosion resistant coating. The coating adheres well to the metal substrate and reaches fully cured condition at room temperature in 72 hours

133.1 Typical Properties / characteristics:

Property	
Color and consistency	Red colored viscous liquid
Viscosity at 25 °C (cps)	20000-40000
Pot life/ Gel time	25 minutes.
Flow Time, Part A, B & C mixed	35 – 50 seconds.
Cure	Ambient
Lap shear strength on Al-Al at RT	90 ksc.

133.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

134 Benzoxazine Polymer

Indian Space Research Organisation at its Vikram Sarabhai Space Centre has developed Benzoxazine Polymer, a matrix resin suitable for thermal insulations, adhesive formulations and encapsulant in PCB industry.

Polybenzoxazine is a suitable candidate matrix resin for high density ablative composites and also for light weight foam composites in aerospace applications due to excellent thermal and thermo-oxidative stability, high char yield, good chemical inertness, abrasion resistance and flame retardancy. It also finds application as an encapsulant in electronic industry.

134.1 Salient Features

1. Excellent flame retardancy
2. Easily processable (solventless process, moderate temperature)
3. Good thermal stability

134.2 Typical Properties / characteristics:

Raw materials	Bisphenol A, Aniline and Para-Formaldehyde
Method	Solventless process
Reaction temperature:	120 °C
Product appearance	Yellowish orange powder
Solubility	Soluble in acetone, chloroform etc.
Curing temperature:	210 °C/3 hrs.
Polymerization temperature (°C)	200/ 2 hours
Thermal stability	>250 °C.
Shelf life	1 year
Storage	Ambient temperature, moisture-free environment
Approximate Production cost	Rs.1000/kg

134.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs /industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below

135 Compensated Alumina (Comal) For Electronic Applications

Alumina (Al₂O₃) is a versatile ceramic and a ‘workhorse’ ceramic that finds place in a wide range of applications— mechanical, thermal, electrical, electronic and even optic. Indian industries are well- versed in alumina products for applications like refractory bricks, insulator tubes, crucibles etc. But, alumina components for electronic and similar high- tech applications are still imported. The drawback of pure alumina for electronic applications is the large temperature-coefficient of relative permittivity. Currently imported alumina ceramics suffer from high drift of dielectric constant with temperature and need firing temperature above 1600°C. But, the compensated alumina (ComAl), developed by VSSC, has near-zero temperature coefficient and can be sintered at $\leq 1475^\circ\text{C}$.

The ceramic has alumina as major content and a couple of additives and dopants. The powder of ComAl can be suitably processed further for making bulk products as per requirement. Bulk green bodies can be fired at $\leq 1475^\circ\text{C}$ for less than 2h to get sintered ceramic. Sintered products can be polished, sliced or cut or machined for various applications. Typical properties of bulk ceramics are shown below

135.1 APPLICATION AREAS:

ComAl ceramics can replace conventional alumina ceramics in various electrical, electronic and RF applications.

VSSC is willing to offer the technology of ComAl to eligible interested parties who are in the field of manufacturing similar items

Interested entrepreneurs are requested to contact the address given below with all relevant particulars regarding their line of current activity, infrastructure available, market assessment of the product, financial arrangements made, turn over and sales of their products for the past years and a copy of their latest annual report.

Firing temperature(°C)	1450 – 1475
Bulk density (g/cc)	3.9 ± 0.1
Resistivity ($\Omega\cdot\text{cm}$)	>109
Coeff. of Thermal Expansion ($10^{-6}/\text{K}$)	7 – 7.2
Thermal conductivity (W/m. K)	24 – 30
Dielectric constant (ϵ_r) @ 5GHz	11 – 12
Loss factor ($\tan\delta$, 10^{-5}) @ 6 GHz	< 7
Qu of resonator @ 12GHz	> 10,000
Temp. coeff. of frequency (Δf , ppm/K)	0 ± 5

135.2 Technology Transfer from ISRO



ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

136 Silicone Polymer Based Low Density Syntactic Foam TPS, SSF P-70

SSF P-70 is a low-density thermal protection system based on silicone polymer, with micro balloon and other fillers as compounding ingredients. This TPS is room temperature curable and can be applied by brushing and spraying techniques. The remarkable features of this system include lower density of

0.38 g/cc, lower thermal conductivity, high specific heat, good ageing resistance and compatibility with wide variety of substrates. Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed a technology for processing and application of different types of silicone polymer based thermal protection systems with tailored properties to meet various mission/ application requirements.

The processing involves incorporation of selected quality fillers and ingredients in specific type of silicone polymer resin and use of suitable curatives to achieve desired thermo-physical properties.

136.1 Salient Features

1. Simplified and cost-effective technology for processing premium quality thermal protection system.
2. Room temperature curable.
3. Flexibility with respect to application procedure such as spraying and brushing.
4. Compatibility with wide variety of substrates including metals, composites etc.
5. Excellent ageing behavior, making it suitable for long term application with no deterioration of properties for more than 2 years.

136.2 Applications

Useful for light weight, high quality thermal protection system for temperatures up to 3000C direct exposure with reasonable stability and capability to retain properties. The system also has good aging characteristics. The system can be applied to desired thickness depending upon the thermal environment envisaged. Reasonable mechanical strength and adhesive properties with large number of substrates has been demonstrated by the system. Ability to retain properties at temperatures up to 150 0C and low temperature flexibility are other highlights of the system owing to the low glass transition characteristics associated with silicone polymers.

1. The product can be used for thermal protection application for protecting

rocket hardware form aerodynamic heating where light weight TPS is required and also as moisture / water impermeable coatings.

2. The system can be tailored for use as coating on metal substrates for outdoor use.

136.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs /industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below.

137 DK65 Ceramic for Microwave Applications

DK65 ceramic is a type of dielectric ceramic with high relative permittivity or dielectric constant ($\epsilon_r \sim 65$) and low dielectric loss ($\tan \delta < 10^{-3}$) at microwave frequencies. VSSC has developed this ceramic technology through conventional solid-state route. The ceramics can be fired to full density by firing below 1400°C in air atmosphere furnaces. The ceramic has been successfully tested as dielectric resonators and as patch antenna in L-bands. Since this ceramic possesses very small drift in dielectric constant with temperature, it is useful for applications like dielectric resonator filters, substrates for GPS, NAVIC patch antennas, dielectric resonator antennas etc., in UHF to C-band of microwave frequencies.

The nominal properties of DK65 ceramic are given below.

Bulk density (g/cc)	5.3- 5.5
Dielectric constant (ϵ_r)	64 ± 2
Unloaded Quality factor (Q_u @ 3 GHz) *	3200-3600
Loss factor ($\tan \delta$, 10^{-4}) @ 3 GHz	≤ 2.65
Temp. coeff. of frequency in 25-75oC (τ_f , ppm/K) *	0 ± 5

* Properties are obtained by testing in microwave frequency range by standard resonance method

137.1 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

138 Low Modulus Flex Seal Compound

Flex Nozzle Control (FNC) is one among the thrust vector control system used in solid rocket propulsion. The system enables the submerged nozzle to be vectored in all directions and to a limited angle, by an actuation system, as the nozzle is connected to the main motor through a flexible joint. The flex seal is made up of alternate layers of metallic shims and elastomeric pads. Natural rubber based elastomeric pads are found to be most suitable element for this application because of its easiness with which it can be formulated to give low shear modulus coupled with high shear strength. The method is further recommended for large size flex seals for bigger size boosters of ISRO.

The technology for realization of this low modulus flex seal rubber compound using Natural rubber, ISNR grade is offered for industrial application. The complete formulation, processing/compounding, process parameter selection, specimen preparation, property evaluation, storage and shelf life are detailed, for the developed material. The material exhibits excellent rubber to metal and rubber to carbon- carbon composite interface adhesion, enabling it for use as multilayer structural element and leak free joint.

138.1 Salient Features

Low shear modulus

High shear strength

Amenable for extrusion, transfer and compression molding processes

Good rubber to metal and rubber to carbon epoxy composite interface property

Sl. no.	Properties of Low modulus flex seal compound	
1	Tensile strength, ksc	100 (Min)
2	Elongation at break, %	600 (Min)
3	Hardness, Shore A	40 (Max)
4	Shear strength, ksc	20 (Min)
5	Shear strain, %	700 (Min)
6	Shear modulus, ksc @ 3.57 ksc shear stress	1.6-2.0
7	Compression set @ 70degC/22hrs, %	40 (Max)

138.2 Applications

Submerged flex nozzle vectoring unit

Anti-vibration structural element

138.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

139 NITI Based Shape Memory Alloys

Shape Memory Alloys (SMA's) are metallic materials, which have the ability to return to a predetermined shape when heated. The most common Shape Memory Metallic Material is an alloy of Nickel and Titanium called Nitinol. Indian Space Research Organisation (ISRO) at Vikram Sarabhai Space Centre (VSSC) has developed a technology for processing NiTi based Shape Memory Alloys of uniform homogeneity with good control on deleterious impurities like Carbon, Nitrogen and Oxygen contamination.

The method consists of materials arrangement inside graphite crucible, melting under argon atmosphere and finally casting.

139.1 Salient Features

Simplified and cost-effective technology for processing premium quality billets in NiTi base SMA's and other reactive alloys

Homogeneous product with excellent control in impurities

Achieves economy in cost and labor and saves time by eliminating the repeated vacuum arc remelting

Unique way of materials arrangement in the high-density graphite crucible to reduce the contamination of the NiTi melt from the crucible

Special tailor-made vacuum induction facility for controlling carbon and oxygen contamination in making NiTi SMA's

139.2 Applications

Useful in economical processing of high-quality cast billets in NiTi SMA's with low carbon, nitrogen, hydrogen and oxygen contamination. These billets can be used to realize wrought products like Plates, Sheets, Foils, Wires, Sleeves, Forged, Rolled and extruded products through further mechanical working. Inclusion content in the billets processed through this technique is very low; hence very thin wires can be drawn without much problem from extruded rods processed from these billets.

The products can be used for realization of collapsible antennas, collars for separation systems, couplings, stepper drive mechanism to drive flaps of satellites, etc.

SMA's have high potential for use in biomedical industries as Bone Plates, Stents, Orthodontic Wires etc.

139.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

140 Ceramic Foam (HTFOAM-1500) by Direct Foaming Technique

HTFOAM-1500 are ceramic foams Silicon carbide (SiC)/Silicon Oxycarbide foam (SiOC) made by direct foaming technique. HTFOAM-1500 has very high operational temperature capability of 1500°C under oxidation atmosphere. The light weight ceramic foam possesses both open and closed cells with good strut density and high compressive strength. They have very low thermal conductivities and hence suitable for various applications viz., thermal insulators, micro-meteoroid and orbital debris (MMOD) shield, electromagnetic shielding and as CMC based sandwich constructions for internal multiscreen applications.

140.1 Salient Features

1. Ceramic foam (SiC) foam with temperature capability of 1500°C under oxidizing atmosphere.
2. Open cell porosity, closed cell porosity, strut thickness can be optimized by varying the processing parameters.
3. Compressive strength and thermal conductivity can be optimized by varying the processing parameters and polymer composition.

Properties	Values
Bulk density (g/cc)	0.23-0.35
Total porosity (%)	80-95
Open porosity (%)	20-35
Closed porosity (%)	65-80
Compressive strength (MPa)	0.2-3.0
Thermal conductivity (W/mK) at RT	0.1-0.2

140.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

141 SiC Foam Tile SICTILE-1650 by Replica Technique

SICTILE-1650 (in the form of tiles of 200x200x20 mm) is an open cell SiC foam tile formed by replica technique that has very high operational temperature capability of 1650°C under oxidation atmosphere. They possess good handling strength with 80-90% open cell porosity. Light-weight SiC foam-based sandwich structures are used for thermal protection systems for aerospace applications. They can be used as volumetric absorbers in the generation of large amounts of electricity by concentrated solar power (CSP) technology. They can also be used as electromagnetic wave absorbing materials and porous burners.

141.1 Salient Features

1. Open cell silicon carbide foam-based tile with temperature capability of 1650°C under oxidizing atmosphere.
2. Open cell porosity, pore size, strut thickness can be optimized by varying the processing conditions.
3. Handling strength can be improved by varying the pore size and density.
4. Thermal conductivity can be optimized by varying the processing parameters and density.

Properties	Values
Bulk density (g/cc)	0.3-0.8
Open porosity (%)	80-95
Compressive strength (MPa)	1-3
Thermal conductivity (W/mK) RT	0.1-0.3 ($\rho = 0.15-0.2$ g/cc)
Coefficient of thermal expansion ($\mu\text{m}/^\circ\text{C}$) (RT-800°C)	0.5- 2

141.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

142 Strontium Perchlorate

Strontium Perchlorate is produced by various process operations like Crystallization of Sodium perchlorate (SPC) crystals, Production of Perchloric Acid, Purification of Perchloric Acid, Production of Strontium Perchlorate and Concentration of Strontium Perchlorate solution.

142.1 Properties

1. Purity as Strontium perchlorate (w/w) :	68 ± 3%
2. Color and appearance :	Clear straw colored
3. Specific gravity at 28 oC :	1.90 ± 0.01
4. Viscosity at 28 oC :	12 ± 3 centi poise
5. Acid value (mg of KOH/ g) :	0.6 (max)
6. pH of 10% Solution :	4.5 - 6.0
7. Chlorate as ClO ₃ - :	0.25%
8. Chloride as Cl- :	0.1%
9. Suspended matter :	Nil

142.2 Applications

Secondary injection thrust vector control in launch vehicles

142.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

143 High Density Sintered Silicon Carbide

Silicon carbide is widely used for high temperature applications. Due to its unique characteristics like excellent low density, high thermal shock resistance, oxidation resistance SiC based materials are also extensively used in optical systems due to low CTE and high thermal conductivity. However, due to the sintering difficulty of silicon carbide, it is difficult to obtain dense SiC. A process is developed through hot pressing procedure and using small quantity of sintering aids (<5wt%) to manufacture SiC with near theoretical density and excellent combination of mechanical and thermal properties.

The nominal properties of High density SiC ceramic are given below:

Density, g/cc	3.22 (99.8% of theoretical)
Flexural strength, MPa	450
Compressive strength, GPa	1.9
Fracture toughness, MPa \sqrt{m}	4.5
Elastic modulus, GPa	350
Thermal conductivity, W/mK	>80
Specific heat, J/Kg/oC	610
Coefficient of thermal expansion (RT to 500oC), soC-1	< 2.5 x 10-6
Electrical resistivity, Ω -cm	2.6 x 10 ⁹

143.1 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

144 D-Type Connector Demating Tool

A mechanical tool for de-mating D-type connectors used in high reliability avionics systems and ground systems used in launch vehicle, satellite and defense applications. This is a simple and handy mechanical tool for effortless de-mating of D-type connectors without causing any damage to the connectors, connector pins or connector wiring.

144.1 Salient Features

1. Indian Patent is granted for the product
2. Easy to operate and produce
3. Does not damage connectors, pins or wiring

144.2 Applications

Used for de-mating D-type connector pairs (male-female)

1. standalone connector pairs
2. connector pairs mounted on PCB
3. connector pairs mounted on chassis
4. connector pairs with wire harness

144.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

145 Hot-pressed Boron Nitride/silica composites

The technology involves a choice of BN powder with correct purity, oxygen content and extent of crystallization, choice of high purity silica powder with required particle size and crystallinity, processing of composite powder with required composition with optimized milling parameters. The technology also involves the hot pressing of the homogenized powder with optimized parameters. The product stands as an cost effective indigenize replacement for imported M26 grade BN.

145.1 Salient Features

It has isotropic properties, higher mechanical strength and lower erosion rate (~20%) compared to imported material.

145.2 Applications:

1. Electric propulsion thrusters
2. High voltage electrical insulators
3. Dielectric applications of glass and silica-based substrates

145.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

146 Hot-pressed Boron Nitride sintered parts

The technology involves choice of BN powder and with correct purity and oxygen content, powder processing and hot pressing with optimized process parameters.

146.1 Salient Features

1. BN discs with isotropic properties.
2. High density >2 g/cc
3. Thermal conductivity >25 W/mK
4. Flexural strength >50 MPa

146.2 Applications:

1. High temperature furnace insulators/muffles/crucibles
2. High temperature and high voltage electrical insulators
3. Refractories like sintering setters
4. Side dams in strip casting process
5. Break rings in continuous casting
6. Ceramic firing supports
7. Glass forming fixtures
8. Applications in metal melting, Atomizing nozzles etc.

146.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

147 SCA 9-1-1

A two-part room temperature curable silicone based low outgassing adhesive which is used for bonding solar cells to pre-treated Kapton substrates in satellites, as vibration isolators for launch vehicles and spacecrafts and for bonding lithium-ion batteries of satellites and launch vehicles.

147.1 Salient Features

1. RT curable two-part silicone adhesive
2. Cost effective and reduced lead time
3. Contributes to end-to-end indigenization of solar panels
4. Exhibits good adhesion on polyimide & metallic substrates including aluminium, steel and titanium
5. Indian patent application is filed for SCA 9-1-1

147.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

148 SUPERCAPATTERY

Hybridization of battery and supercapacitor in a tandem arrangement boost the power capability while ensuring the full utilization of energy more efficiently with significant reduction in mass and volume. Supercapattery (= Supercapacitor + Battery) involves in-situ hybridization which enables direct integration of batteries (high energy density) and supercapacitors (high power density). This results in providing a complementary performance, filling the gap between the two technologies of both energy or power.

Indian Space Research Organization (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed the innovative technology for processing Lithium Supercapattery (Hybrid capacitors) of various capacities viz., 0.5 Ah & 3.0 Ah at 4.0 V. This novel system invoking internal hybridization provides the advantages of Lithium battery as well as Supercapacitors to deliver sustained energy & power in a single system. Supercapattery is unique with advantages such as high energy/ power with low cost, safety, and environmental friendliness.

148.1 Salient Features

No.	Components	Description
1	Configuration	Cylindrical
2	Capacity, Ah	3.0 (1C - rate)
3	Operating voltage, V	4.0 - 2.8
4	Internal resistance, mΩ	10, Nominal
5	Pulse discharge	> 50 C rate
6	Self-discharge, mV	≤ 90 (for 30 days)
7	Mass, g	150, Typical
8	Operating temperature, °C	10 - 40, Nominal 5 - 60, Qualified for space application
9	Energy & Power density	> 80 Wh/kg, >2 kW/kg
10	Interconnections	Screw type

Supercapattery devices perform with operating voltage of Lithium-ion system, ranging from 2.8 V to 4.0 V, while high pulse discharge capability of Supercapacitor (> 50 C) but with the high energy density (> 80 Wh/kg) and power density (>2 kW/kg). The system invokes the characteristics of electrochemical double layer (adsorption-desorption) as well as redox reactions for the charge storage. In addition, an excellent charge retention, low self-discharge and ability to survive extreme electrical, environmental and mechanical conditions. The system is capable of sustaining extended cycles meeting various applications for Space systems viz., pyro, electromechanical actuators as well as commercial applications viz., electric vehicles, portable electronic devices and so on. This cost-effective technology will provide significant advantage due to reduction of

mass and size of the battery systems.

148.2 Applications:

Aerospace: Delivery of peak / continuous current for ignition systems, separation systems, actuators etc.

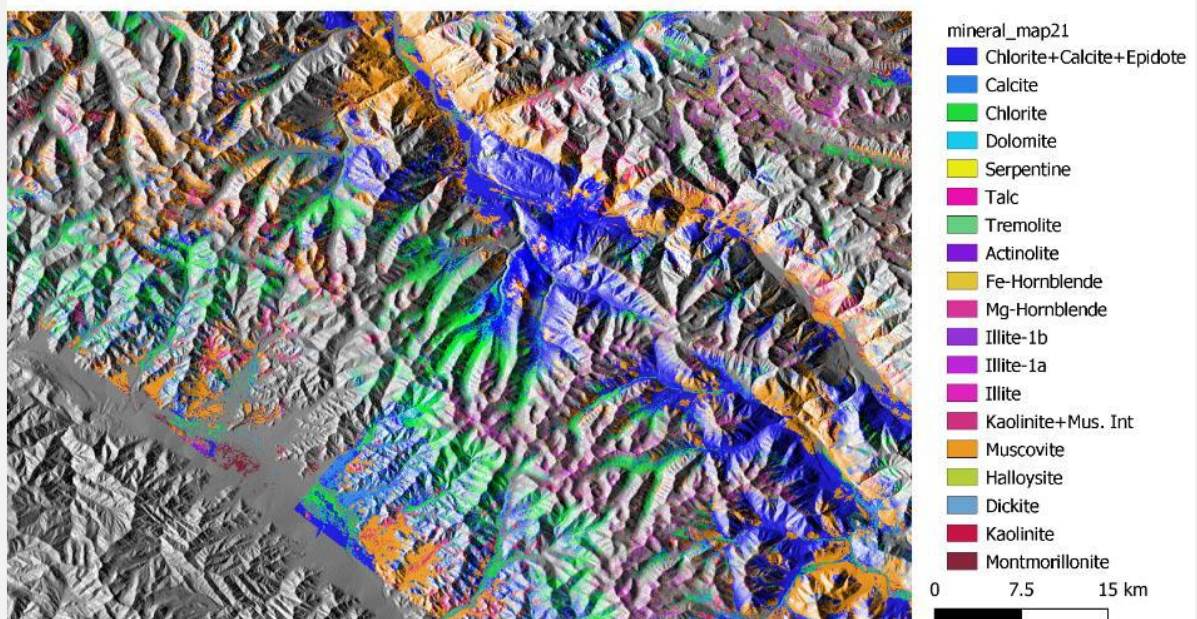
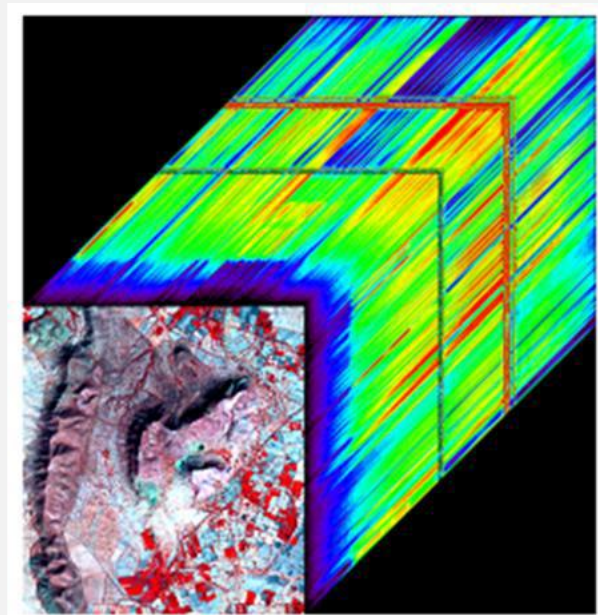
Societal: Applications include in automotive industry, hybrid transportation systems, utility vehicles and powering electronic gadgets.

148.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

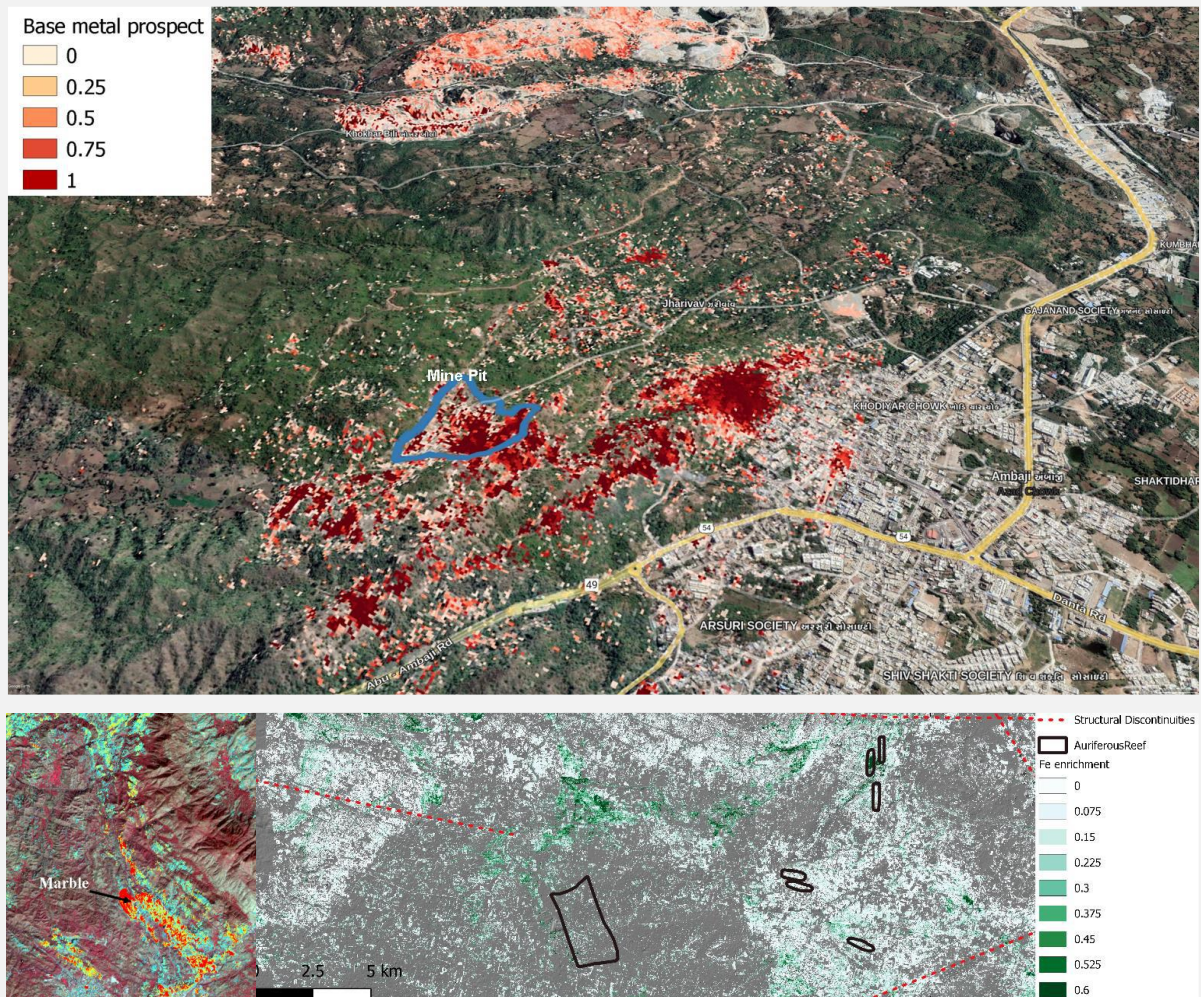
149 Mineral Algorithm

Space Applications Centre (SAC) has developed algorithms for detecting minerals using multispectral and hyperspectral remote sensing. The algorithms can map distribution of non-metallic minerals such as limestones, locate marble deposits and can identify prospect zones for base metal (Pb, Cu, Zn), iron oxides and noble metals such as gold. The algorithm uses absorption features of minerals to detect and map their presence. The wavelength range of diagnostic absorption features of minerals are identified based on analysis of library/field reflectance spectra. The spectral shape matching is performed in spectral range of diagnostic absorption features with unknown image spectra and fit scores are generated. Based on fit scores and other constraints such as band depth, continuum slope, band asymmetry mineral is identified.



149.1 Application:

To reduce the economic cost and time in complex mineral exploration projects, it is important to identify the geographical area/prospect zone for detailed field-based investigations. The developed algorithm can be used to identify the prospect zone with high confidence thereby maximizing the success potential of the mineral exploration projects. It can be highly beneficial for exploration of base metal deposits, iron oxides and gold.



149.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

150 Portable Bathymetry Profiler System

150.1 Introduction

Bathymetry, measurement of water depth, is the vital parameter for wider range of applications such as inland water body storage capacity estimation, sedimentation studies in dams and reservoirs, monitoring & effective management of demand-supply in irrigation projects and hydro power stations. The depth estimations with remote sensing technique either by satellite or airborne sensors (aircrafts/UAVs) need in-situ validation to evaluate the efficacy of the methods/models used. Therefore, the performance of in-situ bathymetry system is critical for validation of derived bathymetry estimations by space-borne and airborne sensors. Autonomous Surface Vehicles (ASV) and Unmanned Aerial Vehicle (UAV) borne bathymetry systems are current trends for bathymetric applications whereas UAV based bathymetry Lidar provides limited depth (< 50 meters) subjected to water quality. The bathy system compactness is the critical requirement for ASV and UAV based operations.

In addition to water depth, different applications require distinct sensors configuration or subtle changes in the available bathymetry system of the user but limited/no scope for hardware customization is available in commercial bathymetry systems. To address the requirement of customization, multi-parameter and multi-platform operability, NRSC has developed a portable immersion type, multi-parameter bathymetry profiler system with multiplatform operability for wide range of water resources & hydrology applications. The system was developed using commercially available off-the-shelf (COTS) components and its works on echo sounding principle to measure water depth.

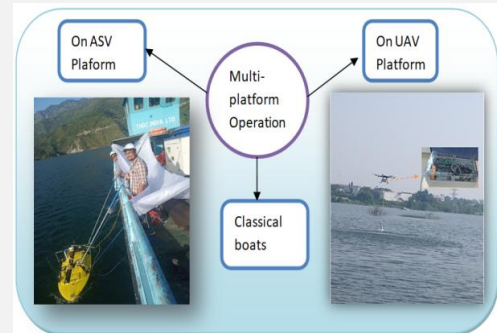
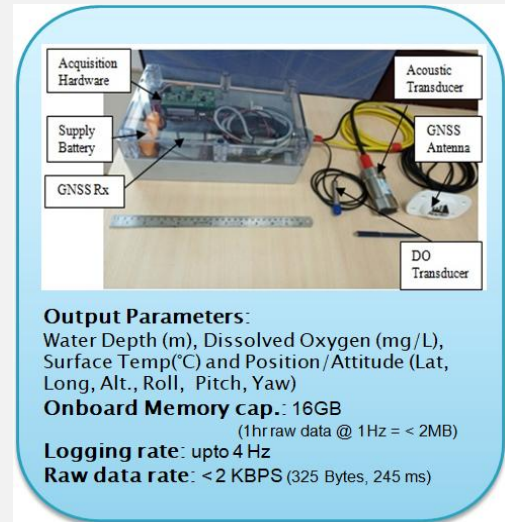
150.2 Salient features -

1. Multi parameter bathymetry system with customization to address specific requirement of water resources applications.
2. As a compact & water proofed system (IP86), it can easily be installed on ASV and UAV platforms.
3. Portable system with low-SWaP (Size 11.8x9.4x4.7 inches, Weight < 4.5 kg and Power typical 5 W)
4. User friendly out data format - coma separated values (.csv) which is easier to import into an open-source GIS software like QGIS etc. for bathymetry DEM/contour map generation or to access in a storage database to enables user for further analysis of measurements.
5. Cost effective system compare to similar kind of imported system.

150.3 Description -

This bathymetry system (Shown in fig.1) is compact multi-parameter system with capability to measure water Depths up to 100 meters, Surface Dissolved Oxygen (DO) & water Surface Temperature (ST), geo-locations in synchronized manner. The raw data stored in onboard memory card and Java based software utility provides output data in user friendly file format (.cvs). It also has provision to add other water quality sensors (up to 4) like turbidity, pH etc. to its hardware for addressing customized requirements of water resource (like aquaculture studies) applications. Further it can be potentially used as a standalone water quality assessment system for water resource applications in addition to in-situ validation system.

Due to compact size & waterproof packaging the developed system is suitable for installations on remotely operated boat (ASV) & UAV platforms which results potential saving in logistic efforts and operational time/cost. The present system configuration provides measurements using single frequency acoustic transducer; which limits its usage in direct sediment estimation where dual frequency transducers are preferred. However, the subtle changes in system configuration/replacement of transducer can be easily implemented to address the dual frequency application requirements.



150.4 Potential Applications-

1. A validation system for satellite remote sensing derived bathymetry as well as airborne (Aerial/UAV) estimated bathymetry.
2. A standalone water quality assessment system for multi-parameter measurements (Depth, DO, ST along with geo-location) in water resource applications.

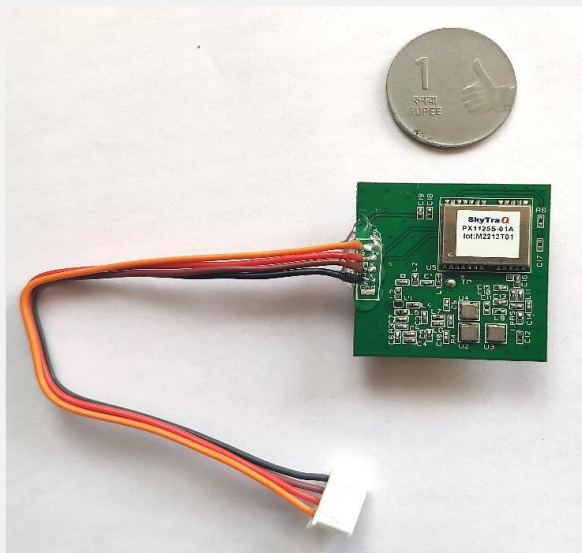
3. A good choice to cater specific applications requirements where system customization is the need.

150.5 Technology Transfer

NRSC/ISRO, offers to transfer this technology of the Bathymetry system developed by NRSC to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may write to Director, NRSC stating the end use of the technology with details of their present activities & infrastructure.

151 Small size and Low power NavIC Receiver for Radio Sonde Application

Space Applications Centre (SAC) has developed a low-cost, small-size, low-power NavIC based satellite navigation receiver. Indigenously developed satellite-based navigation system - NavIC (Navigation with Indian Constellation) by ISRO provides PNT services in the Indian region. Use of Multi GNSS system provides better availability and accuracy when compared to processing signals from single constellation. NavIC satellites being in GSO/GEO orbits provides substantial improvement in availability and geometric requirement of accuracy. This receiver uses NavIC L5 SPS and GPS L1 C/A signals for estimating its position. As satellites from two constellations are used, the position accuracy and availability is better compared to use of GPS L1 C/A only receivers. The receiver has inbuilt L1+L5 antenna and NavIC capable receiver module with on-board RF circuit to suppress out-of band interference, UHF interference in particular.

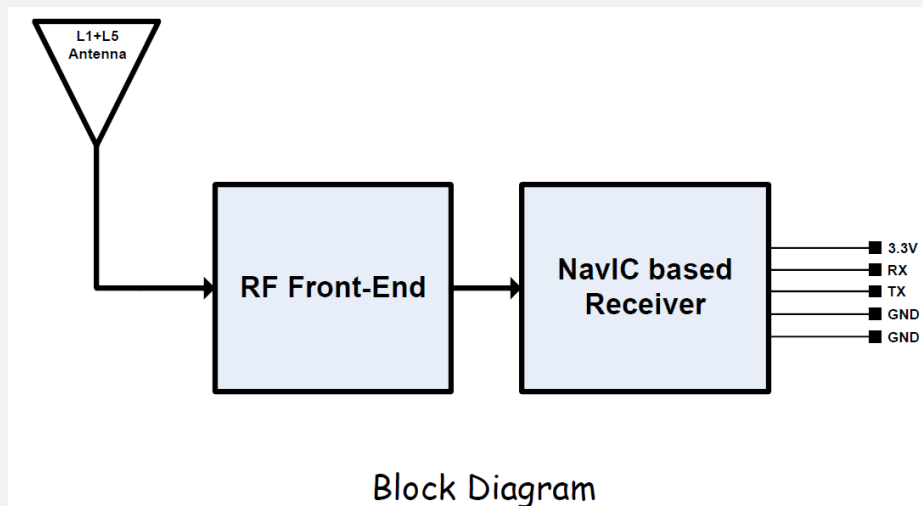


151.1 Application

Radio Sonde devices used for atmospheric profiling uses satellite-based navigation receivers. The Radio Sonde devices consists of sensors to measure atmospheric parameters, microcontroller, Radio Transmitter and GNSS receiver. These devices are battery operated, light weight and one-time usable and are flown on balloons. The GNSS receivers are used in Radio Sonde devices for getting position, velocity and time information. As size, weight, power and cost are important parameters of these devices, GNSS receiver design for this application should also have better design in these aspects. Also, receiver should be capable of handling interference from a high-power radio transmitter. This receiver is designed to handle UHF interference and can be used for such size, cost and power sensitive applications.

151.2 Specifications

1. NavIC based GNSS Receiver
2. NavIC L5 SPS and GPS L1 C/A signal reception with integrated L1+L5 patch
3. antenna
4. TTFF: Hot start 1s, Cold Start <30s
5. Position Update Rate: 1 Hz
6. Position Accuracy: <10m 3D RMS
7. Velocity Accuracy: 0.1m/s
8. Altitude: 55 km
9. Output: NMEA 0183 v3.1 on 3.3V LVTTTL UART Serial Interface @ 9600 baudrate
10. Supply Voltage: 3.3V \pm 10%
11. Power Consumption: <40mA @ 3.3V
12. Output Connector: 4 pin berg
13. Size: 35mm x 35mm x 12.5mm
14. Weight: ~25 g
15. Operating Temperature: -40 oC to +85 oC



151.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

152 Hard Black Non-Reflective Anodising at Room Temperature

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed hard, black non-reflective anodizing process on Aluminum alloys. The hard anodic oxide coatings produced under special conditions have high hardness values and very good non-reflective characteristics compared to normal black anodic coating. Hard anodic oxide coatings find application in the engineering industry for components where abrasion resistance is the required in addition to optical properties.

152.1 Salient Features

Hard, Black, non-reflective anodizing process is carried out at room temperature compared to conventional hard anodizing process, which is carried out at -5 oC, thus saving a considerable cooling load. The burning and powdering problems associated with conventional hard anodizing process are eliminated resulting in no-rejection.



152.2 Major Specifications

Thickness (micron)	ASTM-B-244 Eddy Current method	50±10 micron
Microhardness (HV)	ASTM-E 384, Diamond Indenter	250 - 500
Insulation value (Electrical)	10-100 V range, DC	30-1.5 GΩ

152.3 Technology Transfer from ISRO

URSC/ISRO offers to transfer this hard, black non-reflective anodizing process on Aluminum alloys developed by URSC to industries in India with adequate experience and facilities. Industries interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities.

153 CV-CC Solar Array Simulator

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed CV-CC Solar Array Simulator (SAS). It is designed to simulate the V-I characteristics of solar arrays.

153.1 Salient Features

This unit features open circuit voltage of 60V or 100V & programmable short circuit current (0.5 - 5A) with current settling time of less than $3\mu\text{s}$ to respond to a dynamic load that can vary from nominal load to short circuit and vice versa.



Front View CV-CC SAS



Top View CV-CC SAS

153.2 Major Specifications

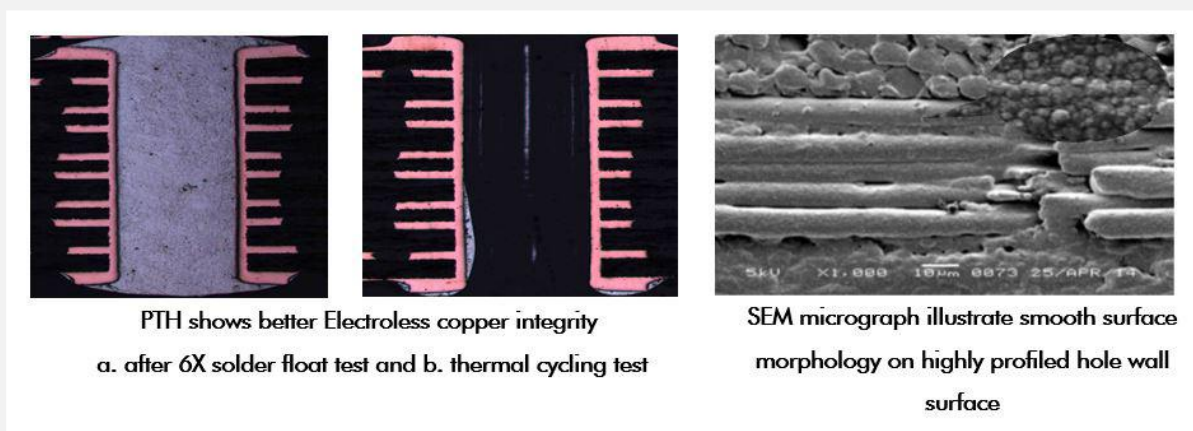
Parameter	Specifications
Input Voltage	230V AC, $\pm 10\%$, 50 Hz, 1Phase
Output Voltage	60V DC $\pm 2\text{V DC}$, 100V DC $\pm 2\text{V DC}$
Output Current	0.5A to 5.0 A in steps of 500mA Short circuit current is adjustable through remote programming on RS-485
Ripple & Noise	Current :100 mA pk-pk (max) , < 50mA rms
Output Response	1. When output is shorted and short is removed output voltage will rise to 60V/100V in less than $3\mu\text{s}$. 2. For switching response test, from 10Hz to 25KHz and for duty cycles from 10% to 90% transient response time is less than $3\mu\text{s}$
Protections	OVP, OCP and OTP
Remote Interface	RS-485
Dimensions	19" standard instrument rack mountable , 1U (44mm)

153.3 Technology Transfer from ISRO

URSC/ISRO offers to transfer of CV-CC Solar Array Simulator developed by URSC to industries in India with adequate experience and facilities. Industries interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities.

154 Chemical Formulation of Stable, Low build Electroless Copper Concentrate for High Reliability Plated through Hole Interconnections

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed the technology for Chemical Formulation of Stable, Low build Electroless Copper Concentrate for High Reliability Plated through Hole Interconnections. This technology deals with the formulation of highly stable and low build Electroless copper concentrate for the metallization of drilled holes in Printed Wiring Boards [PWBs]. This can be used by PWB manufacturers to realize highly reliable PTHs both in High Tg laminates and Microwave laminates.



154.1 Salient Features & Major Specifications

1. Low build, excellent stable bath and operate at ambient temperature (25 ± 5 OC).
2. Continuous copper seed layer without voids.
3. Provides high quality deposit with consistent performance.
4. Suitable for high aspect ratio PTHs.
5. Enhanced PTH integrity in High Tg multifunctional epoxy and microwave laminates under thermal excursions.
6. Excellent shelf life.
7. Substrate: Glass epoxy copper claded laminate with low/ high TG and microwave laminate with ceramic /woven glass PTFE laminate.
8. Surface treatment: Plasma treated drilled holes. Max. Aspect ratio: 1:10.
9. pH of working bath the solution: 11 to 13.
10. Loading capability: 5.5Sq .dm/ltr of freshly prepared solution.
11. Deposited copper thickness 20-25 microinch in 20 minutes.

154.2 Technology Transfer from ISRO

URSC/ISRO offers to transfer this technology of Chemical Formulation of Stable, Low build Electroless Copper Concentrate for High Reliability Plated through Hole Interconnections to industries in India with adequate experience and facilities. Industries interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities.

155 Paraffin actuator-based Hold Down and Release Unit

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed Paraffin actuator-based Hold Down and Release Unit. The Paraffin actuators work on the principle of converting the volumetric expansion of wax on melting to do work by moving the actuator shaft with a large force. The actuators provide a high force to a low mass advantage. These actuators are suitable for use near contamination sensitive payloads. These actuators are easily resettable and have no expendables.

The Hold Down and Release Mechanism (HDRM) employs a paraffin actuator to release a preloaded hold down bolt. The system consists of a special linkage mechanism which provides a high mechanical advantage to release a higher preload with a smaller release force. The mechanism is very compact and is easily resettable.



155.1 Salient Features

1. Paraffin Actuator: Low mass, high force.
2. Non explosive type actuator.
3. Resettable and reusable.
4. Low shock.
5. HDRM: Preload to release force ratio (14:1).
6. Inbuilt telemetry.
7. Compact.

155.2 Major Specifications

Paraffin Actuator Specifications		HDRM Unit Specifications	
Output Force	200 N	Pre-Load capability	1000N
Stroke Length	12 mm	Mass	180 g
Operating Time	< 180 seconds	Size without actuator	40 mm x 40 mm x 44 mm
Size	19 mm dia X 75 mm		
Voltage	28-33 V D.C.		
Heating Source	Foil Heater		
Actuation Temp	>50 °C		
Mass	75 g		
Life (Number of Operations)	100 cycles		

155.3 Technology Transfer from ISRO

URSC/ISRO offers to transfer this technology of Paraffin actuator-based Hold down and Release Unit developed by URSC to industries in India with adequate experience and facilities. Industries interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities.

156 Special Purpose Fixture (SPF) for Assembly and Integration of Spacecraft

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed Special Purpose Fixture (SPF) that is used to enable Assembly, Integration and Test (AIT) of spacecraft. It offers three degrees of freedom of motion that enable

1. Tilting of spacecraft to an elevation angle between +/- 90°.
2. 360° rotation of spacecraft about its Azimuth (Az.) axis.
3. Translation (up & down motion) along vertical axis.

156.1 Salient Features

1. Easy accessibility to different location, Modular Design with flexibility for configuration changes.
2. Modular Design allows to change the configuration according to Satellite mass, Centre of Gravity for test or integration requirements.
3. 3 DOF motions using precision ball screw, linear motions guides, slewing bearings.
4. Low backlash, Self-holding and stay put braking features.
5. Low acceleration / deceleration transmission drives and controls.
6. Mobility using non-marking wheels.
7. Air levitation using four Air pads enables smooth movement of the fixture on cleanroom flooring.
8. Worm driven Levelling jacks & Tow bar interface for powered towing.
9. Safety Limit switches, proximity switches, logical controls for fool proof operations.



156.2 Major Specifications

1. Max. External Dimensions : 4700 mm X 2600 mm x 3400 mm

2. Self-Weight : 6500 kg
3. Allowable Mass : Maximum- 2500 kg (Dry Spacecraft)
4. Allowable Static Mass : 5000 kg. (No motion is allowed)
5. C.G. height : 2000 mm (from the mounting plane)
6. Max. Allowed Envelope : Diameter - 3750 mm (About Az. axis)

156.3 Technology Transfer from ISRO

URSC/ISRO offers to transfer this technology of developed Special Purpose Fixture (SPF) by URSC to industries in India with adequate experience and facilities. Industries interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities.

157 Monolithic Composite Cylindrical Sandwich Shells Process

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed Monolithic Composite Cylindrical Sandwich Shells which are structurally efficient composite sandwich cylinders, for all satellite structure applications.



157.1 Salient Features

Light weight CFRP (Carbon Fiber Reinforced Plastic) composite sandwich cylinder.

157.2 Description

1. Composite Sandwich Shell is used as main thrust cylinder of satellite structures, made up of composite skins bonded to Aluminium core through manual layup and autoclave curing process.
2. Manufacturing Process: Cylinder is of sandwich construction. Top and bottom skins of the cylinder are made up of prepregs made up of ultra-high modulus carbon fibre. The layup of prepreg upon the tool surface is done manually. The skins are bonded to the honeycomb core through film adhesive and through vacuum bagging and autoclave curing process.
3. Types: Specified by the inner diameter of the component which is the outer diameter of the tool. Two types according to the outer diameter of the tool are 886 mm and 1162 mm. Length of the cylinder is limited by the length of the tool and autoclave size.
4. Facilities required: Cold stores, clean room, degreasing bath, autoclave.

157.3 Technology Transfer from ISRO

URSC/ISRO offers to transfer this technology Monolithic Composite Cylindrical Sandwich Shells Process developed by URSC to industries in India with adequate experience and facilities. Industries interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities.

158 Heat pipe Embedded Honeycomb Sandwich Panels - Special Tooling and Process

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed Heat pipe Embedded Honeycomb Sandwich Panels - Special Tooling and Process for all satellite structure applications

158.1 Salient Features

1. Manufacturing Process for HP Embedded Aluminium honey comb sandwich panel.
2. Provides better/easier thermal management for satellite equipment panels
3. Types of Heat-pipe network configuration - Criss-cross type, multi-bend type & Straight type with single or dual core or combination.



158.2 Major Specifications

Achieving Stringent Specification in terms of Thickness, Location, Flatness, Orientation Control of each embedment

1. Flatness: 0.1mm /100mm(inboard)
2. Flatness: 0.2mm /200mm (out board)
3. Flatness: 0.5mm /1000mm
4. HP Joint height control: 25.75 + / - 0.05 mm
5. Bond line thickness between heat pipes: 0.15mm
6. Parallelism b/w HP axes to Panel edge: $\leq 0.5\text{mm}$
7. Perpendicularity between I/b & O/b HP: $\leq 0.5\text{mm}$
8. SPHD Positional tolerance: $\leq 0.5\text{mm}$
9. Perpendicularity between I/b & O/b HP: $\leq 0.5\text{mm}$
10. SPHD Positional tolerance: $\leq 0.5\text{mm}$

158.3 Technology Transfer from ISRO

URSC/ISRO offers to transfer this technology Heat pipe Embedded Honeycomb Sandwich Panels - Special Tooling and Process developed by URSC to industries in India with adequate experience and facilities. To manufacture, industries must have the knowledge of composite structure manufacturing, clean room, cold storage and autoclave facilities. Industries interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities.

159 CFRP Honeycomb Core

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed CFRP Honeycomb Core to develop thermally stable light weight structure which can be used for optical payload bench for satellite applications.



159.1 Salient Features

1. Light weight, Robust Process.
2. Very low CTE along thickness compared to Aluminium honey comb core.
3. Product can be realised with any type of prepreg material.
4. Process is flexible.
5. Manufacturing Cost is reasonable

159.2 Major Specifications

Property	CFRP Honeycomb core	Aluminium Honeycomb Core
Core Density	33 kg/m ³	32 kg/m ³
Linear CTE	Near Zero in all directions	+23.2 μm/m/ °C
Mechanical Properties like Shear Strength, Shear Modulus, Compressive Strength and Compression Modulus.	Superior as compared to Aluminium Honeycomb core	
Service Temperature Range (-50 °C to +150 °C)	Very good	Good

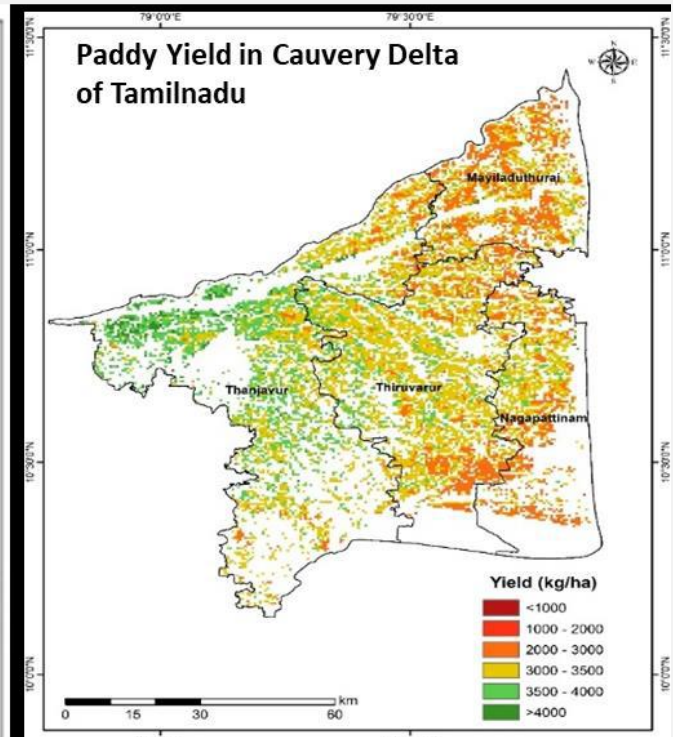
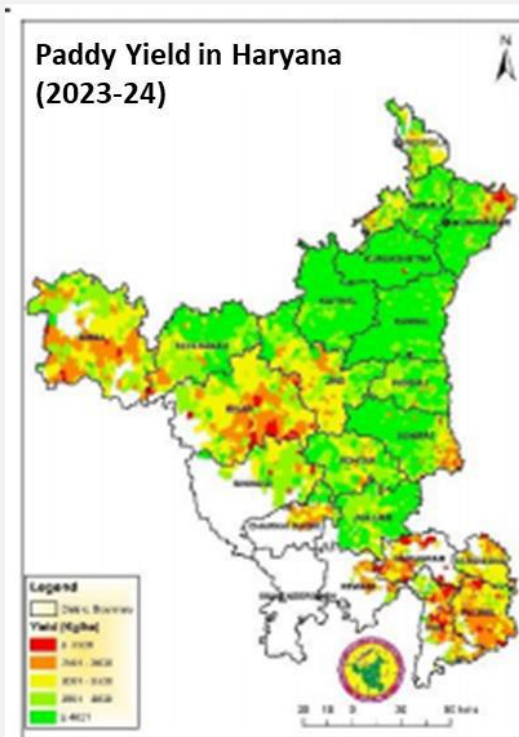
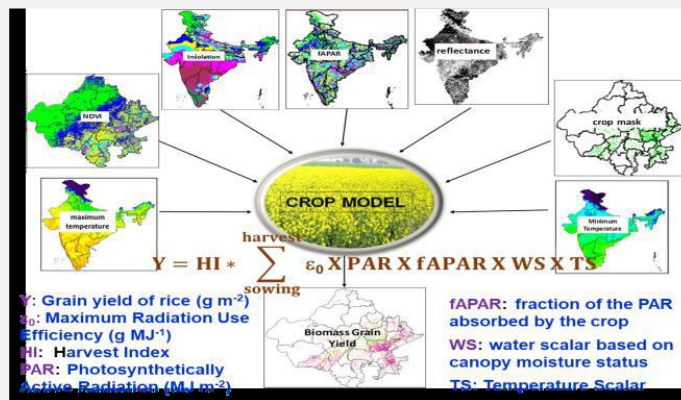
159.3 Technology Transfer from ISRO

URSC/ISRO offers to transfer this technology of CFRP Honeycomb Core developed by URSC to industries in India with adequate experience and facilities. Industries interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities. To carry out this activity industry must have facilities like cleanroom, autoclave and composite structure manufacturing knowledge.

160 Semi Physical Crop Yield Model

160.1 Approach for Semi Physical Model (SPM) using RS Optical Data

Yield is the important component of crop production and is the most sought-after quantity using satellite data in the field of agriculture, Past experience has shown that the empirical nature of vegetation index-based yield models as well as the intensive data requirement of the complex mechanistic crop simulation models made both types of models unsuitable for regional and spatial crop yield prediction especially for operational use. Hence, Space Applications Centre (SAC) has developed an intermediate method based on the use of remote sensing and the physiological concepts such as the photo-synthetically active solar radiation (PAR) and the fraction of PAR absorbed by the crop (fAPAR) in Monteith's radiation use efficiency-based equation for crop yield estimation. This model uses most of the input from space-based observation and is scalable based on the resolution of the available input data from space.

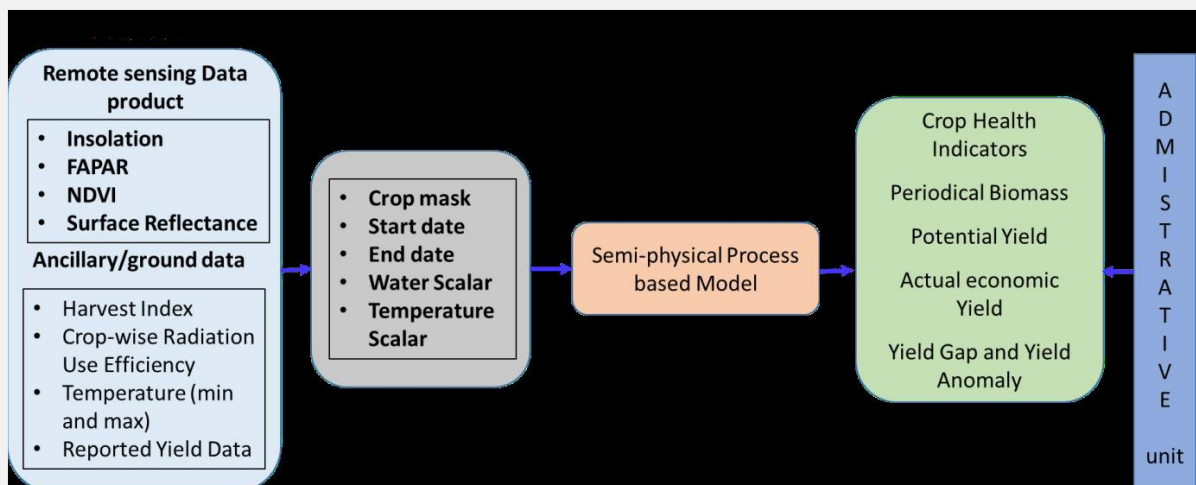


160.2 Applications area

This model has been evaluated for 11 crops at district and state level ((Wheat, Kharif Maize, 'Rabi pulse, Mustard, Cotton, Sugarcane, Jute, Soybean, Kharif Groundnut, Rabi groundnut, Summer Groundnut) and 4 crops (rice, wheat, cotton and soybean) for block and village level yield estimation. Accuracy was found to be 95 % at state level, > 80 % at block and district scale and <30% at GP level. These models are useful for district and state level crop forecasting, for generating yield gradation maps for selecting site of crop cutting experiment as well as for crop insurance settlement purpose (being implemented this year for rice and wheat under YESTECH program)

160.3 Specifications:

This model use data from multiple Indian and global EO missions • SPM can be implemented in a standalone version as well as on cloud platform • Input data for this will be free of cost, hence once automated, will be a low-cost technology for yield estimation at different scale • Need 18 months' time for implementing the automation version (both standalone and cloud-based platform)



Concept of Semi-physical yield model with optical remote sensing data

160.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

161 Highly Accelerated Thermal Shock (HATS) Test System

161.1 Assessment of PCB via Reliability

As per international IPC protocol IPC-9151D, via reliability assessment becomes paramount in qualification and acceptability of a board for onboard applications. At present, there is no equipment vendor or test service provider in India for HATS testing. Hence, considering the importance of the test, a HATS system was successfully developed indigenously under a technology development program at SAC Ahmedabad.

The via reliability assessment is done by subjecting the PCB samples (coupons) to a thermal shock from - 40 °C to +145 °C and vice versa, within 120 sec and maintaining the samples at extreme temperatures for 180 sec. This forms a single thermal cycle. The cycle is repeated for 500 times. Each PCB coupon has electrical circuits (nets) which are comprised of vias and trace interconnects.



161.2 Advantages

1. Indigenously developed system
2. Quick in testing of samples (within 3.5 days)
3. Highly configurable and scalable system and test parameters
4. System design as per the requirements of IPC-9151D standard
5. Simple and easy to operate, no specialized training required
6. Affordable testing cost and less duration

161.3 Applications

The system can be used for vendor qualification, material qualification, technology qualification and batch acceptance test for FM use PCBs. All FM PCBs can HATS tested within 3.5 days (500 cycles). This system is recommended for all on-board PCBs.

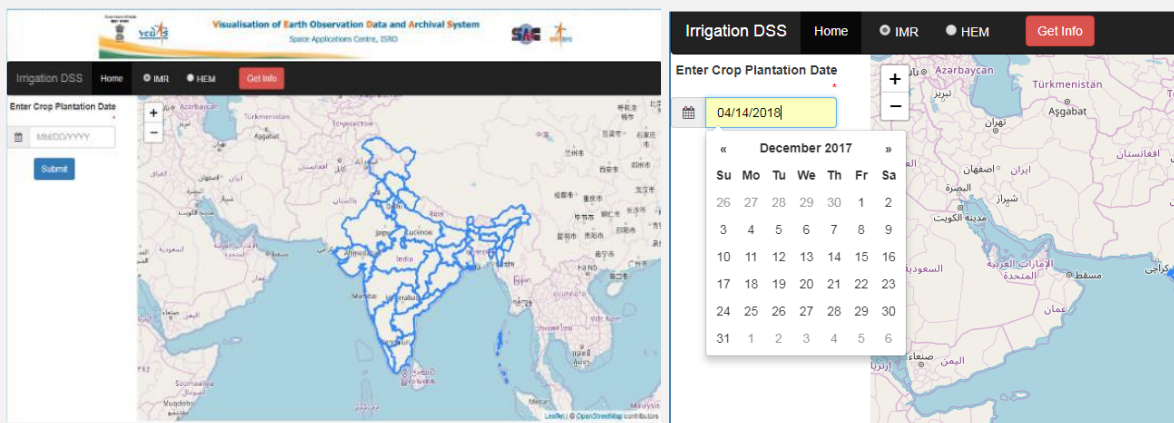
161.4 Technology Transfer from ISRO

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162 Irrigation Advisory Model

162.1 Block/Taluka level Irrigation

The biggest challenge in agriculture is to increase the crop production by minimizing the water loss. India has total 4% of the world's fresh water. Presently Indian agriculture is using 80% of total available water in the country. The monsoonal rainfall is the important element of Indian economy because country GDP is heavily dependent on agriculture. The uncertainty of rainfall always a threat for sustainable growth of agriculture and food security. The irrigation water management plays important role in increasing food grain production for growing population. Improvement in management of irrigation system showed potential to increase crop water productivity. To further boost the concept of more crop per drop there is need to develop irrigation advisory system on a spatial scale. It will provide the guidance to the farming community for judicious use of the water resources in our country.



162.2 Remote Sensing Applications area

An algorithm is developed to estimate daily reference evapotranspiration (ET₀) at country scale operationally using Indian Geostationary Meteorological satellites INSAT-3D/3DR through an automated processing chain and available through MOSDAC (Meteorological and Oceanographic Satellite Data Archival Centre) portal. Similarly, GSMaP_merged daily rainfall product is developed By SAC and operational at Krishi-DSS (VEDAS portal). The vegetation index from polar satellite is used to generate reference crop ET (ET_c). The further mechanism is developed in the form of peso-code to generate daily crop water demand as per the cumulative values of ET_c, rainfall and applied irrigation by the user for the defined period to compute daily irrigation demand. Then generated medium range (72-hourly) forecast is added to produce gross irrigation scheduling for the targeted location.

162.3 Technology Transfer from ISRO

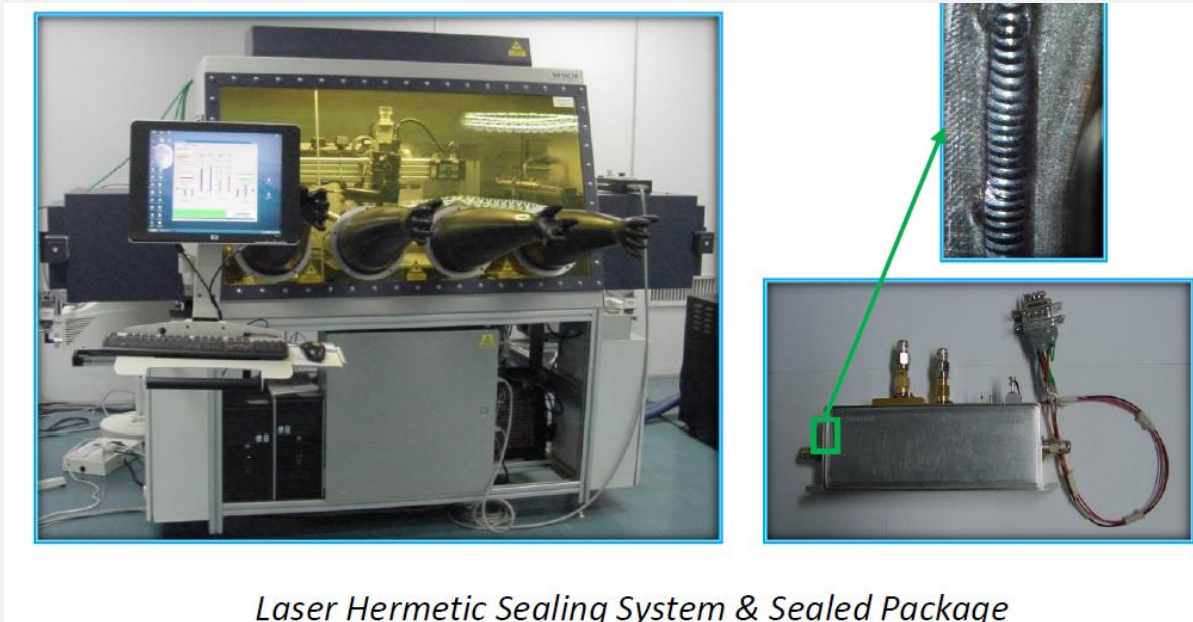
ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

163 NON-CONTACT HERMETIC SEALING OF MICROELECTRONIC PACKAGES USING PULSED LASER

Space Applications Centre (SAC) has developed laser-based Aluminium-Aluminium and Kovar-Kovar hermetic sealing process for microelectronic packaging applications. Seal joints resulting from the use of this technology meet the requirements of MIL-STD883/1014. The technology has been extensively used for the hermetic sealing of a wide array of packages for SAC’s communication, navigation and remote sensing payloads.

163.1 Applications area

Sealed RF packages hosting bare MMIC chips have been used in the development of miniaturised microwave subsystems for advanced communication and navigations payloads. These bare chips are assembled on ceramic substrates using different microelectronics assembly processes. MMIC chips are sensitive to the moisture, corrosive gases etc. so to get stable and desired performance, these bare chips must be protected from the adverse environmental effects. Therefore, to protect these chips and produce highly reliable metal joints, laser hermetic sealing of RF packages has been carried out and the seal joint meeting MIL-STD-883/1014 standard requirements.



163.2 Specifications:

laser based technology has been developed for non-contact laser hermetic sealing of RF packages and meeting fine leak requirements as per MIL-STD-883 test method 1014 standards.

1. Technology: - Non-Contact Laser Hermetic Sealing Technology.

2. Material: - Al 6061 to Al 4047”, Nd:YAG: Wavelength 1064 nm.
3. Application Area: - Microwave remote sensing, navigational & communicational payloads.
4. Advantage: - Non-contact method, low HAZ, Suitable for fragile substrates, Production friendly etc.
5. Technology Space Qualified process: - Al 6061 to Al 4047”

163.3 Salient Features

1. Patented non-contact sealing method amenable for sealing of fragile modules
2. Sealing process qualified for space use
3. Laser: Nd:YAG, Wavelength: 1064 nm
4. Low Heat Affected Zone (HAZ)
5. Fine leak rates better than 10^{-7} atm cc/sec of He

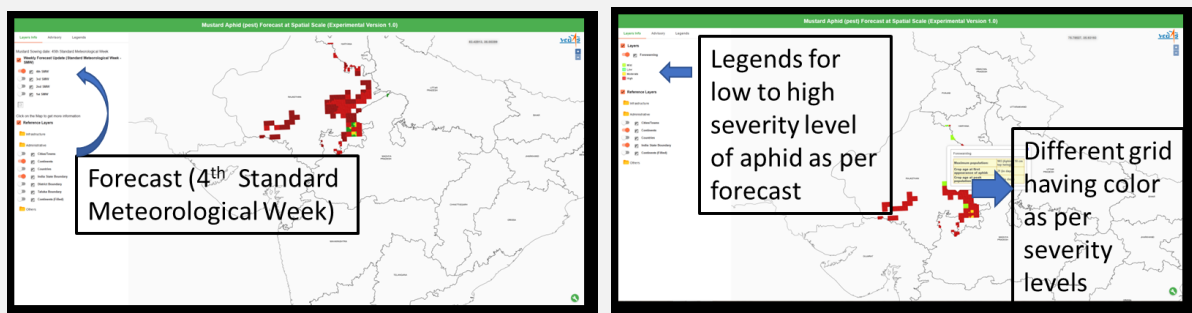
163.4 Technology Transfer from ISRO

SAC/ISRO offers to transfer this Laser based Hermetic Sealing Process to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may register and submit their proposal to IN-SPACE, Ahmedabad at www.inspace.gov.in

164 Geospatial Pest Forewarning System

164.1 Pest and Disease forewarning models for Agricultural Crops

Insect-pests are a major limiting factor in crop production in major part of India. In the infestation of pests and diseases crop cycle and weather plays an vital role. Timely forewarning of pests and disease during crop season are crucial for proper, foresighted, and informed planning to reduce the cost of cultivation and to reduce the growing uncertainty in agricultural sector. In India government's plant protection department typically uses ground based manual monitoring of pest population density and disease severity in a limited spatial area; however, they were unable to meet the scientific control requirements for timely and spatially continuous information on pest and disease occurrence and progression over large areas. A well calibrated and validated weather-based remote sensing data driven model can be an effective scientific tool for forewarning pests and diseases well in advance at spatial scale.



164.2 Remote Sensing Applications area

To reducing unintended consequences of chemical toxicity on the agriculture-ecosystem from repeated use of chemical pesticides in agricultural crops. SAC team had developed pest and disease forewarning models for mustard aphid and yellow stem borer for rice crop using longterm meteorological data from surface observatory and weather forecast (assimilated satellite data) model output with crop sowing/transplanting date from space borne data. The developed forewarning models able to predict (a) crops age at first appearance of pest, (b) the crops age at maximum population of pest, and (c) maximum population of pests at spatial scale as well as at point scale as per the availability of the input data. The models were validated with in situ pest data over different locations. The protocol and peso-code can be provided to the user community.

164.3 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

165 Satcom Digital Modem (SDM)

165.1 Introduction

Space Applications Centre (SAC) of Indian Space Research Organization (ISRO) has developed a Satcom digital modem ASIC build on 180nm CMOS technology, which supports IESS waveform for various modulation schemes and different Forward Error Correction techniques namely Convolution, ReedSolemn & Turbo to be used in SATCOM ground segment. SPI/UART interface allows user to configure the MODCOD for required applications. SDM can operated in full duplex mode up to 40 MSPS symbol rate. It has in-built PRBS Generator/Analyzer and digital Noise Generator to enable standalone built-in self-test.

SDM supports wide range of modulation/FEC/data range support, hence can be used in various MSS based SATCOM applications like. Reporting terminal, asset tracking, Satellite Mobile radio etc

Modem ASIC has been interfaced with ADC/DAC and successfully tested & evaluated noise performance for all combinations of modulation scheme & FEC for data rate ranging from 2.4kbps to 40Mbps. ASIC has undergone through temperature cycle ranging from (-10oC to 60o C).

165.2 Technical Specification

	<u>Features</u>
1	0.18μ CMOS Digital Technology
2	Modulation Schemes - BPSK/QPSK/8-PSK/16-QAM
3	Data Rate - 2.4kbps-40 Mbps
4	FEC Coding – Convolution, RS, Turbo
5	RRC Filtering - Roll off 20%, 25%, 35% & 40%
6	Scrambler - CCITT V.35, IESS-315
7	ADC/DAC Interface – 14 Bit digital I & Q (SDR/DDR)
8	Interface - Data: LVTTL, and M&C: SPI, UART
9	Test Mode- Normal, CW, OFF ,PRBS
10	Supply – 3.3V for I/O, 1.8V for core Power - 1.5 watt @ 100 MHz System clock 0.6 watt @ 20 MHz System clock

165.3 Available Version

SDM-164 pins-CQFP-Available (V1.0)

SDM-176 pins-LQFP-Available (V2.0)

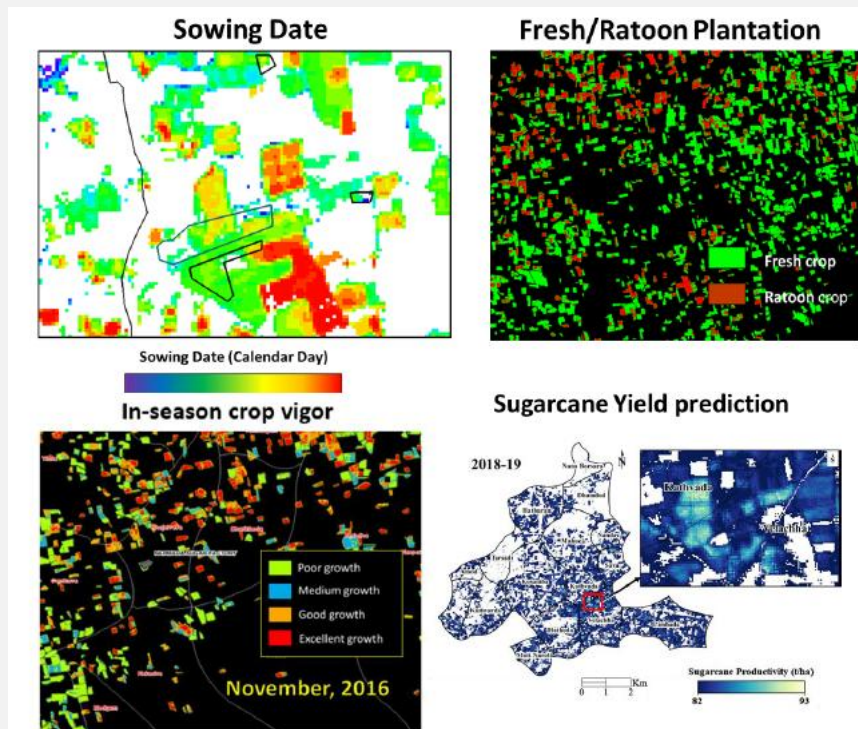


165.4 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

166 Geospatial Management System for Sugar Mills

The sugarcane industry in India holds the second position globally, contributing approximately 15% of the world's sugar production and supporting a vast network of farmers, mill workers, and entrepreneurs. With over 700 sugar mills installed, including 250+ mills in cooperative structures, the industry relies heavily on timely and accurate information for efficient management. Farmers receive remuneration based on cultivated area, regulated by the mill's profit or loss, while the Fair and Remunerative Price (FRP) is determined by the Commission for Agricultural Costs and Prices (CACPC). Prior knowledge of sugarcane crop health and production is essential for effective harvest planning and profit maximization. Remote sensing data offers valuable insights when coupled with various modeling techniques, including empirical and machine learning approaches.



166.1 Remote Sensing Applications area

The models were developed over Gujarat and Maharashtra utilizing multivariate optical and Synthetic Aperture Radar (SAR) data for estimating sugarcane planting date, fresh vs ratoon crop discrimination, in-season crop vigour and yield at micro-scale levels. Results indicated strong predictive capabilities, Sugarcane crop classification accuracies of >85% have been obtained utilizing AI/ML based modelling framework. Mill-level production forecasting (with less than 10% deviation from reported production), This model has significant potential to inform better sugarcane management practices and facilitate data-driven decisionmaking for growers, ultimately enhancing crop yield predictions and spatial distribution at the field scale.



166.2 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

167 10W X-Band LTCC based TR Module

167.1 10 W X Band LTCC TRM

Space Applications Centre (SAC) has developed 10W X-band LTCC based Transmit Receive (TR) module. Utilizing cutting edge technologies like LTCC packaging, GaAs MMICs, laser hermetic sealing; the TRM exuberates best in class performance and minimum SWaP. This robust design enables production worthy TRM with repeatable performance.



167.2 TRM Technology

1. GaAs based custom MMICs.
2. LTCC based RF packaging.
3. Laser sealable hermetic package.
4. High Thermal conductivity materials.

167.3 Potential Applications

1. Active Phased array antenna-based space borne SAR imaging satellites for civilian & strategic applications.
2. Airborne SAR for surveillance imaging.
3. AESA (nose radar) for fighter jets.
4. Ground based Intercepting and tracking RADARs.

167.4 TRM: Salient Features

1. 10 W transmit peak power.
2. Low noise figure receiver.
3. Inbuilt receiver protection for reflected transmit power

4. Antenna duplexing.
5. In-built calibration.
6. Digital control of Gain and phase.

167.5 Technology Transfer from ISRO

ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs / industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment.

168 PMC 30 Silicone coating system

Vikram Sarabhai Space Centre has developed a good number of specialty coatings to meet the specific requirements in Launch Vehicles and Satellites. These coatings may also find various industrial applications. PMC 30 is a room temperature curable silicone based coating system, containing micro-balloons and other fillers, which imparts low thermal diffusivity to the system. They are used in Thermal Protection System in launch vehicles and cryo tank. They are processed by the preparation of premix in dual speed mixer and blending of fillers and premix in sigma mixer.

168.1 Typical Properties / characteristics:

Part A: Red colored, dough material

Part B: Transparent.

Density: 0.6 g/ cc

168.2 Technology Transfer from ISRO

ISRO offers to license this know-how to capable small/medium scale specialty silicone-based polymer manufacturers, looking for new product line. Interested parties are requested to respond immediately with details of their present activities and product lines, capabilities, infrastructure, their own product assessment and their plans for implementing the technology.

169 Coating Compound SESCO 125

Vikram Sarabhai Space Centre has developed different types of coating compounds catering to specific applications in Launch Vehicles and Satellites. These materials may also find various industrial applications. These are derived from resins and different curing agent combinations, modified with various classes of materials such as flexibilizer, toughening agent, fillers, pigments, cure accelerators etc. SESCO-125 is a Poly Dimethyl Siloxane (PDMS) based room temperature curable silicone based coating system, containing inorganic fillers and other additives, which imparts flame retardancy to the system on which it is coated. It is used in the flame retardant coating on launch pedestals and in liquid engine. SESCO-125 is processed by mixing polymer and fillers in sigma mixer and blending in triple roller mill. Part A of the product is a grey colored, viscous material and Part B is Transparent.

169.1 Product Specifications

1. Density, g/cc	: 1.5 + 0.2
2. Tensile strength at RT, ksc	: 8 -18
3. Elongation at RT, %	: 70 - 200
4. Lap shear strength on Al, ksc	: 3 -7
5. Lap shear strength on PC-10, ksc	: 3 -7
6. Specific heat at 100 oC cal/g/ oC	: 0.25 - 0.35
7. Thermal conductivity at 100 oC, al/ oC /sec.cm x 10 ⁻⁴	: 8.5 + 1.0
8. Limiting oxygen index, %	: 33 (min)

169.2 Technology Transfer from ISRO

ISRO offers to license this know-how to capable small/medium scale specialty silicone-based polymer manufacturers, looking for new product line. Interested parties are requested to respond immediately with details of their present activities and product lines, capabilities, infrastructure, their own product assessment and their plans for implementing the technology.

170 Triband (S, X, Ka) Antenna dual circularly polarized Monopulse feed for LEO satellite Auto tracking and Data reception.

170.1 Introduction

High-resolution satellite data containing more volume of information is need of the hour, but at the same time it causes a huge surge in satellite data rate. This calls for transmission and reception of huge data in a short period of satellite pass, increasing the data rate by many folds. To transmit/ receive such high-speed data, large bandwidth antennas with single/dual/multi-band operation is the fundamental requirement. To avoid spectral crowding in X-band, transmission at Ka-band is solution to enable high-resolution high data rate transmission. So, we have S/X/Ka Tri-band feed is indigenously designed and developed in-house to cater multiband data reception from single antenna system.

170.2 Salient Features:

Novel features of proposed system:

1. Frequency bands supported- – S, X and Ka band simultaneous RHCP and LHCP.
2. Monopulse Auto tracking Capability: – S band - RHCP & LHCP
 - a. X band - RHCP & LHCP
 - b. Ka band - RHCP & LHCP (switchable in feed)
3. G/T achieved: – S band: 17.0 dB/deg K
 - a. X band: 31.5 dB/deg K
 - b. Ka band: 34.5 dB/deg K
4. Multiband composite feed in a single cassegrain plane.
5. Ka band TE₂₁ Monopulse auto tracking for LEO satellites.

170.3 Description:

The S/X/Ka Tri-band feed is indigenously designed and developed in-house. This tri-band feed configuration comprises of multimode Ka-band dielectric rod, 2×2 square array of dielectric rods for X and S-band. The developed and realized tri-band feed is very compact, cost effective and gives state of art performance in terms of optimum illumination of sub-reflector with symmetric low cross-polarized

radiation pattern. The designed feed is fabricated, assembled, tested at CATF and integrated in 7.5m cassegrain antenna system at IMGEOs, NRSC, Shadnagar. This will be useful in receiving data in all the three bands from remote sensing LEO satellites. Multimode Monopulse for Ka-band and Multi-element Monopulse in X & S-band is a novel approach to achieve a highly efficient multiband composite feed. Tri Band antenna system will be advantageous in receiving data from Remote Sensing Satellites in S, X and Ka bands satellites single antenna system. Multi-element Monopulse in S-band and X-band is achieved with square array of optimally designed dielectric rods.

170.4 Major components of the feed:

The proposed Integrated Triband feed design configuration is consisting of

1. multimode dielectric rod as Ka band feed element,
2. Ka-band TE₂₁ mode coupler;
3. Ka-band tracking network;
4. 2x2 dielectric rod array for X band;
5. X-band MPC special waveguide;
6. X-band phase matched Auto Track network;
7. 2x2 dielectric rod array for S-band
8. S-band phase matched Auto Track network and
9. required RF uplink/downlink subsystems.



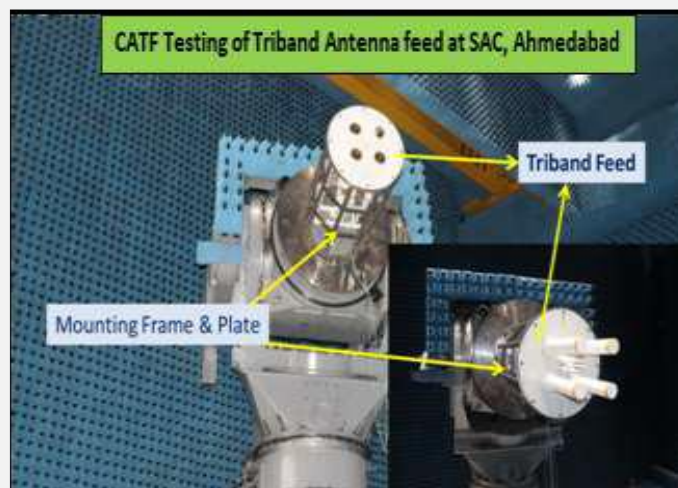
Fabricated S/X/Ka Triband Feed



Fabricated Ka band Components



Triband Feed installed in 7.5m Antenna



Testing of fabricated S/X/Ka Triband Feed at CATF Facility

171 S, X Dual band Antenna Feed for LEO satellite Auto tracking and payload data reception.

171.1 Introduction

Modern remote sensing satellites transmit information in different frequency bands. Therefore, the ground station antenna should be compatible enough to support multiple frequency bands using a single aperture antenna. So, Design and realization of a dual band, dual polarized composite Monopulse tracking feed, covering S-band (2.0-2.3 GHz) and X-band (7.8-8.5 GHz) is successfully accomplished by NRSC.

171.2 Salient Features:

Frequency bands: S and X simultaneous.

1. Monopulse Auto tracking Capability:
 - a. S band - RHCP & LHCP
 - b. X band - RHCP & LHCP
2. Data Reception Capability:
 - a. S band and X-band: Simultaneous RHCP & LHCP
3. G/T achieved:
 - a. S band: 17.0 dB/deg K @ 5 deg EL
 - b. X band: 32.0 dB/deg K @ 5 deg EL

171.3 Description

X-band feed is a five element Monopulse feed, comprising a corrugated horn acting as the main or Sum element surrounded by four circular septum polarizers serving as tracking elements. S-band feed is a four element Monopulse feed consisting of square dielectric array arranged in 2 X 2 configurations. S/X composite feed is systematically designed, fabricated and experimentally characterized in LAB facility with network analyzer and at CATF for Radiation characteristics. The designed composite feed is fully operational in S/X Band Antenna at NRSC, IMGEOs. The specifications of G/T with 32.0 dB/K in X-band and 17 dB/K in S-band are achieved in Antenna System. The proposed feed is highly efficient, compact, simple and cost-effective. The realized Antenna Feed is perfectly suitable for ground station reflector antenna, meeting the stringent specifications for Auto Track and data reception.

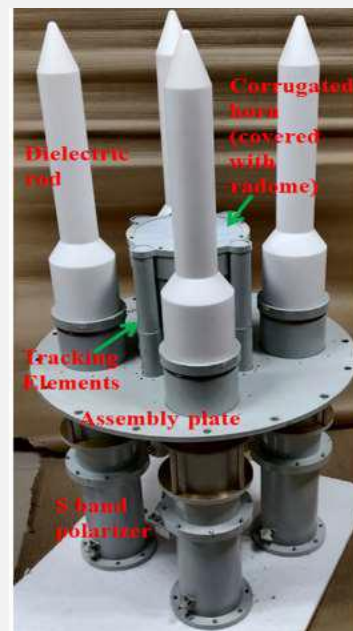
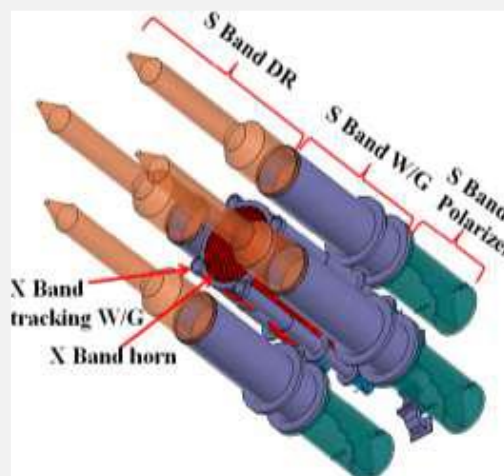
171.4 Antenna Feed Specifications:

- | | |
|-----------------------------|-------------------------------|
| 1. Frequency Range (X Band) | : 7.8 to 8.5 GHz |
| 2. Frequency Range (S Band) | : 2.2 to 2.3 GHz |
| 3. Primary Feed Gain | : 21 dBi |
| 4. Polarization | : RHCP&LHCP |
| 5. Auto Track Capability | : RHCP/LHCP |
| 6. Axial Ratio (X Band) | : <1.0 dB |
| 7. Axial Ration (S Band) | : < 1.5 dB |
| 8. X band G/T | : 32.0 dB / deg K at 5 deg EL |
| 9. S band G/T | : 17.0 dB / deg K at 5 deg EL |

171.5 Major components of the feed:

The proposed S-X band tracking feed consists of

1. X-band corrugated horn,
2. X-band tracking elements;
3. X-band Auto Track network;
4. S-band 2x2 dielectric rod array;
5. S-band phase matched tracking network
6. RF uplink/downlink systems



Designed model and Fabricated model of S/X Dual band Feed

172 Two/Tri-axis Antenna Control Servo System (ACSS)

172.1 Introduction:

This note describes the preliminary details of the Antenna Control Servo System for the S/X/Ka band Remote Sensing Data Reception System at National Remote Sensing Centre (NRSC), Indian Space Research Organization (ISRO).

NRSC has designed and developed Two axis/ Tri-axis antenna control servo systems for remote sensing data reception from IRS series of satellites. The Data Reception System is for providing payload data reception support for ISRO's current & next generation remote sensing satellites for various applications. The satellites transmit data to ground in S/X/Ka bands. S&ASG (Servo & Automation Systems Group) has taken up the responsibility for in-house design and development of Antenna Control Servo Systems (ACSS) for ground stations based on their requirements. The Antenna Control Servo System will control the antenna position in AZ and EL axis with tracking accuracies of the order of 30mdeg. The antenna system is mounted on a three-axis tracking mount (elevation over azimuth over train) to point the antenna over full hemispherical coverage without any key hole. The tilt axis is programmable and will be utilized during a pre-pass activity. ACSS will support PTS mode & auto track mode using single channel mono-pulse technique with S/X/Ka band tracking. This report covers the configuration of the Antenna control servo system, architecture and details of main electronic modules such as controllers, motor drives and other subsystems, functions and interfaces with other systems.

172.2 Experience in developing and delivering digital Servo control Systems

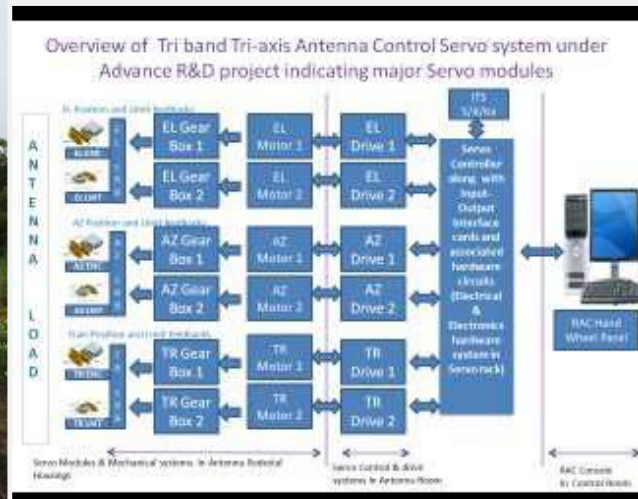
Servo & Automation Systems group has the following experiences in developing in-house ACSS and delivered the systems, which are currently in operations as detailed below:

1. First, In-house digital ACSS is developed in 2018 -deployed @AS5 antenna, IMGEOs and regularly tracking non-IRS missions in auto track mode and it is currently in operation.
2. Second, In-house Design and Development of ACSS for INCOIS, S/X band Ground station, which was established in 2022 for OS3 data reception and currently in operation.
3. Tri-axis antenna servo system at IMGEOs Development & Commissioning done in July 2022 for S/ X band tracking and data reception. Which is later upgraded to Tri band (S/X/Ka) under Advance R&D in 2023 for S/X/Ka band tracking and data reception from C03. It is currently in operation.

172.3 Our Capabilities

- a. Design, Modelling, Simulation and Analysis of Two axis and Tri axis Antenna Control Servo Systems for Satellite Ground stations
- b. Design formulation, Servo algorithm, firmware, hardware, software development, System Fabrication, Implementation, Integration, Testing, Tuning, Optimisation and Commissioning of Two axis and Tri axis ACSS systems for Ground stations

One of the ACSS developed and operationalized in the IMGEOs antenna terminal is exhibited in below figure.



Block diagram of the ACSS along with tri-axis antenna

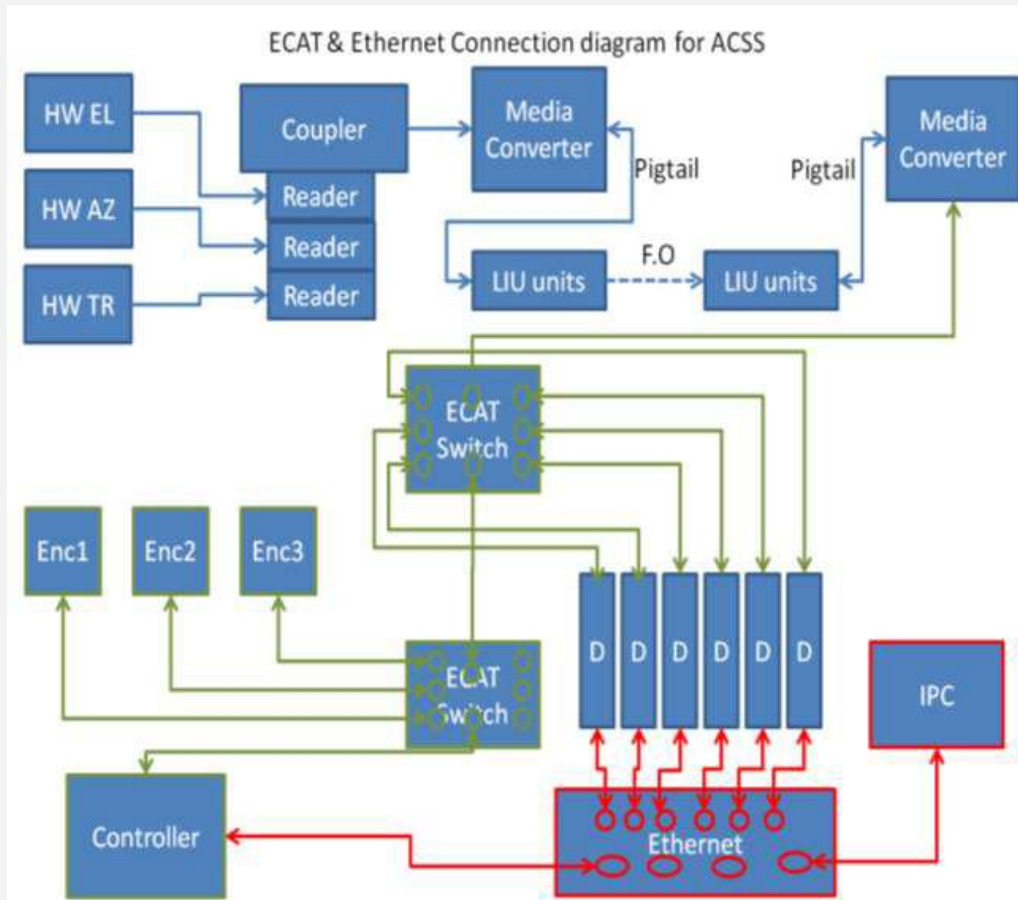
172.4 Salient features:

Tri axis Antenna control system was realized to meet the ka-band tracking accuracy requirements of 25 milli deg. - Use of On-axis encoder in Elevation axis to avoid data pick-off errors from SRB.

1. 7° Programmable tilt, axis and its control system.
2. Implementation of adaptive control in Power PMAC.
3. Optimum tilt axis orientation algorithm.
4. Antenna Control application software.
5. All axes with dual motor and dual drive control system to minimize back-lash.
6. Safety features/ limits in both software and hardware domains.

172.5 ACSS Interface diagram

The ACSS interface diagram in below figure shows how the different sub systems of ACSS are interconnected



ACSS interface diagram

172.6 Overall technical specifications of Tri-axis ACSS:

SL NO	Parameter	Description
1	Mount	Three axis, fully steerable EL over AZ over Train
2	Train axis tilt	70 Maximum programmable
3	Servo operating modes	Standby, Ready, Manual, Slew and Designate
4	Servo tracking modes	Program, S-Auto, XR-Auto, XL-Auto, Ka auto, Auto sequence
5	Type of Motor	Brushless AC servo motor with resolver feedback
6	Drive configuration	Dual drive in Counter-torque arrangement
7	Position Resolution	0.0010
8	Encoder Transducer	22 bit with SSI interface and hardware zeroing facility
9	Antenna Coverage limits	AZ $\pm 360^\circ$; EL -5° to $+185^\circ$; Train $\pm 180^\circ$
10	Position loop bandwidth	1.0 Hz typical
11	Maximum Velocity	15 $^\circ$ /sec in AZ, 6 $^\circ$ /sec in EL, 6 $^\circ$ /sec in Train.
12	Maximum Acceleration	6 $^\circ$ /sec ² in AZ, 3 $^\circ$ /sec ² in EL, 3 $^\circ$ /sec ² in Train.
13	Tracking accuracy	X band: 0.03 $^\circ$ Ka band :0.025 deg
14	Pointing accuracy	0.050
15	Operating wind velocity	60 KMPH

172.7 Tracking accuracies of the system as achieved detailed in below table:

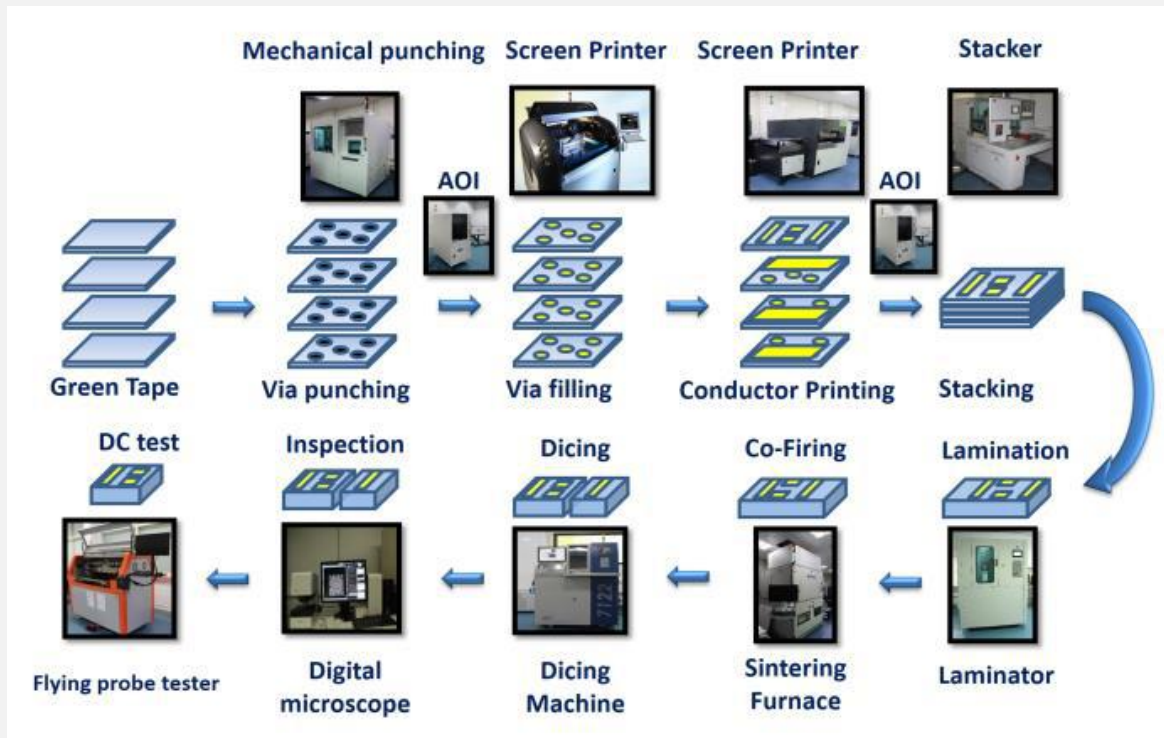
Date	Mission/ Orbit	Max EL of pass	AZ RMS (deg)	EL RMS (deg)	BRE (deg)	Remarks
09.08.2023	C03_20513	25.00	0.007	0.010	0.012	Ka-band tracking is good
30.08.2023	C03_20831	36.72	0.004	0.005	0.006	Ka -band tracking is good
31.08.2023	C03_20846	20.15	0.004	0.007	0.008	Ka -band tracking is good
01.09.2023	C03_20862	21.09	0.005	0.007	0.009	Ka -band tracking is good
08.09.2023	C03_20968	58.00	0.007	0.006	0.009	Ka -band tracking is good
13.09.2023	C03_21051	18.26	0.003	0.005	0.006	Ka -band tracking is good
14.09.2023	C03_21059	78.14	0.010	0.006	0.012	Ka -band tracking is good
15.09.2023	C03_21082	74.49	0.007	0.010	0.012	Ka -band tracking is good
15.09.2023	C03_21074	54.81	0.005	0.006	0.008	Ka -band tracking is good
26.09.2023	C03_21241	54.02	0.004	0.006	0.007	Ka- band tracking is good
06.10.2023	C03_21393	81.6	0.008	0.012	0.012	Ka -band tracking is good
03.11.2023	C03_21818	64.33	0.005	0.007	0.008	Ka -band tracking is good
04.11.2023	C03_21833	36.49	0.005	0.010	0.011	Ka -band tracking is good
05.11.2023	C03_21848	23.31	0.004	0.009	0.010	Ka -band tracking is good
05.11.2023	C03_21849	22.45	0.006	0.010	0.012	Ka -band tracking is good
06.11.2023	C03_21864	34.41	0.005	0.007	0.008	Ka -band tracking is good

Conclusion: The achieved Ka-band tracking accuracy is 15mdeg.

Note: ACSS can be designed and fabricated for two axis/ Tri-axis antenna control systems based on requirements.

173 LOW TEMPERATURE CO-FIRED CERAMIC (LTCC) MULTI-CHIP MODULE TECHNOLOGY

Space Applications Centre (SAC) of Indian Space Research Organisation (ISRO) has developed Low Temperature Co-Fired Ceramics (LTCC) Multi Chip Module (MCM) and package fabrication and assembly technology. SAC's LTCC foundry process is qualified for space use. Its Design Rule Check (DRC) and Process Design Kit (PDK) features are unique for any LTCC foundry, globally.



173.1 Salient Feature

1. Multi-layer heterogeneous integration platform
2. Embedded passives
3. Compatibility to eutectic and epoxy based bare die attach, wire bonding, SMD component soldering, brazing of metal parts
4. Patented Laser Hermetic Sealing process
5. Automated Design Rule Check (DRC) integrated with standard RF design software
6. Copy righted Process Design Kit (PDK)

173.2 Material

1. FerroA6MEbasedallGoldsystem
2. DuPont951basedallGoldsystem

173.3 Technical Specifications

Tile size	8" X 8 " (unfired)
Layer thickness	10 mil (unfired)
No. of layers	20 (max.)
Conductor width	75 micron \pm 10% (min.)
Via dimension	200 micron \pm 10% (unfired)
Via separation	2.5 X via-diameter (min.)
Type of Cavities	Stepped, blind, through
Min. cavity size	1 mm X 1 mm
Module size	50 mm X 50 mm (max.)

173.4 Technology Transfer from ISRO

SAC/ISRO offers to transfer LTCC technology to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may register and submit their proposal to IN-SPACE, Ahmedabad at www.inspace.gov.in

174 DK45 CERAMICS FOR RF & MICROWAVE APPLICATIONS

Dielectric ceramics are preferred for Satellite communications to miniaturization. These ceramics must show low dielectric loss (high Q-values), high relative permittivity (ϵ_r) and temperature stable dielectric properties. To fulfil these requirements, ceramics having higher relative permittivity ($\epsilon_r > 40$), maintaining high $Q_{xf} > 35,000$ and near-zero temperature-coefficient of frequency. DK45 is a solid solution mixed perovskite with attractive dielectric properties and can replace $\epsilon_r 36$ ceramics at almost all applications. DK45 ceramics can be realized effectively through solid state processing method used for technical ceramics using electronic grade oxide raw material powders that are safe to handle and available in India. Starting from raw materials, the process route involves preheating, mixing, calcination, milling, forming (compacting), sintering, machining (if required) and annealing.

Typical properties of bulk ceramics are shown below.

Bulk density (g/cc)	4.7 ± 0.1
Resistivity ($\Omega \cdot \text{cm}$)	$\geq 10^{12}$
Coeff. of Thermal Expansion ($10^{-6}/\text{K}$)	12.0
Dielectric constant (ϵ_r)	44 ± 1
Quality factor (Q_u @ 3 GHz)	$> 15,000$
Dielectric Loss factor ($\tan \delta$, 10^{-5} @ 4 GHz)	6.667
Temp. coeff. of frequency (τ_f , ppm/ $^{\circ}\text{C}$)	0 ± 5

174.1 APPLICATION AREAS:

Potential ceramic material for UHF to X bands of applications. In many established circuits using $\epsilon_r 36$ based ceramics, DK45 is a better replacement.

174.2 Technology Transfer from ISRO

VSSC/ISRO offers to transfer DK45 ceramics for RF & Microwave applications technology to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may register and submit their proposal to IN-SPACE, Ahmedabad at www.inspace.gov.in

175 Anodization of 3D printed Al-10Si-Mg alloy

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed anodization process on additively manufactured or 3D printed Al-10Si-Mg alloy for spacecraft thermal control applications. The process has been granted Indian patent.

175.1 Salient Features

This process on Al-10Si-Mg is carried out in mixture of sulfuric acid and oxalic acid electrolyte in both potentiostatic and galvanostatic mode process, at a temperature of 15-25 °C at a constant current density of 5-30 A/ft² or a constant voltage of 10-50 V with a DC power supply. The thickness of oxide layer formed is $\cong 15 \pm 5 \mu\text{m}$. The oxide coating processed in sulfuric acid-oxalic acid mixture exhibits high infrared emittance ($\epsilon_{\text{IR}} \geq 0.85$) and high solar absorptance ($\alpha_{\text{S}} \geq 0.90$). This indicates that oxide coating on AM Al-10Si-Mg alloy is tending to flat absorbers for better thermal control of spacecraft.



175.2 Specifications

Thickness of the anodic coating	15±5 μm
Thermo-optical properties	solar absorptance (α_{S}) ≥ 0.90 infrared emittance (ϵ_{IR}) ≥ 0.85
Nano hardness	2.5-3.0 GPa

175.3 Technology Transfer from ISRO

VSSC/ISRO offers to transfer DK45 ceramics for RF & Microwave applications technology to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may register and submit their proposal to IN-SPACE, Ahmedabad at www.inspace.gov.in

176 IMS -2 Bus (Indian Mini Satellite - 2 Bus)

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed IMS-2 mainframe bus technology to provide a platform for satellites with user defined payload. These satellites are envisaged to be launched on-board PSLV into a LEO sun-synchronous orbit with a design life of around 5 years.

176.1 Salient Features and Applications

1. This satellite is of weight class 450 kg with Mainframe bus weight of 300 ± 10 kg and Payload weight up to 150 ± 10 kg.
2. Single bus system with redundancy for all subsystems.
3. This class of satellite has attained high importance in various fields of applications with user defined payloads like remote sensing, space science, defence, technology demonstration for space application, Earth Observation Missions (EOM) for agriculture, forestry, geology, ocean & atmospheric monitoring, Hyper Spectral Imaging etc.

176.2 Major Specifications

Sub-System	Specifications
Structure	<ol style="list-style-type: none"> 1. Spacecraft Mass: 450 kg (Main frame cuboid ~ 300 ± 10 kg, Payload: ~ 150 ± 10 kg). 2. Main frame Bus: 1098 mm x 1118 mm x 615 mm. 3. Payload Module: User defined. 4. Compatible for PSLV load specifications
Propulsion	<ol style="list-style-type: none"> 1. Active Mono-propellant system with 25 kg fuel tank
Mechanism	<ol style="list-style-type: none"> 1. HOP actuator/Frangi bolt-based Deployment mechanism.
Thermal	<ol style="list-style-type: none"> 1. Passive thermal control with Augmented Heaters
BDH & SSR	<ol style="list-style-type: none"> 1. Integrated Baseband Data Handling (BDH) & Solid-State Recorder (SSR) system. 2. Maximum input peak rate (raw mode) from payload - 3.2 Gbps. 3. Maximum storage capacity of 2.8 Tbits with Flash based memory modules for payload.
OBC	<ol style="list-style-type: none"> 1. On Board Computer with HX 1750 Processor. 2. 8 MB on-board memory.
RF systems	<ol style="list-style-type: none"> 1. S-band TM transmitter & TC Receiver <ol style="list-style-type: none"> a. 64 Kbps/ 128 Kbps (Tx) b. 4Kbps, PCM/PSK/FM (Rx)

	<ol style="list-style-type: none"> 2. X-Band Data Transmitter <ol style="list-style-type: none"> a. Data rate up to 960 Mbps with 8PSK modulation 3. SPS Receiver <ol style="list-style-type: none"> a. 12-channel Multi GNSS Receiver (MGR) at L1 and L5 frequencies b. Data Transmitting antenna is Dual-Gimballed Antenna.
AOCS	<ol style="list-style-type: none"> 1. Pointing accuracy: $\pm 0.1^\circ$ (3σ) on all 3 axes. 2. Drift Rate: $\pm 5.0 \times 10^{-4} \text{ }^\circ/\text{s}$ (3σ). 3. Three axes stabilized with high-torque reaction wheels with 15Nm and 0.3Nm torque capability. 20 A-m2 Magnetic torquers for attitude control & momentum dumping. 4. Sun & Star sensors / Magnetometers for sun pointing and for safe attitude control.
Power Systems	<ol style="list-style-type: none"> 1. SA Power generation of 700 W at EOL, with 2 panels on each side of size 1.2 m x 0.81 m. 2. Single Li-ion Battery (67 Ah) tied bus system with Raw bus voltage of 30 to 42V. 3. Mainframe load: ~ 300W. 4. MIL1553B based TMTC Interface
Payload	<ol style="list-style-type: none"> 1. Payload Mass: 150\pm10 kg. 2. Payload Power support upto 300W. 3. Payload module is mechanically independent.

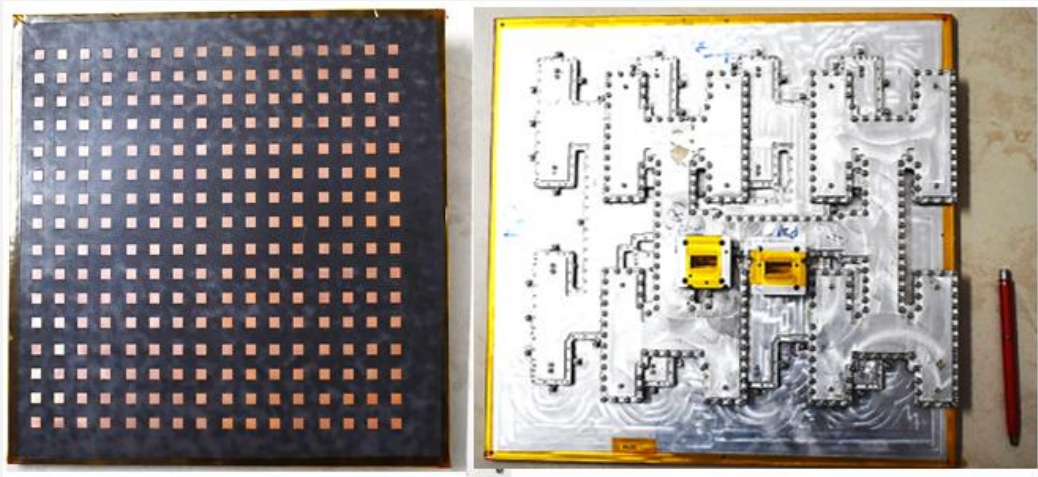
176.3 Technology Transfer from ISRO

URSC-ISRO offers to transfer IMS-2 BUS technology to industries in India with adequate experience and facilities. Industries interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities. Enterprises interested in obtaining knowhow may register and submit their proposal to IN-SPACE, Ahmedabad at www.inspace.gov.in

177 Ku Band Flat Panel Patch Array Antenna

The Ku Band Flat Panel Patch Array Antenna is a Ku-band SOTM (Satcom on the Move) antenna. It is a satellite communication antenna designed to provide real-time data connectivity while the vehicle, vessel, or platform is in motion. It is designed for the broadband frequency range of operation (10.7GHz - 13.25GHz) which operates over a 25% frequency bandwidth for both the linear polarizations.

SOTM antennas have a broad range of technology applications across various industries. These antennas are commonly used in applications such as military communication, maritime communication, emergency services, and remote work in vehicles or trains. With their ability to offer consistent, high-speed data transfer while on the move, KU-band SOTM antennas enable seamless communication across remote, dynamic environments, transforming the way we stay connected.



Antenna Top Layer

Antenna Integrated with Waveguide Feeder Network

Antenna Specifications	
Antenna Size	340mm X 340mm
Transmit (Tx) Gain	~ 29dBi
Receive (Rx) Gain	~ 28dBi
Tx Frequency Band	12.75 – 13.25 GHz
Rx Frequency band	10.7 – 11.45 GHz
Polarization	Dual Linear

177.1 Technology Transfer from ISRO

SAC/ISRO, offers to transfer this technology of the **Ku band Flat Panel Array Antenna** designed by SAC to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may register and submit their proposal to Indian National Space Promotion & Authorization Centre (IN-SPACE), Ahmedabad.

<https://www.inspace.gov.in>

178 Ka-band Flat Panel Meta-Surface Antenna

Space Applications Centre (SAC) has developed an integrated Ka Tx-Rx flat panel meta surface antenna (MSA) for HTS ground terminals. The design of the MSA employs microwave holography, extensive tensor mathematics and metamaterial concept to achieve novel properties.

The developed MSA consists of periodic sub-wavelength elements distributed along the aperture. Based on the requirements, the shape, size, and orientation of these sub-wavelength elements are varied to obtain diverse radiation characteristics.

The developed MSA is extremely low profile and lightweight as it only utilizes a thin RF laminate. The feeding mechanism of the MSA is exceptionally simple as it is fed via a single probe at the center, thereby avoiding complex and lossy feed networks.

The developed MSA offers high gain and low axial ratio which is essential for point-to-point communication. The developed MSAs are mounted on a metallic baseplate and enclosed by an RF transparent radome.

178.1 Application

1. Ka-band HTS ground terminal
2. SOTM system
3. mm-Wave 5G and future 6G applications
4. Space applications such as inter satellite links (ISL), micro-satellite etc.

178.2 Specifications

Sr. No.	Parameter	Unit	Value	
			Ka-Rx	Ka-Tx
1	Operating Frequency Band	GHz	19.8 – 20.4	29 – 29.6
2	Return Loss	dB	≥10	≥10
3	Polarization	-	LHCP	RHCP
4	Gain over the Band	dBi	≥30	≥29
5	Peak Gain	dBi	32.3	29.8
6	Axial Ratio at Boresight	dB	≤1	≤1
7	3dB Beamwidth at Center Frequency	deg	~2.65	~2.75
8	Radome Loss	dB	~0.6	~1.1
9	Size	mm	580 x 370 x 50	
10	Mass	kg	~5.5	

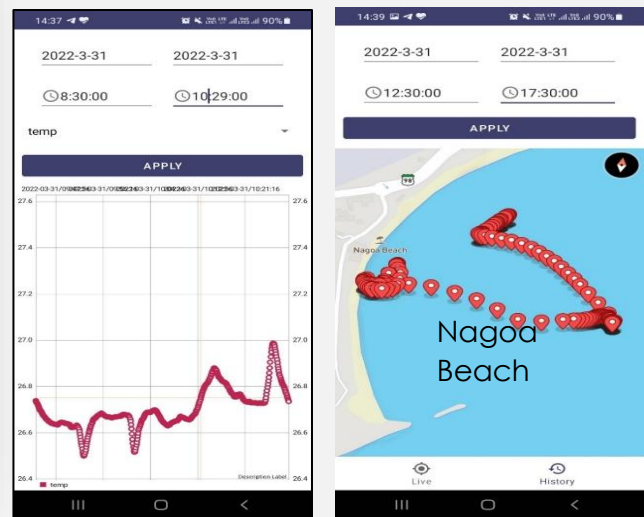
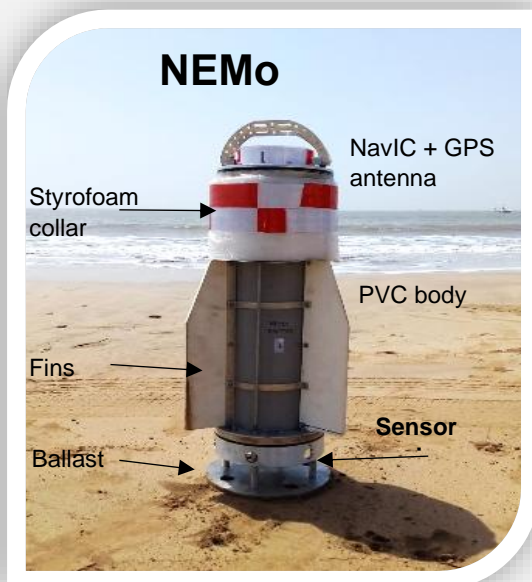
178.3 Technology Transfer from ISRO

SAC/ISRO, offers to transfer this technology of the **Ka-band Flat Panel Meta-Surface Antenna** designed by SAC to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may register and submit their proposal to Indian National Space Promotion & Authorization Centre (IN-SPACE), Ahmedabad.

<https://www.inspace.gov.in>

179 NavIC based Environmental Monitoring (NEMo) Drifter

Space Applications Centre (SAC) has developed NavIC based Environmental Monitoring (NEMo) Drifter. It is an innovative application of IRNSS (NavIC) equipped with miniature water quality sensors to measure key environmental parameters in the surface waters of wide marine environments like beaches, canals, rivers, estuaries, lakes, lagoons, reservoirs etc., where such kind of observations are very important and less studied. The NEMo drifter with real-time transmission capability via internet/radio/satellite, visualization via web server/app interface, would be a unique floating laboratory and help in understanding various complex physical and chemical processes of marine or coastal environment with minimal efforts. NEMo drifters are helpful in measuring important water quality parameters like temperature, pH, salinity, dissolved oxygen, turbidity, along with surface water currents and position in any marine environment for wide variety of applications including:



Android App Interface

179.1 Application Area

1. Rip currents identification
2. Bathing water quality in beaches
3. Search & Rescue operations
4. Bloom tracking & Beach Nourishment effects
5. Coastal research etc.

179.2 Specifications

1. Plug & Play device.

2. Rugged Mechanical design with no moving parts from off-the-shelf and readily available PVC material.
3. Low-cost Atlas Scientific® water quality sensors (user optional).
4. Data is stored in microSD card and can be downloaded after retrieval.
5. Uses 3G/4G Internet service for real-time transmission of data.

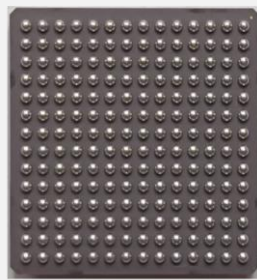
179.3 Technology Transfer from ISRO

SAC/ISRO, offers to transfer this technology of the **NavIC based Environmental Monitoring (NEMo) Drifter** designed by SAC to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may register and submit their proposal to Indian National Space Promotion & Authorization Centre (IN-SPACe), Ahmedabad.

<https://www.inspace.gov.in>

180 Low Power NavIC / GNSS Baseband ASIC Receiver

Space Applications Centre of ISRO has designed and developed NavIC + GNSS Baseband ASIC (NavASIC V3) to cater the navigation requirements of various ground and airborne applications with low power and small form factor. Memory based code generator up to 10230 length is implemented to support existing and futuristic signals. The ASIC supports All-in-view open GNSS signals including all open NavIC signals through 12 acquisition engines and 100 tracking channels. It has 32-bit dual core processor IP clocked up to 540 MHz along with several peripherals for various applications. The chip is developed with optimized power, performance and area (PPA). The ASIC also offers anti-jamming and anti-spoofing features.



Credit Card size Receiver Module
(57mm x 68mm)

S/N	Parameter	Specifications
1.	ASIC type & node	Digital Baseband ASIC (with on-chip PLL)
Performance and Features		
2.	Supported constellations	All NavIC signals, GPS, Galileo, GLONASS, Beidou, SBAS, QZSS Along with Pulsed CDMA Signal Support
3.	Acquisition and Tracking Channels	4 Acquisition Engines with 2046-tap correlators and 8 Massive Acquisition Engines with 10230-tap correlators 100 Nos. of Tracking Channels
4.	Sensitivity	Acquisition: 25 dB-Hz Tracking: 22 dB-Hz
5.	TTF	Cold Start < 60 seconds (open sky, combined solution) Re-acquisition < 6 seconds (open sky, combined solution)
6.	Observables	Code and Carrier Phase
7.	Other Features	CW and Pulse Interference Mitigation Navigation Message Authentication
On-chip Processing Capability		
8.	On-chip CPU and Memory	Dual Core 32-bit Processor with 4 Mb SRAM and FPU
9.	Configurable Processor Clocks	180/300/420/540 MHz
Interfaces		
10.	Digital IF ADC Input Width	8-bit/5-bit/2-bit configurable
11.	External Clocks	20 or 56-65 MHz ADC Sampling Clock

		16/20 MHz PLL reference clock
12.	Number of ADC Inputs for Digital IF	4 Nos. of 8-bit input OR 8 Nos. of 2-bit input OR 4 Nos. of 5-bit input ADC Inputs are Configurable for various modes
13.	Data Interfaces	UART, SPI, I2C, MIL-1553, GPIOs
14.	Timing	1-PPS IN and 1-PPS OUT
Physical and Electrical Characteristics		
15.	No. of Functional & Total IOs	130, 196
16.	Core & IO Voltage	0.9V, 3.3V
17.	Power	0.2-0.7W*
18.	Package	Hermetically Sealed Ceramic Flip-chip BGA
19.	Die Size	6.5mm x 6.5mm
20.	Package Size	15mm x 15mm
*Average Power measured in various modes in lab environment.		

180.1 Applications

1. Low power Handheld Terminals, Vehicle Tracking Systems, Timing Applications, Asset Tracking
2. Real-Time Aircraft and Launch Vehicle Tracking.
3. GAGANYAAN Crew module tracking & other short-life LEO missions
4. Supports low and high dynamics applications with upto velocity of 10 km/sec, acceleration: 40 m/s², Jerk 13.5 g/s
5. Either NMEA (default) or RTCM output is supported.

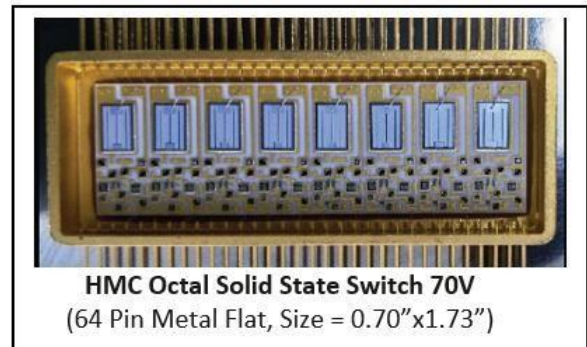
180.2 Technology Transfer from ISRO

SAC/ISRO, offers to transfer this technology of the **Low Power NavIC / GNSS Baseband ASIC Receiver** developed by SAC to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may register and submit their proposal to Indian National Space Promotion & Authorization Centre (IN-SPACE), Ahmedabad.

<https://www.inspace.gov.in>

181 Octal Solid State Switch HMC

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed Octal Solid State Switch HMC to meet Electrical performance with High Reliability requirements for Space Application with minimum size and weight.



181.1 Salient Features

- Eight isolated P-Channel MOSFET based Solid State Switches for Heater switching.
- Each switch can handle maximum of 50W load and HMC totally can be used for up to 275W of heater load.
- HMC can be used for Pulse switching also.
- Parallel capacity of switches for the increased heater load.
- Either NMEA (default) or RTCM output is supported.
- Meets Electrical performance with High Reliability requirements for Space Application.
- Meeting derating requirement as per ISRO standard.
- All discrete semiconductor devices (in unencapsulated die form) used are compliant to JANKC (Class-K) as per MIL-PRF-19500.
- Hybrid design and fabrication processes comply to ISRO-PAS-206 guidelines.
- Thick film process technology adopted for realisation of the HMC.
- Housed in a 64 pin metal flat package with 50mil pin pitch.

181.2 Major Specifications

- Raw bus Voltage V_{RB} : 26-42V / 42V-72V
- Input drive using +5V.
- Output Voltage: $V_{RB} - 0.5V$ @ Full load.

- Isolated eight switches with individual switch can handle up to 50W of heater load (Typical 42V-1.1A or 70V-0.7A).
- HMC can be used for up to 275W of heater load.
- Switching function by P-Channel Rad Hard MOSFET up to 100kRad
- Meet EMI requirement of ISRO Standards (based on MIL-461C)
- Operating Temperature Range: -55°C to 125°C.
- Hermetically sealed 64 Pin KOVAR Flat Package with Au plating meeting the leak rate of 5×10^{-8} atm- cc/sec of He
- Package Size: 0.705"x1.730"x0.210".
- Weight: <14 gm.

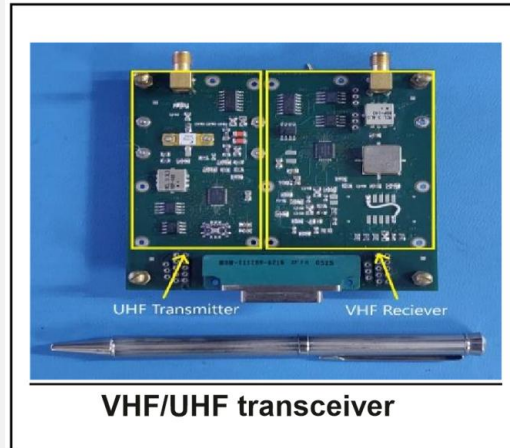
181.3 Technology Transfer from ISRO

URSC-ISRO offers to transfer technology of Octal Solid State Switch HMC developed by URSC to industries in India with adequate experience and facilities. Industries interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities.

<https://www.inspace.gov.in>

182 VHF-UHF TRANSCEIVER

U R Rao Satellite Centre (URSC) of Indian Space Research Organisation (ISRO) has developed a miniaturized VHF/UHF transceiver using System on Chip (SoC) for application in nanosatellites. This scheme provides the functionality of both transmission and reception of data.



182.1 Salient Features

- Both transmission and reception of the data in a single standard PC-104 card.
- Low mass (~120 grams)
- Applicable to nanosatellites

182.2 Major Specifications

S/N	VHF Receiver Specifications	
1.	Frequency	148-150 MHz
2.	Frequency resolution	1 KHz
3.	Modulation	FSK
4.	Doppler	±4 KHz
5.	Data Rate	1.2 Kbps
6.	Sensitivity @ 1.2 Kbps	Better than -110 dBm for BER of 10 ⁻⁵
7.	Dynamic Range @ 1.2 Kbps	-110 dBm to -80 dBm or wider
8.	Noise Figure	5dB max.
9.	DC Power	<100 mW
10.	Voltage	+3.3 V ± 5% 10mA

S/N	UHF Transmitter Specifications	
1.	Frequency	435-438 MHz
2.	Frequency resolution	1 KHz
3.	Modulation	FSK
4.	Data Rate	1.2 Kbps
5.	RF output Power	10dBm.
6.	Frequency stability	±3 ppm
7.	Spurious	<-50 dBc
8.	Harmonics	<-30 dBc

9.	DC Power	<100 mW
10.	Voltage	+3.3 V

182.3 Technology Transfer from ISRO

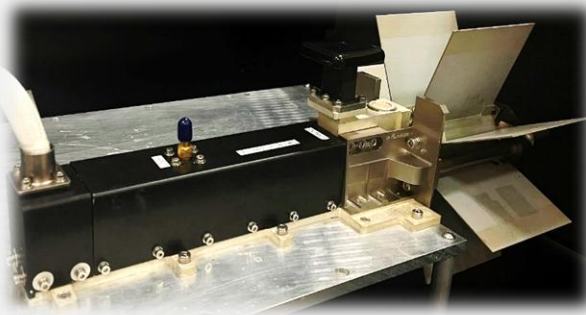
URSC-ISRO offers to transfer this technology of VHF-UHF Transceiver to industries in India with adequate experience and facilities. Industries interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities.

<https://www.inspace.gov.in>

183 Space Grade Traveling Wave Tube

Space Applications Centre (SAC) has successfully developed Traveling Wave Tube (TWT) and qualified for space application. The TWT is the most efficient of the existing High Power Amplifier technologies available for space application. The technology is highly guarded and globally only few vendors supply TWTs for space application.

The TWT mainly consists of 4 sub-assemblies namely- Electron Gun, Slow Wave Structure (SWS), Periodic Permanent Magnet Stack (PPM) and Collector. The electron gun emits an electron beam which interacts with RF in SWS and transfers the energy to RF to provide amplified RF output. The remaining energy in the beam is collected in the collector.



Space Grade Traveling Wave Tube



Piece-parts of TWT

More than 25 different materials, 20 different processes are involved in the development. The TWT is an assembly formed by brazing/welding of 250 piece parts with more than 100 leak-proof joints. Requires very high precision in piece parts fabrication & alignments using specially designed jigs during subassembly & assembly level brazing.

The assembly is processed to create Ultra High Vacuum (UHV) of 10^{-10} mbar in it. The UHV processed TWT goes through rigorous tuning, testing, Burn-in for 6 months to be ready for packaging. The yearly production capacity is dependent on the availability of no. of TWT test power supplies.

The technology is generic across the frequency bands - L to Q bands and out power. The jigs and piece parts change from design to design however the whole infrastructure can be used across the designs.

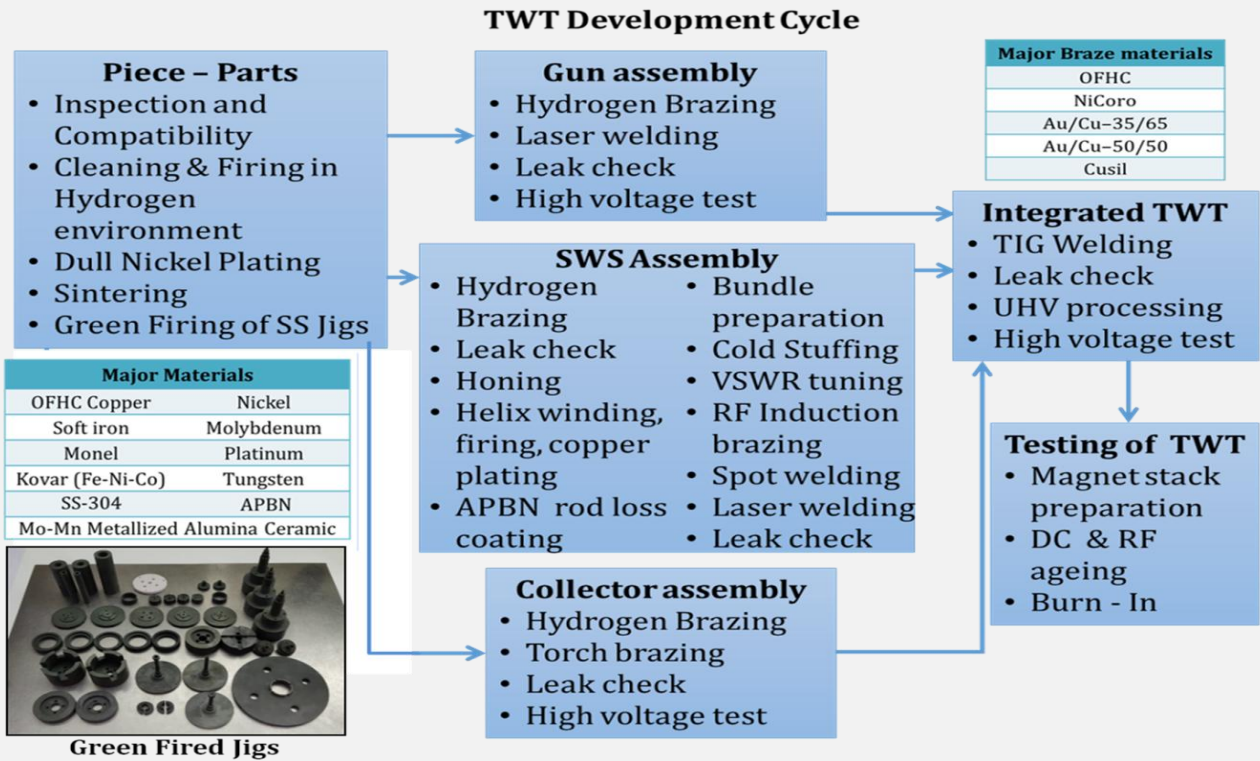
183.1 Applications area

The TWTs will be integrated with respective EPCs to be used as Traveling Wave Tube Amplifier (TWTA) in satellite payloads. For a typical 24-transponder communication payload, 30 TWTA are required.

Project Linkage : All Future communication payloads

183.2 Specifications:

TWTs in frequency bands ranging from L to Q band at various power levels (40 - 440 W)



183.3 Technology Transfer from ISRO

SAC/ISRO, offers technology transfer of the **Space Grade Traveling Wave Tube** developed by SAC to potential industries in India. Enterprises meeting the following pre-requisites and interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities.

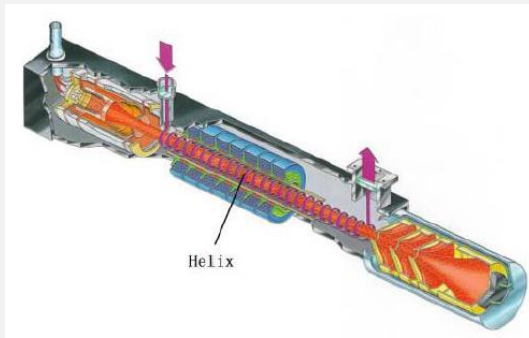
Pre-requisites

1. Indian company registered for development of space/defense/aerospace electronics.
2. Availability of Permanent manpower with requisite qualifications (B. E.: Mechanical, Metallurgy and ECE, Diploma: ECE, ITI: welder, Fitter, Electronics, Instrument)
3. Financially stable and solvent company (in view of long realization time of technology)

<https://www.inspace.gov.in>

184 Copper Plating Procedure on Tungsten-Rhenium helix for TWTA

Space Applications Centre (SAC) has developed a Copper Plating procedure on helix made of Tungsten-Rhenium to improve efficiency of Traveling Wave Tube Amplifier (TWTA).



Copper Plated Helix

184.1 Applications

Helix is a key component of TWTA, which is widely used in radar, communication satellites etc. and is conventionally made of tungsten or its alloy. Tungsten being low conductor of electricity leads to power losses during amplification in TWT.

Coating the helix surface with copper reduces the insertion losses during amplification process which significantly leads to improvement in efficiency/output power of TWTA.

184.2 Specifications:

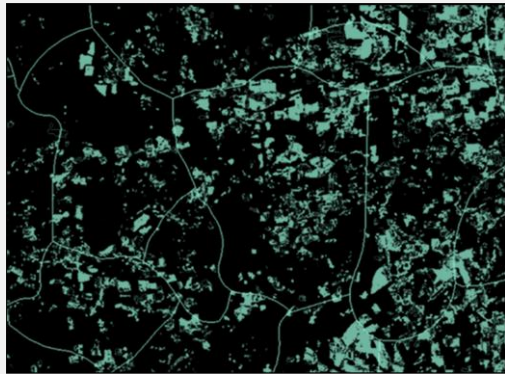
Parameter	Unit	Value
Base Material	-	Tungsten/Tungsten-Rhenium
Thickness	µm	4 - 6
Can Sustain Temperature	°C	550
Can Sustain Pressure	torr	10 ⁻¹⁰

184.3 Technology Transfer from ISRO

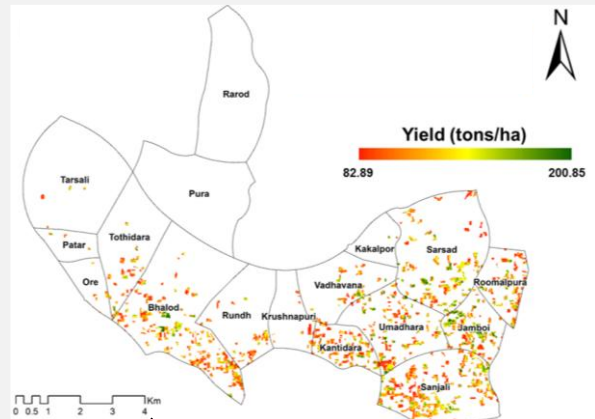
SAC/ISRO, offers to transfer this technology of the **Copper Plating process on Tungsten-Rhenium helix for TWTA** developed by SAC to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may write giving details of their present activities, infrastructure and facilities.

<https://www.inspace.gov.in>

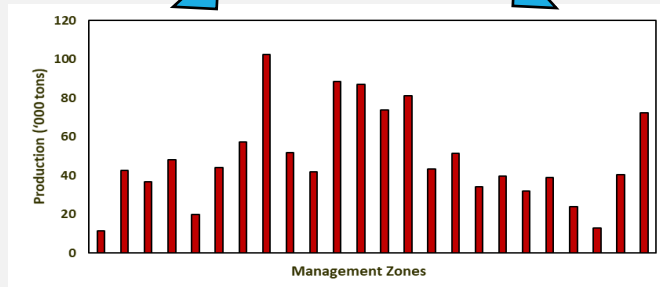
185 Algorithm for Sugarcane Crop Production Estimation



ACREAGE



YIELD



Zonal Production

185.1 A Technique for Sugarcane crop production Estimation at mill catchment level

The sugarcane industry in India holds the second position globally, contributing approximately 19% of the world's sugar production and 15% of global consumption. With over 524+ operational sugar mills across India, including 250+ mills in cooperative structures, the industry relies heavily on timely and accurate information about sugarcane for efficient management. Farmers receive remuneration based on cultivated area, regulated by the mill's profit or loss, while the Fair and Remunerative Price (FRP) is determined by the Commission for Agricultural Costs and Prices (CACP). Prior knowledge of sugarcane crop health and production is essential for effective harvest planning and profit maximization. Remote sensing data offers valuable insights when coupled with various modeling techniques, including empirical and machine learning approaches.

185.2 Remote Sensing Applications area:

The algorithm was developed over Gujarat and Maharashtra utilizing multi-date

optical and Synthetic Aperture Radar (SAR) data for sugarcane crop mapping and yield modelling in the cooperative sugar mill catchment areas. The findings demonstrate the effectiveness of this approach for generating accurate crop area and yield maps. Results indicated strong predictive capabilities, sugarcane crop classification accuracies of >85% have been obtained utilizing AI/ML based models. Also mill-level production forecasting has been done with less than 10% deviation from reported production.

The following are the offerings:

- Algorithm for sugarcane crop area identification
- Algorithm for sugarcane yield estimation

185.3 Technology Transfer from ISRO

SAC/ISRO, offers to transfer this technology of the **Algorithm for Geospatial Sugarcane Crop Production Estimation** developed by SAC to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may register and submit their proposal to Indian National Space Promotion & Authorization Centre (IN-SPACe), Ahmedabad.

<https://www.inspace.gov.in>

186 Ceramic Adhesive (BMV-BOND)

BMV-BOND is a novel pre-ceramic adhesive comprising of a preceramic polymer (methylvinylborosiloxane-BMV) as the binder resin and ceramic fillers as reinforcement. The adhesive can be processed at 175°C and can be used for repair works of graphite, C/C and C/SiC composites for high temperature applications (up to 1650°C). The adhesive undergoes in-situ polymer to ceramic conversion during actual operations at high temperatures to form mixed oxide and non-oxide ceramics.

As on-site bonding of substrate structures of any size and shape is possible by localized heating the adhesive can be used for joining structures of any size or shaper easily which make the fabrication process cheaper. The adhesive can also be used a sealant or crack repair material, can be used in vacuum or oxidizing environment.

186.1 Applications

High temperature adhesive for joining C/C, C/SiC and graphite materials and for sealing he cracks on the above substrates which improves the service life of the above materials.

186.2 Technology Transfer from ISRO

VSSC/ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs/industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below.

<https://www.inspace.gov.in>

187 CERACURE 10A

Ceracure 10A is a polymeric precursor for the preparation of stoichiometric silicon carbide. Ceracure 10A can be used for the preparation of high temperature ceramic matrix composites, ceramic coatings, ceramic adhesives, light weight ceramics etc.

187.1 Applications

Ceracure 10A can find applications in the field of aerospace, automobile and electronic industries.

187.2 Technology Transfer from ISRO

VSSC/ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs/industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below.

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188 C/SiC Fasteners for High Temperature Applications

Carbon fiber reinforced silicon carbide (C/SiC) based M8 fasteners are useful for high temperature assembly applications. The C/SiC fasteners are realized by isothermal-isobaric chemical vapour infiltration (CVI) process with progressive densification and machining to the profile of M8 fasteners.

Being lightweight with high specific strength and retention of thermo-mechanical properties up to 1650°C, these fasteners are reliable for high temperature joints required in the re-entry missions of ISRO. The C/SiC fasteners is preferred for such joint assembly applications since it exhibits low thermal expansion resulting in minimal dimensional change at high temperatures. This aids in no loss of joint preload at high temperatures up to 1650°C. C/SiC fasteners allow for the detachable joining of large-scale ceramic structural components, facilitating inspection and overhauling that permanent bonding (like brazing) cannot provide.

188.1 Applications

C/SiC fasteners find applications in defense and aerospace industries such as fastening of carbon-ceramic brake components, exhaust nozzles, turbine guide vanes and thermal protection system, as it ensures weight reduction of joint and dimensional stability of components during thermal cycling. C/SiC fasteners are utilized for fastening applications in high-temperature materials test rigs as well as oxidation, ablation, thermal cycling setups for advanced materials research and test facilities. C/SiC fasteners can also be used in the advanced power generation industries for fastening applications in the industrial high-temperature heat exchangers and furnaces, kiln baffles, ceramic liners and shrouds. Owing to their long-term durability in offering chemical inertness in corrosive environments, the C/SiC fasteners find extensive applications in chemical and petrochemical process industries for joint assembly applications in high-temperature catalytic beds and corrosive gas handling systems.

188.2 Technology Transfer from ISRO

VSSC/ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs/industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below.

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189 DK-30 Ceramic

High-dielectric and low-loss ceramics are preferred for Filters, Oscillators, Duplexers, Multiplexers etc. in RF and Microwave communication systems. Such ceramics are preferred for Satellite systems for miniaturisation of devices. Many challenges are involved in making ceramics with low dielectric loss (or high Q-values), high relative permittivity (ϵ_r) and small temperature coefficient at microwave frequencies. For example, a typical narrow-band filter working in S-band using ceramic dielectric resonators may need relative permittivity ($\epsilon_r > 30$), high $Q \times f > 50,000$ and near-zero temperature-coefficient of frequency ($\tau_f < 10$ ppm/K). DK30 is a complex perovskite with very good dielectric properties for applications in S, C and X bands. DK30 ceramics can be realized industrially through solid-state processing used for technical ceramics starting from electronic grade oxide / carbonate raw material powders that are safe to handle and available in India.

Bulk density (g/cc)	7.6 ± 0.1
Resistivity (Ω.cm)	≥ 10¹¹
Coeff. of Thermal Expansion (10⁻⁶/K)	8-12
Dielectric constant (ϵ_r)	30 ± 1
Quality factor (Q_{uxf} @ 4.5 GHz)	> 100,000
Dielectric Loss factor ($\tan\delta$, 10⁻⁵ @ 4.5 GHz)	< 4.0
Temp. coeff. of frequency (τ_f, ppm/K)	0 ± 5

189.1 Salient Features

- Low dielectric loss (high Q-values), high relative permittivity (ϵ_r) and temperature stable dielectric properties
- Potential ceramic for microwave applications

189.2 Applications

Potential ceramic material for UHF to X bands of applications as dielectric resonator, dielectric substrate, antenna etc.

189.3 Technology Transfer from ISRO

VSSC/ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs/industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below.

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190 HEMSICOT

Silica based ceramic coating on flexible/rigid silica felt- HEMSICOT is for the preparation of Silica based ceramic coating formulation which gets converted to silica by curing at room temperature for 48 hours.

190.1 Applications

- Ceramic formulation can be used as high temperature coating (upto 1000°C) over silica based felts, blankets/metals/polymers.
- Find applications in the field of aerospace, high temperature ovens and furnaces, and automobile industries.

190.2 Technology Transfer from ISRO

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191 Methylvinylborosiloxane (BMV)

Silica Methylvinylborosiloxane (BMV) is one such resin used for fabrication of fiber reinforced ceramic matrix composites by Polymer Infiltration Pyrolysis (PIP) route.

191.1 Applications

- Can be used for fabrication of ceramic matrix composites, ceramic coatings and lightweight ceramics.
- Can be used as a precursor for C/SiBOC & C/SiC CMC which find application in high temperature area for aerospace, defense and tribological applications.

191.2 Technology Transfer from ISRO

VSSC/ISRO is willing to offer the knowhow of this technology to suitable entrepreneurs/industries in India. Capable manufacturing industries interested in acquiring this knowhow may write with details of their present activities, requirements and plans for implementation, infrastructure and technical expertise available with them, their own market assessment, if any, and plans for diversification to the address given below.

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192 Ku Band ALC Channel Amplifier

The Ku ALC Channel Amplifier (CAMP) is one of the important subsystem used in Ku band communication payload. Channel amplifier used to provide required input drive to Ku band Traveling Wave Tube Amplifier (TWTA). Channel amplifier unit is also equipped with step attenuators for controlling the transponder gain through tele-command from the ground. Ku band CAMP have a nominal gain of ~ 60 dB and output power ~ 6 dBm.

192.1 Design

CAMP consists of indigenous developed broad band RF MMIC amplifiers and digital attenuators. The CAMP have capability to be operated either in Automatic Level Control (ALC) mode or Fixed Gain Mode (FGM) by ground command. CAMP have a digital TM output to know the status of present mode of operation. It has Analog telemetry to indicate approximate operating condition of transponder in FGM mode and in ALC mode. Unit dimension is 75mmx119mmx29mm.

ALC CAMP can provide very high dynamic range of 30 dB in fixed gain mode (FGM) and Automatic Level Control mode (ALC), to meet the requirements of linearity (IMD3), noise figure and input over drive. SAC developed Ku-band ALC channel amplifier consists of two main parts: RF circuit and supporting bias & control circuits. RF circuits consists of MMIC based RF amplifiers, Voltage variable attenuators and digital attenuators. An equalizer is used to achieve gain flatness over the frequency range. The supporting circuits provide supply and control voltages to the RF circuits.

192.2 Key Specifications

SN	Parameters	Unit	Spec
1	Frequency Band	GHz	10.7 – 11.3
2	Operation mode		FGM and ALC
3	Output Power ALC	dBm	+6 ± 1.0
4	Gain (FGM)	dB	50 ± 1.0
5	Temperature Stability	dB	≤ 0.8
6	Gain Flatness	dB	≤ 2.0
7	Gain Flatness over any 40 MHz	dB	≤ 0.3
8	Commandable gain control	dB	0 - 30
9	Commandable gain control in ALC	dB	0 -15
10	Two Tone IMP @ -27 dBm, 30 dB FCA	dBc	≤ -25

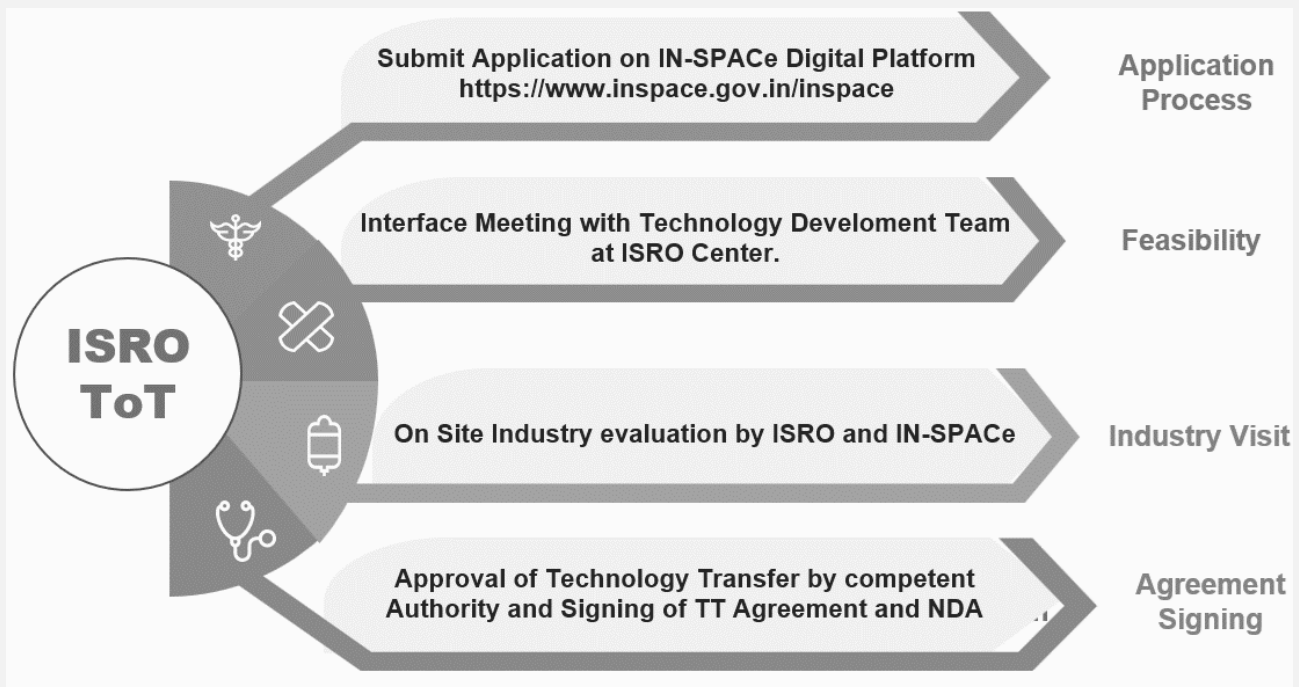
11	Input / Output Return loss	dB	≥ 17
12	In-Band Spurious	dBc	< -60
13	Harmonic power level	dBc	≤ -25

192.3 Technology Transfer from ISRO

SAC-ISRO, offers to transfer this technology of the **The Ku ALC Channel Amplifier (CAMP)** developed by SAC to industries in India with adequate experience and facilities. Enterprises interested in obtaining knowhow may register and submit their proposal to Indian National Space Promotion & Authorization Centre (IN-SPACE), Ahmedabad.

<https://www.inspace.gov.in>

General Technology Transfer Process



Contact Address:

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IN-SPACE Headquarters
Department of Space,
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Bopal-Shilaj Road,
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