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TECHNOLOGY OFFERS FROM ISRO FOR KNOW HOW TRANSFER TO INDUSTRIES
TECHNOLOGY TRANSFER & INDUSTRY COOPERATION

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FILM ADHESIVE EFA 4330
(STRUCTURAL ADHESIVE FOR HONEYCOMB SANDWICH FABRICATION)

EFA 4330 is a adhesive developed by Indian Space Research Organisation at its Vikram Sarabhai Space Centre. Film adhesives are widely used for fabrication of honeycomb sub-structures both metallic and composite type. They find extensive application in aerospace due to light weight and the high strength offered to the joint. They can also be used in shipping and boat manufacturing industry for fabrication of sandwich structures and other composite assemblies.

SALIENT FEATURES

- Accommodate vehicle sway of ±1mm
- One-component, heat curable, toughened, high strength polymer film adhesive
- Heat curable (175°C & 125°C type)
- Ensures filleting (pore filling) during curing, leading to very high bond strength in honeycomb sandwich.
- Space qualified

<table>
<thead>
<tr>
<th>Properties</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness, µ</td>
<td>100 ±10</td>
</tr>
<tr>
<td>Areal density (gsm)</td>
<td>180 ±10 &amp; 100±10</td>
</tr>
<tr>
<td>Lap shear strength at 25°C (Al/Al), MPa</td>
<td>32 – 34</td>
</tr>
<tr>
<td>LSS at 100°C (Al/Al), MPa</td>
<td>26 – 28</td>
</tr>
<tr>
<td>LSS at-196°C(Al/Al), MPa</td>
<td>26 – 28</td>
</tr>
<tr>
<td>LSS after Humidity Exposure (Al/Al, MPa)</td>
<td>28 – 30</td>
</tr>
<tr>
<td>Honeycomb Flat wise tensile strength at 25°C , MPa</td>
<td>4.5 – 5</td>
</tr>
<tr>
<td>TML</td>
<td>0.642</td>
</tr>
<tr>
<td>CVCM</td>
<td>0.026</td>
</tr>
</tbody>
</table>

Schematic of Film adhesive bonding in Honeycomb fabrication
Indian Space Research Organisation at its Vikram Sarabhai Space Centre (VSSC) has developed a number of specialty coatings to meet the specific requirements in Launch Vehicles and Satellites. These coatings may also find various industrial applications. One such coating system is HESC-29.

HESC 29 is a special coating system developed as a high temperature resistant enamel coating. This coating finds application as a high solar emissive topcoat on polymer composite surfaces. It is also used as a high emissive and thermal insulative coating on the PCB sensor cards for specific applications. This room temperature curable, silicone based coating system contains special inorganic fillers, which imparts high emissivity to the system. It can withstand temperatures in the range of 80 to 280°C. ISRO requires about 30 to 50kg of this compound per annum. Other applications of HESC-29 include anticorrosion and weather/ rain proof coating on metallic/ composite substrates. The coating is weather and high temperature resistant and lasts long. It is a two-part resin system. When the two parts are mixed together and coated, curing takes place at ambient conditions. It can be easily coated/brushed on any substrates.

Typical Properties / Characteristics:

<table>
<thead>
<tr>
<th>Part A</th>
<th>White, viscous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part B</td>
<td>Transparent liquid</td>
</tr>
<tr>
<td>Ford cup viscosity (Ford cup No. B 4)</td>
<td>20-40 sec. after diluting with toluene</td>
</tr>
<tr>
<td>Adhesion tape test</td>
<td>No peeling from substrate.</td>
</tr>
</tbody>
</table>
MDA is a low density ablative composite developed for providing effective thermal protection to a re-entering space capsule, under moderate heat flux conditions (10-40 W/cm²). MDA, bonded to the Carbon Fibre Reinforced Plastics (CFRP) and aluminium substrates has been successfully used as thermal protection system (TPS) for the base region of the first Space Capsule Recovery Experiment. This proprietary TPS is based on an ablative polymer, reinforcing fibre and micro-balloon fillers, mixed in a specified composition and cured under controlled compaction to achieve the required density (Final cure temperature: 180°C). This composite will be machined to the design requirements and bonded to the aero thermo structure (ATS) using

**Typical Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Typical Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g/cc)</td>
<td>0.5</td>
</tr>
<tr>
<td>Compressive strength (MPa)</td>
<td>8 to 12 MPa</td>
</tr>
<tr>
<td>Thermal conductivity (W/mK)</td>
<td>0.12</td>
</tr>
<tr>
<td>Specific heat (J/g°C)</td>
<td>1.2</td>
</tr>
<tr>
<td>Coefficient of thermal expansion (50-1500 C)</td>
<td>25 x 10⁻⁶</td>
</tr>
</tbody>
</table>

*Shelf life: 3 years at ambient temperature in an environment free from moisture and dust.*

**APPLICATION**

- **Lightweight thermo-structural material for thermal protection & insulation**
Indian Space Research Organization at its Vikram Sarabhai Space Centre has developed SESCO 125, a flame retardant coating for launch pedestal and related applications. SESCO 125 is a flame resistant coating based on polysiloxane. It is a two part system. Resin hardens on mixing both parts at room temperature.

**SALIENT FEATURES**

- Two part siloxane based system containing suitable fillers
- Imparts excellent flame retardancy Heat curable (175°C & 125°C type)
- Flame retardant coating for launch pedestals. It is weather resistant and water repellent. It can be used for general purpose too.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour and appearance (procured resin)</td>
<td>Grey, viscous</td>
</tr>
<tr>
<td>Viscosity at 30° CPs</td>
<td>4000 Ps</td>
</tr>
<tr>
<td>Cure schedule at RT (25° ± 5° C)</td>
<td></td>
</tr>
<tr>
<td>Gelation Time, minutes</td>
<td>20</td>
</tr>
<tr>
<td>Cure Time, hours</td>
<td>24</td>
</tr>
<tr>
<td>Properties of cured system</td>
<td></td>
</tr>
<tr>
<td>Density, g/cc</td>
<td>1.55-1.65</td>
</tr>
<tr>
<td>Tensile strength at 25°C, ksc</td>
<td>9-13</td>
</tr>
<tr>
<td>Elongation at 25°C, %</td>
<td>100-180</td>
</tr>
<tr>
<td>Lap shear strength at 25°C,ksc:</td>
<td>5-10</td>
</tr>
<tr>
<td>Limiting oxygen index, %</td>
<td>33-43</td>
</tr>
</tbody>
</table>
Adbond EPG 2601 is a adhesive developed by Indian Space Research Organisation at its Vikram Sarabhai Space Centre. Adbond EPG 2601 is a high strength ambient curing toughened epoxy adhesive with good elevated temperature properties. They can find application for structural bonding of metallic, composite and ceramic structures.

**SALIENT FEATURES**

- Two part Room Temperature Setting adhesive system containing urethane-epoxy with special fillers
- Cure achieved by mixing resin with the curative at ambient temperature
- Excellent strength adhesive for metal/ceramics/composite bonding
- Very low out-gassing; Excellent thermal conductivity and electrical insulation properties
- Adhesively bonded joint capable of withstanding thermal shock and thermal cycling.
- Space qualified
## Properties of Adbond EPG-2601

<table>
<thead>
<tr>
<th>Properties</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part-A</strong></td>
<td></td>
</tr>
<tr>
<td>Colour and appearance</td>
<td>Black paste</td>
</tr>
<tr>
<td>Viscosity at 30°C, ps</td>
<td>3000</td>
</tr>
<tr>
<td><strong>Part-B</strong></td>
<td></td>
</tr>
<tr>
<td>Colour and appearance</td>
<td>Brown viscous liquid</td>
</tr>
<tr>
<td>Viscosity at 30°C, (Sp. No. S21, RPM-0.5), Ps</td>
<td>400</td>
</tr>
<tr>
<td>Pot life at 30°C, minutes</td>
<td>45</td>
</tr>
<tr>
<td>Cure schedule at RT (25° ± 5° C)</td>
<td></td>
</tr>
<tr>
<td>Handling strength, hrs</td>
<td>48</td>
</tr>
<tr>
<td>Full strength, day</td>
<td>4</td>
</tr>
<tr>
<td><strong>Properties of cured adhesive</strong></td>
<td></td>
</tr>
<tr>
<td>Specific gravity at 25°C</td>
<td>1.45</td>
</tr>
<tr>
<td>Hardness (Shore-D)</td>
<td>73</td>
</tr>
<tr>
<td>Thermal conductivity at 80°C, cal/cm.s.°C</td>
<td>$1 \times 10^{-3}$</td>
</tr>
<tr>
<td>Coefficient of thermal expansion [below Tg], /° C,</td>
<td>$5 \times 10^{-5}$</td>
</tr>
<tr>
<td>Out-gassing properties:</td>
<td></td>
</tr>
<tr>
<td>a) TML-WVR, %</td>
<td>$\leq 1.0$</td>
</tr>
<tr>
<td>b) CVCM, %</td>
<td>$\leq 0.1$</td>
</tr>
<tr>
<td>Lap shear strength [LSS] [on Al –Al at 25°C], MPa</td>
<td>22 – 24</td>
</tr>
<tr>
<td>LSS at 125°C on Al/Al, MPa</td>
<td>16 – 18</td>
</tr>
<tr>
<td>LSS [ksc] on Al-Al at 25°C after humidity exposure, MPa</td>
<td>22 – 24</td>
</tr>
<tr>
<td>LSS [ksc] on Al-Al at 25°C after thermo-vacuum exposure</td>
<td>22 – 24</td>
</tr>
</tbody>
</table>
Indian Space Research Organization at its Vikram Sarabhai Space Centre has developed adhesives ADBOND EPP 3521 and ADBOND PN 2901.

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 posses 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.

Adbond PN 2901 adhesive has been developed to serve bonding of Velcro to metal surfaces. The adhesive formulation is based on a reactive blend of rubbers, phenolic resins, epoxy resins and tackifiers in a suitable solvent mixture and is attained after the cure under ambient conditions. The adhesive joint withstands the space environmental conditions.
Indian Space Research Organisation at its Vikram Sarabhai Space Centre has developed SILCEM R9, a room temperature curable single component adhesive 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 on exposure to humid air, it hardens by itself to a solid rubbery mass.

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

<table>
<thead>
<tr>
<th>Properties</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (Hardened Mass)</td>
<td>g/cc</td>
<td>1.25 - 1.35</td>
</tr>
<tr>
<td>Tensile strength @ RT</td>
<td>ksc</td>
<td>22 - 42</td>
</tr>
<tr>
<td>Tensile strength @ 120°C</td>
<td>ksc</td>
<td>518 - 35</td>
</tr>
<tr>
<td>Elongation @ RT</td>
<td>%</td>
<td>225 - 350</td>
</tr>
<tr>
<td>Elongation @ 120°C</td>
<td>%</td>
<td>110-300</td>
</tr>
<tr>
<td>Lap shear strength @ RT</td>
<td>Ksc</td>
<td>13-30</td>
</tr>
<tr>
<td>Lap shear strength @ 120°C</td>
<td>Ksc</td>
<td>13-28</td>
</tr>
<tr>
<td>Thermal conductivity at 100°C</td>
<td>W/ m.K</td>
<td>0.25-0.5</td>
</tr>
<tr>
<td>Hardness</td>
<td>Shore A</td>
<td>45 - 60</td>
</tr>
</tbody>
</table>
CSNM 0102 is a adhesive developed by Indian Space Research Organisation at its Vikram Sarabhai Space Centre. Adhesive CSNM 0102 is a special type of epoxy resin for cryogenic structural/thermocouple bonding. It is a two part epoxy-amine system and hardens on mixing Part A and Part B at room temperature.

**SALIENT FEATURES**

- Two part Toughened Epoxy adhesive containing speciality fillers
- Cure achieved by mixing two parts in the given ratio at ambient temperatures
- Imparts excellent thermal conductivity
- High strength adhesive for metal/ceramics/composite bonding
- Suitable for bonding of thermocouples of room temperature and cryogenic applications
- Space qualified
### Properties of Adhesive

<table>
<thead>
<tr>
<th>Properties</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CSNM 0102 Part-A:</strong></td>
<td></td>
</tr>
<tr>
<td>Colour and appearance</td>
<td>Grey viscous liquid</td>
</tr>
<tr>
<td>Viscosity at 30° C, ps</td>
<td>340</td>
</tr>
<tr>
<td><strong>CSNM 0102 Part-B:</strong></td>
<td></td>
</tr>
<tr>
<td>Colour and appearance</td>
<td>Brown liquid</td>
</tr>
<tr>
<td>Viscosity at 30° C, ps</td>
<td>60</td>
</tr>
<tr>
<td>Pot life at 25° C, minutes</td>
<td>60</td>
</tr>
<tr>
<td>Cure schedule at RT (25° ± 5° C)</td>
<td></td>
</tr>
<tr>
<td>Handling strength, hrs</td>
<td>24</td>
</tr>
<tr>
<td>Full strength, day</td>
<td>3</td>
</tr>
<tr>
<td>Properties of cured adhesive</td>
<td></td>
</tr>
<tr>
<td>Specific gravity at 25° C</td>
<td>1.11</td>
</tr>
<tr>
<td>Hardness (Shore-D)</td>
<td>72-74</td>
</tr>
<tr>
<td>Thermal conductivity at 80° C, cal/cm.s.°C</td>
<td>$6.7 \times 10^{-4}$</td>
</tr>
<tr>
<td>Coefficient of thermal expansion, /° C, (25-60° C range)</td>
<td>$7.5 \times 10^{-5}$</td>
</tr>
<tr>
<td>Lap shear strength on Al – Al, ksc</td>
<td></td>
</tr>
<tr>
<td>i) At RT</td>
<td>220-230</td>
</tr>
<tr>
<td>ii) At 473 K (200°C)</td>
<td>20-30</td>
</tr>
<tr>
<td>iii) At 77 K (LN2)</td>
<td>140-160</td>
</tr>
<tr>
<td>iv) At 20 K (-253°C)</td>
<td>130-150</td>
</tr>
<tr>
<td>v) At RT, [after thermal shock (77 K to 300 K,)]</td>
<td>17-190</td>
</tr>
</tbody>
</table>
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.

**SALIENT FEATURES**

- Excellent flame retardancy
- Easily processable (solventless process, moderate temperature)
- Good thermal stability

<table>
<thead>
<tr>
<th>Product appearance</th>
<th>Yellowish orange powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw materials</td>
<td>Bisphenol A, aniline and paraformaldehyde</td>
</tr>
<tr>
<td>Method</td>
<td>Solventless process</td>
</tr>
<tr>
<td>Reaction temperature</td>
<td>120 °C</td>
</tr>
<tr>
<td>Solubility</td>
<td>Acetone, chloroform etc.</td>
</tr>
<tr>
<td>Curing</td>
<td>210 °C/3 hrs</td>
</tr>
<tr>
<td>Catalyst</td>
<td>Not needed</td>
</tr>
<tr>
<td>Thermal stability</td>
<td>&gt;250 °C</td>
</tr>
<tr>
<td>Shelf life</td>
<td>1 year</td>
</tr>
<tr>
<td>Storage</td>
<td>Ambient temperature, moisture-free environment</td>
</tr>
<tr>
<td>Production cost (approx.)</td>
<td>Rs.1000/kg</td>
</tr>
</tbody>
</table>
EPIFIL 9661 RESIN

Indian Space Research Organisation at its Vikram Sarabhai Space Centre has developed Cryo adhesive, EPIFIL 9661 for polyimide pipe fabrication by helical winding of polyimide film on a mandrel. Pipe lines fabricated using the adhesive withstood various qualification tests for pressure, cryo propellant exposure, leak, deflection, vibration, burst pressure etc. at room temperature and also at cryo temperature conditions. The adhesive is presently used to bond the metallic (SS321) end fittings in the polyimide pipes for transporting liquid hydrogen and liquid oxygen.

This adhesive system has low viscosity, long pot life, ambient cure and flexibility and is capable of bonding polyimide film/ steel/ fibre-glass, required for the fabrication of polyimide pipes. EPIFIL 9661 also finds application as the matrix resin for making filament-winding application on the liquid oxygen side polyimide pipeline using Kevlar as the fabric.
Indian Space Research Organisation at its Vikram Sarabhai Space Centre has developed PMC 30, a room temperature curable silicone based coating system, containing micro-balloons and other fillers, which imparts low thermal diffusivity to the system. It is used as Thermal Protection System in Heat shield of PSLV, GSLV and cryo tank insulation.

**PROCESSING OF PMC-30**

(LOT SIZE: 500 KG)

- Preparation of premix in dual speed mixer
- Blending of micro balloons and premix in sigma mixer

<table>
<thead>
<tr>
<th>Typical Properties / characteristics:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color and consistency</td>
</tr>
<tr>
<td>Part A</td>
</tr>
<tr>
<td>Part B</td>
</tr>
<tr>
<td>Density</td>
</tr>
</tbody>
</table>
RWPC-03 is a waterproofing compound developed by Indian Space Research Organisation at its Vikram Sarabhai Space Centre for the waterproofing of silica foam tiles and for silica felt/fabric based flexible insulation.

It is an alkoxy silane based system, processed by controlled hydrolysis of siloxanes and is environment friendly. The treatment involves applying an aqueous solution of the organo-polysiloxane waterproofing agent 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 <1.5% using this compound. It can potentially be used as general purpose water proofing compound for silica based components including composites.

**Typical Properties / characteristics:**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color and consistency of RWPC-03</td>
<td>Transparent liquid</td>
</tr>
<tr>
<td>Water absorption of water proofed silica tile</td>
<td>&lt;1.5 % by weight</td>
</tr>
<tr>
<td>Water absorption of water proofed flexible</td>
<td>&lt;2% by weight</td>
</tr>
<tr>
<td>insulation</td>
<td></td>
</tr>
</tbody>
</table>
Indian Space Research Organisation at its ISRO Satellite Centre (ISAC) has developed a novel gold plating process which will find wide commercial and industrial applications.

Gold is a relatively scarce noble metal. The metal does not form a coherent oxide film on its surface even at very high temperature and therefore, it has a very low contact resistant. Gold electroplating process offers a means to obtain long lasting decorative finishes, improved electric contact and conductivity, stable thermo-optical properties etc. Gold electroplating process offers a means to obtain long lasting surface finishes, improved electric contact and conductivity etc.

**SALIENT FEATURES**

- Cyanide based, pulse plating technology
- Undercoat of electroless nickel and withstands temperature cycling of -196°C to +150°C
- Stable thermo-optical properties (Infra-red emissivity of 0.03)

**APPLICATION**

- Decorative (Jewellery, cutlery, fancy goods etc.)
- Engineering / Industrial
  - In electronics, to provide a corrosion-resistant electrically conductive layer on copper, typically in electrical connectors and printed circuit boards (copper laminated fiber board substrates).
  - Pure gold plating is used in semiconductor industry (over copper interconnects, HMCc, silicon etc).
  - Gold plating offers good corrosion resistance, good solderability and has a very good wear resistance. Hence it is used in electrical switch contacts, connector pins and barrels, and other applications where intermittent electrical contact occurs.
- Gold plating is practiced in aerospace application mainly for
  - Passive thermal control application. Thermal control is achieved by using thermo optical properties of gold.
• To enhance the electrical conductivity of the surface
• Microwave integrated circuits (MICs) fabrication
• Corrosion resistance (during storage time prior to launch)

APPLICABLE INTERNATIONAL STANDARD

<table>
<thead>
<tr>
<th>Plating Process</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold Plating Process</td>
<td>MIL-DTL-45204D, TYPE III, GRADE A</td>
</tr>
<tr>
<td>Electroless Nickel Process</td>
<td>ASTM – B656 -91</td>
</tr>
<tr>
<td></td>
<td>ASTM – B 733 -86</td>
</tr>
</tbody>
</table>

SUITABLE SUBSTRATES
• Aluminum and its alloys
• Kovar
• Stainless Steel
• Copper and its alloys
• Be-Cu
• PCBs

COATING SPECIFICATION

<table>
<thead>
<tr>
<th></th>
<th>5± 1 μ (Gold)</th>
<th>5 to 10 1 μ (Ni-P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>THICKNESS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MICROHARDNESS (HV)</td>
<td>≅ 80 – 100</td>
<td></td>
</tr>
<tr>
<td>IR EMITTANCE ($\epsilon_{IR}$)</td>
<td>&lt; 0.05</td>
<td></td>
</tr>
<tr>
<td>SOLAR ABSORPTANCE ($\alpha_S$)</td>
<td>≈ 0.20</td>
<td></td>
</tr>
</tbody>
</table>
Indian Space Research Organisation at its ISRO Satellite Centre (ISAC) has developed a micro arc oxidation process for magnesium alloys which will find wide commercial and industrial applications.

Magnesium and its alloys are rapidly becoming the material of choice across a wide cross section of industries such as aerospace, automotive, consumer electronics, defence and biomaterials. The traditional problems of magnesium are its susceptibility to corrosion and poor wear/scratch resistance. Micro Arc Oxidation (MAO), also known as Plasma Electrolytic Oxidation (PEO) or Spark anodization is relatively a new surface treatment technique, which uses a high voltage, high current process to obtain a hard, corrosion resistant oxide coating on the surface of metal surface. This produces a hard, dense ceramic like coating formed on magnesium alloy surface have a superior corrosion control properties comparable to stainless steel. In addition, the coating offers better thermo-optical properties, abrasion/ wear resistant properties.

**SALIENT FEATURES**

- High voltage, high current process, which is carried out at +25°C with an AC power supply
- Hard ceramic like coating with superior corrosion resistant and abrasion / wear resistant properties
- Green Process and no pre-cleaning of component needed
- Tailor-able coating thickness and hardness
APPLICATION(S)

MAO coatings find application in the various engineering industry for components, which require corrosion resistant and very high wear resistant surface such as pistons, cylinders, and hydraulic gear and for variety of components in aerospace industry. These coatings also improve the tribological properties of the components. These coating are also used in various components of automobile industries to improve their durability, corrosion resistance and heat radiation characteristics. It also offers high heat resistance. Components coated with thick MAO film can withstand unusually high temperature for a short duration. Also, the high insulation value of coating makes it useful in developing a dielectric layer with a breakdown strength of about 25 -30 V/micron thick coating. This coating is also used in Mobile phones and laptop casing.

APPLICABLE INTERNATIONAL STANDARD

- MIL-M-3171 C (Magnesium alloys, Processes for pretreatment and prevention of corrosion)
- MIL-M-45202C (Magnesium alloys, Anodic treatment)

SUITEABLE ALUMINUM ALLOYS

- AZ31B

COATING SPECIFICATION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness (micron)</td>
<td>ASTM-B-244 Eddy Current method 25±5 micron</td>
</tr>
<tr>
<td>Microhardness (HV)</td>
<td>ASTM-E 384, Diamond Indenter ≥ 300</td>
</tr>
<tr>
<td>Insulation value (Electrical)</td>
<td>At 700 V range, DC ≥ 3 GΩ</td>
</tr>
<tr>
<td>Corrosion properties</td>
<td>(Rp (corrosion resistance) value measured by Electro-chemical workstation) 5.95 X 10^5 Ω.cm²</td>
</tr>
</tbody>
</table>
PULSE HARD ANODIZATION PROCESS

Indian Space Research Organisation at its ISRO Satellite Centre (ISAC) has developed a pulse hard anodization process which will find commercial and industrial applications.

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.

**SALIENT FEATURES**

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

**APPLICATION(S)**

- Hard anodic oxide coatings find application in the engineering industry for components where abrasion resistance is the required primary characteristic of the coating
- Automobile Industry (Pistons, Cylinders, Hydraulic gears)
- Aerospace Industries (Variety of components like sliding / rotating mechanisms with solid lubricants, Thermal barrier coating, Thermal control coating etc.)
- Chemical and flame resistant surfaces
- Cooking utensils
- Highly insulating (electrical) dielectric coating
Interest Exploration Note

APPLICABLE INTERNATIONAL STANDARD


SUITABLE ALUMINUM ALLOYS

- AA-6061
- AA-7075
- AA 1100
- AA2024
- AA 2219

COATING SPECIFICATION

<table>
<thead>
<tr>
<th>Thickness (micron)</th>
<th>ASTM-B-244 Eddy Current method</th>
<th>60±10 micron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microhardness (HV)</td>
<td>ASTM-E 384, Diamond Indenter</td>
<td>250 - 500</td>
</tr>
<tr>
<td>Insulation value (Electrical)</td>
<td>10-100 V range, DC</td>
<td>30-1.5 GΩ</td>
</tr>
</tbody>
</table>

Comparison with conventional Hard Anodizing Process

<table>
<thead>
<tr>
<th>Processing Parameters</th>
<th>Conventional Hard Anodizing</th>
<th>Pulse Hard Anodizing</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>-5 ±2</td>
<td>10 ±2</td>
<td>Considerable saving in cooling load and cost. Solution conductivity is better and permits higher current density processing.</td>
</tr>
<tr>
<td>Current Density(A.ft⁻²)</td>
<td>35 ±5</td>
<td>45 ±5</td>
<td>Faster, better and harder coating</td>
</tr>
<tr>
<td>Voltage (V)</td>
<td>24 -90</td>
<td>16 - 32</td>
<td>Heating at the interface of Component &amp; electrolyte is eliminated. Burning problem is eliminated</td>
</tr>
<tr>
<td>Time (min)</td>
<td>80 -120</td>
<td>40-60</td>
<td>The time taken to build up a thickness of 50-70 microns is halved. Results in harder coating without powdering.</td>
</tr>
</tbody>
</table>

Properties of the Coating

<table>
<thead>
<tr>
<th></th>
<th>60±10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness (micron)</td>
<td></td>
</tr>
<tr>
<td>Microhardness (HV)</td>
<td>250-350</td>
</tr>
<tr>
<td>Insulation value</td>
<td>30-2.5 GΩ</td>
</tr>
<tr>
<td>Coff. Of friction</td>
<td>0.3 to 0.5</td>
</tr>
<tr>
<td>Corrosion resistance (R_p in Ω .cm²)</td>
<td>18.7 X 10⁶</td>
</tr>
</tbody>
</table>
Indian Space Research Organisation at its ISRO Satellite Centre (ISAC) has developed a room temperature low voltage hard anodization process which will find commercial and industrial applications.

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.

**SALIENT FEATURES**

- Room Temperature, low voltage hard anodizing is a novel and innovative process, which is carried out at +25°C compared to conventional hard anodizing process carried out at -5°C, thus saving a huge cooling load.
- The burning and powdering problems associated with conventional hard anodizing process are eliminated

**APPLICATION(S)**

Hard anodic oxide coatings find application in the engineering industry for components where abrasion resistance is the required primary characteristic of the coating.

- Automobile Industry (Pistons, Cylinders, Hydraulic gears)
- Aerospace Industries (Variety of components like sliding / rotating mechanisms with solid lubricants, Thermal barrier coating, Thermal control coating etc.)
- Chemical and flame resistant surfaces
- Cooking utensils
- Highly insulating (electrical) dielectric coating
**APPICABLE INTERNATIONAL STANDARD**

**SUITABLE ALUMINUM ALLOYS**
- AA-6061
- AA-7075
- AA 1100

**COATING SPECIFICATION**

<table>
<thead>
<tr>
<th>Property</th>
<th>Conventional Hard Anodizing</th>
<th>Pulse Hard Anodizing</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>-5 ± 2</td>
<td>25 ± 2</td>
<td>Considerable saving in cooling load and cost. Solution conductivity is better and permits higher current density processing.</td>
</tr>
<tr>
<td>Current Density (A.ft⁻²)</td>
<td>35 ± 5</td>
<td>60 ± 5</td>
<td>Faster, better and harder coating</td>
</tr>
<tr>
<td>Voltage (V)</td>
<td>24 - 90</td>
<td>14 - 20</td>
<td>Heating at the interface of Component &amp; Electrolyte is eliminated. Burning problem is eliminated</td>
</tr>
<tr>
<td>Time (min)</td>
<td>80 - 120</td>
<td>30 - 40</td>
<td>Considerable saving in production time and hence more throughput. Results in harder coating without powdering.</td>
</tr>
</tbody>
</table>

**Comparison with conventional Hard Anodizing Process**

**Properties of the Coating**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness (micron)</td>
<td>60 ± 10</td>
</tr>
<tr>
<td>Microhardness (HV)</td>
<td>250 - 350</td>
</tr>
<tr>
<td>Insulation value (Electrical)</td>
<td>30 - 2.5 GΩ</td>
</tr>
<tr>
<td>Coff. Of friction</td>
<td>0.3 to 0.5</td>
</tr>
<tr>
<td>Corrosion resistance</td>
<td>18.7 X 10⁶</td>
</tr>
</tbody>
</table>

**Suitable Aluminum Alloys**
- AA-6061
- AA-7075
- AA 1100
Indian Space Research Organisation at its ISRO Satellite Centre (ISAC) has developed a silver plating process which will find commercial and industrial applications.

Aluminum and its alloys are used extensively in aerospace industries due to its low density and good mechanical properties. Silver has highest electrical conductivity. The silver plating on aluminium alloy components such as RF filters improves surface conductivity and hence reduces the insertion losses. As the silver is prone to tarnish due to oxidation and reaction with sulphur containing media, gold plating of about 1 micron thick is plated over silver to prevent tarnishing.

**SALIENT FEATURES**
- Cyanide based, pulse plating technology
- Undercoat of electroless nickel or copper depending on the application
- A superficial overcoat of gold to prevent silver from tarnishing

**APPLICATION**
- Decorative (Jewellery, cutlery, fancy goods etc.)
- Engineering / Industrial
  To enhance the electrical conductivity of the surface

**APPLICABLE INTERNATIONAL STANDARD**

<table>
<thead>
<tr>
<th>Plating Process</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver Plating Process</td>
<td>ASTM-B-700 QQ-S-365D (fed)</td>
</tr>
<tr>
<td>Electroless Nickel Process</td>
<td>ASTM – B656 -91 ASTM – B 733 -86</td>
</tr>
</tbody>
</table>

**SUITABLE SUBSTRATES**
- Aluminum and its alloys

**COATING SPECIFICATION**

<table>
<thead>
<tr>
<th>Thickness</th>
<th>5 ± 2 μ (silver)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 to 10 1 μ (Ni-P)</td>
</tr>
<tr>
<td>Microhardness</td>
<td>≅ HVQQ-S-365D (fed)</td>
</tr>
</tbody>
</table>
Indian Space Research Organisation at its Space Applications Centre (SAC), Ahmedabad, has developed a process to carry out silver plating in aluminium waveguide. It is an intricate process considering the complexity and shape of the component. Uniform deposition (inside & outside) throughout the component is achieved using this process. Silver plated waveguides are used in communication payloads of satellites. Silver plating on Aluminium is required to obtain good RF performance. Silver provides the best known electrical conductivity and is solderable.

**PRE REQUISITES**
- Industry must possess basic electroplating know how.
- Industry must possess electroplating set up including baths, anodes, power supply etc.

**SPECIFICATIONS**
- Electroless Nickel Plating Thickness : 6 to 8 microns
- Silver Plating Thickness : 5 to 8 microns
THERMAL CONTROL COATING

Indian Space Research Organisation at its Space Applications Centre (SAC), Ahmedabad, has qualified the process of thermal control coating for spacecraft subsystem component made of materials such as Anodized Aluminium, Chromated Aluminium, Bare Aluminium, Electroless Nickel Plated Invar, Bare Invar, Silver Plated Aluminium, Chromated Magnesium, Black Anodic Coated Magnesium etc for use in space industry. Black paint is utilized on the interior of spacecraft to facilitate radiant heat transfer among internal components. The process will find wide commercial and special applications.

Commonly used space qualified paints are available in two colours – Black & White. The Thermo Optical properties of Thermal Control Coatings are given below:

<table>
<thead>
<tr>
<th>Coating Type</th>
<th>Emissivity ($\varepsilon$)</th>
<th>Solar Absorptive ($\alpha$)</th>
<th>$\alpha/\varepsilon$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>0.90</td>
<td>0.90</td>
<td>1.00</td>
</tr>
<tr>
<td>White</td>
<td>0.85</td>
<td>0.20</td>
<td>0.23</td>
</tr>
</tbody>
</table>

SPECIFICATIONS

- Total Mass Loss (TML) : ≤1.0 %
- Collected Volatile Condensable Material (CVCM) : ≤0.1 %
- Colour : Black & White
- Appearance : Flat / Matt Finish
- Dry Film Thickness (DFT) : 50 to 70 micron

PRE REQUISITES

- Industry must possess painting know how
- Conditioned thermal painting booth(s) and painting guns
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed a large number of adhesives to meet specific requirements in Launch Vehicles and Spacecraft applications. These adhesives may also find industrial applications.

Heat curable epoxy film adhesive is one such adhesive which has the unique characteristics for film formation and provides excellent bonding between diverse adherents. The properties can be fine tuned to meet specific applications. The filleting characteristics of the resin provide excellent bonding between corrugated, uneven adherent surfaces and is especially suited for honeycomb faces. It provides adhesive strength that is retained up to 120° C.

**SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Raw materials</th>
<th>Diglycidyl ether of bisphenol-A, Novolac epoxy, Dicyandiamide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>Solvent based process</td>
</tr>
<tr>
<td>Reaction temperature</td>
<td>190° C for making modified resins</td>
</tr>
<tr>
<td>Product appearance</td>
<td>Grey colored thin film</td>
</tr>
<tr>
<td>Solubility</td>
<td>Soluble in ethyl methyl ketone</td>
</tr>
<tr>
<td>Curing</td>
<td>Autocatalytic curing</td>
</tr>
<tr>
<td>Curing temperature</td>
<td>175° C for 2 hours</td>
</tr>
<tr>
<td>Thermal stability</td>
<td>&gt; 300</td>
</tr>
<tr>
<td>Shelf life</td>
<td>1 year</td>
</tr>
<tr>
<td>Storage</td>
<td>-18° C</td>
</tr>
<tr>
<td>Approximate Production cost (Rs.)</td>
<td>6000 per m2</td>
</tr>
</tbody>
</table>
APPLICATION(S)

Useful for fabrication of different honeycomb composite structures for aerospace, wind energy, naval industries etc.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed technologies for processing and application of different types of silicone polymer based Thermal Protection Systems (TPS) with tailored properties to meet various mission/application requirements.

SSF P70 is a low density Thermal Protection System (TPS) based on silicone polymer, with microballoon and other fillers as compounding ingredients. This Thermal Protection System is room temperature curable and can be applied by brushing and spraying techniques. The remarkable features of this system includes low density of 0.38 g/cc, lower thermal conductivity, high specific heat, good ageing resistance and compatibility with wide variety of substrates.

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.

**SALIENT FEATURES**

- Simplified and cost effective technology for processing premium quality Thermal Protection System
- Room temperature curable
- Flexibility with respect to application procedure such as spraying and brushing
- Compatibility with wide variety of substrates including metals, composites etc.
- Excellent ageing behaviour, making it suitable for long term application with no deterioration of properties for more than two years
- 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 °C and low temperature flexibility, owing to the low glass transition characteristics associated with silicone polymers

APPLICATION(S)

- Useful for light weight, high quality Thermal Protection System for temperatures up to 300 °C direct exposure with reasonable stability and capability to retain properties.
- The product can be used for thermal protection application for protecting launch vehicle and related hardware from aerodynamic heating where light weight Thermal Protection System is required and also as moisture / water impermeable coatings.
- The system can be tailored for use as coating on metal substrates for outdoor use.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed a number of polymers and polymer based products for meeting specific requirements in Launch Vehicles and spacecraft applications. Some of these products may also find industrial applications. ‘PEDCOAT’, a solid propellant motor liner system based on Hydroxyl Terminated Poly Butadiene (HTPB) resin and carbon black filler is one such item. PEDCOAT liner composition used for solid motor application is realised in two steps - the liner premix production and final mixing of pre-mix with the curative. Mixing with curative is done as per requirements prior to the application on to the solid motor insulator. Final product being a urethane based system, necessary precautions are to be taken to control the moisture content in the product during processing and storage.

**SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Raw materials</th>
<th>HTPB Resin, Tri Methylol Propane (TMP), Carbon Black, Vanadium Pentoxide, Di butyl Tin Dilaurate (DBTDL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>TMP melting, mixing of appropriate quantities of ingredients as per the approved sequence, stirring under heating in a reactor</td>
</tr>
<tr>
<td>Reaction temperature</td>
<td>70-90 °C.</td>
</tr>
<tr>
<td>Product appearance</td>
<td>Black colored, slurry type</td>
</tr>
<tr>
<td>Curing temperature</td>
<td>Room Temperature</td>
</tr>
<tr>
<td>Shelf life</td>
<td>1 year</td>
</tr>
<tr>
<td>Storage</td>
<td>Ambient storage in sealed condition</td>
</tr>
</tbody>
</table>
MAJOR MACHINERY REQUIRED FOR PREMIX
A reactor for making the pre mix - a jacketed vessel provided with twin speed agitators (one low speed and other high speed, ~ 25 rpm & 705 rpm), hot oil circulation jacket and evacuation facility.

TESTING EQUIPMENTS
Standard equipments for analysis of raw materials and products- viscosity, specific gravity, particle size, purity analysis etc. Moisture testing is carried out using Karl Fisher method.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed a number of polyimide materials, catering to specific applications in launch vehicles and satellites. Polyimide is a versatile and strategic material finding many industrial applications. Polyimide remains stable over a wide range of temperature, from -273 deg C to +400 deg C, making it suitable for electrical insulation at low thermal gradient. Polyimide films also find application in flexible printed circuits. The technology can be suitably customised for meeting specific requirements such as adhesives, sealant, coating and potting compound.

ISRO offers the technology for the preparation of Polyamic Acid and production of Polyimide Film of 2.50 m X 1.20 m size with thickness ranging from 25 microns to 150 microns.

**TYPICAL PROPERTIES / CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color and Consistency</td>
<td>Yellowish</td>
</tr>
<tr>
<td>Shelf Life</td>
<td>&gt; 7 years</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>&gt; 14,000 psi (&gt;985 ksc)</td>
</tr>
<tr>
<td>Tear Strength</td>
<td>&gt; 7 N (50 micron)</td>
</tr>
<tr>
<td></td>
<td>&gt; 4 N (25 micron)</td>
</tr>
<tr>
<td>Elongation</td>
<td>&gt; 20 % (50 micron)</td>
</tr>
<tr>
<td></td>
<td>&gt; 15 % (25 micron)</td>
</tr>
<tr>
<td>Electrical Resistance</td>
<td>100 Mohm at 500 V DC</td>
</tr>
<tr>
<td>Dielectric Strength</td>
<td>5-6 KV/mil</td>
</tr>
<tr>
<td>Volume Resistivity</td>
<td>7.8 X 1014 ohm cm</td>
</tr>
<tr>
<td>Thermo Gravimetric Analysis</td>
<td>Stable upto 500 deg C</td>
</tr>
<tr>
<td>Collected Volatile Condensable Matter</td>
<td>&lt; 0.1 %</td>
</tr>
<tr>
<td>Total Mass Loss</td>
<td>&lt; 1 %</td>
</tr>
</tbody>
</table>
Indian Space Research Organisation at its Space Applications Centre (SAC) has developed electroplating and electroless plating 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.

**SILVER PLATING ON ALUMINUM 6061T6**

- Silver Plating on Aluminum 6061-T6 alloy for electrical conductivity & solderability, corrosion protection and good base for thermal control coatings
- Silver plating on Aluminum is used for components like waveguides, adaptors, HRFs, filters etc.
SILVER PLATING ON INVAR

- Silver Plating on Invar for good electrical conductivity, solderability and good base for thermal control coatings
- Silver Plating on Invar is used for manifolds, cavities, iris and adaptors

SILVER PLATING ON COPPER

Silver Plating on Copper helix conductors for solderability to helix antenna and feed network

GOLD PLATING ON ALUMINUM 6061T6

- Gold plating on Aluminum 6061T6 is developed and qualified with electroless nickel undercoat
- Gold plating is required on aluminum boxes for avoiding EMI and improving EMC properties and protects them from corrosion

GOLD PLATING ON KOVAR

- Kovar is used for fabrication of carrier plates. Gold plating on Kovar is used to improve solderability of gold plated alumina substrates onto carrier plates
- Gold plating on Kovar is optimized to achieve required solderability and corrosion protection with less gold plating thickness
GOLD PLATING ON MAGNESIUM
• Magnesium AZ31B alloy is one of the space qualified material which can give weight reduction advantage over Aluminum 6061T6
• Gold plating on Magnesium AZ31B is required for EMI/EMC and corrosion protection
• Magnesium is one of the hard to plate materials

OTHER GOLD PLATING PROCESSES
• Gold plating SS-304- for electrical conductivity and corrosion protection
• Gold plating on Invar – for solderability
• Gold plating on phosphorous bronze – corrosions protection on reeds, shims

ELECTROLESS NICKEL PLATING ON INVAR
• Electroless Nickel Plating on Invar Optical structures, mirror mounts etc, for corrosion protection and good base for thermal control coatings

ELECTROLESS NICKEL PLATING ON ALUMINUM 6061T6
• Electroless Nickel Plating on Aluminum boxes and covers for corrosion protection and good base for thermal control coatings
BLACK ANODIZING & CHROMATING ON ALUMINUM 6061T6

• Black Anodizing & Chromating on Aluminum 6061-T6 alloy packages to achieve high emissivity and solar absorptivity, nonconductive surface, corrosion protection on selective area of packages; chromating on remaining area for electrical conductivity, corrosion protection and good base for thermal control coatings.

ANODIZING ON ALUMINUM 6061T6

• Anodizing on Aluminum 6061-T6 Alloy for getting nonconductive surface, corrosion protection, and good base for Thermal Control coatings.
TOUGHENED EPOXY
EPY-PEEKTOH

Indian Space Research Organisation at its Vikram Sarabhai Space Centre (VSSC) has developed EPY PEEKTOH toughened epoxy having elevated temperature curing and single component PEEK toughened epoxy matrix resin. The specialty of the formulation is high glass transition temperature and low outgassing properties. This is an ideal matrix resin for processing thick carbon fabric laminates (≥ 30 mm) without de-lamination.

SALIENT FEATURES

Elevated temperature curing, high glass transition temperature toughened epoxy suitable for processing thick carbon fabric laminates.

TYPICAL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile matter at 65°C for 5 hours (%)</td>
<td>0.04</td>
</tr>
<tr>
<td>Viscosity at 65°C (poise)</td>
<td>60-80</td>
</tr>
<tr>
<td>Shore-D hardness at 30°C</td>
<td>&gt; 85</td>
</tr>
<tr>
<td>Specific gravity at 30°C</td>
<td>1.1 – 1.4</td>
</tr>
<tr>
<td>Flexural strength at 25°C (MPa)</td>
<td>110 – 120</td>
</tr>
<tr>
<td>TML-WVR (%)</td>
<td>≤ 1.0</td>
</tr>
<tr>
<td>CVCM (%)</td>
<td>≤ 0.1</td>
</tr>
<tr>
<td>Glass transition temperature (°C)</td>
<td>210</td>
</tr>
</tbody>
</table>

APPLICATION(S)

EPY PEEKTOH resin is mainly used for fabrication of YOKE panel hinge insert for satellites.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed technologies for processing and application of different types coatings with tailored properties to meet various mission/application requirements.

The anti-corrosion paste is a mix of finely blended barium chromate powder and a water repellent polymer. It is a thick composition with proven no-flow characteristics in humidity and moderate temperature (100°C) conditions. It exhibits anti-corrosion properties in salt solution (no signs of corrosion even after 30 days) and also in galvanic corrosion environment.

**SALIENT FEATURES**

- High anti-corrosion properties
- Good paste consistency and composition
- Non-drying paste for prolonged use
- No-flow features in severe temperature and humidity exposures
- Inexpensive formulation

**APPLICATION**

The paste can be effectively applied in threads or joints and over metallic structures to effectively prevent corrosion.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed superhydrophobic coatings. These are prepared from a combination of polymers and nanoparticles. These coatings possess high water contact angle (around 160 °) with excellent water roll-off properties. The coatings can be applied by spraying over different substrates to form good water repellent coatings.

SALIENT FEATURES

- High water contact angle
- Extreme water repellency
- Excellent water roll-off properties
- Sprayable (wide area application)
- Economically viable

APPLICATION(S)

It can find myriad applications in preventing moisture induced corrosion in metals, water repellent coatings in radomes and dishes, moisture barrier for polymers/composite structures and to roll-off condensed water from metallic structures.
NRCM-204 CORROSION RESISTANT COATING

Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed technologies for corrosion resistant coating material to meet various mission/application requirements. 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.

SALIENT FEATURES

• Ambient temperature curing
• Corrosion resistant material to protect from harsh oxidizing environment

PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSS (Al/Al) at RT, ksc</td>
<td>≥ 10</td>
</tr>
<tr>
<td>Tensile Strength, ksc</td>
<td>≥ 5</td>
</tr>
<tr>
<td>Tensile Modulus, ksc</td>
<td>5 to 15</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>70 to 120</td>
</tr>
</tbody>
</table>

APPLICATION(S)

NRCM 204 offers a highly corrosive resistant coating which can be coated over metals and composites for almost all type of corrosion which includes acids, bases, etc. Conventional polymeric materials will not withstand the highly corrosive environment.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed adhesive system for bonding natural rubber to metal/composite. Adhesive NREP-9505 and Primer EATCI-9802 are the combination of room temperature setting epoxy adhesive and primer for bonding natural rubber to metal/composite. Adhesive NREP-9505 comprises of modified epoxy resin and modified amine curative compatible to natural rubber. Primer is a solution of an oxidizing agent to treat rubber surface to improve the adhesion characteristics.

**SALIENT FEATURES**

- Ambient temperature curing
- Capable of bonding natural rubber
- High strength adhesive system curing at room temperature for natural rubber bonding

**APPLICATION(S)**

NREP-9505 and EATCI-9802 will find application for bonding natural rubber to metal/composite.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed EFA 4330F, a single component, foam adhesive for structural bonding applications. It cures at elevated temperature (175° C for 2 hours) and forms and fills the honeycomb on lateral bonding applications. The adhesive comprises of modified epoxy, foaming agents, latent curative and reinforcing fillers.

**UNsupported Film Adhesive, EFA-4330**

**Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Film thickness</td>
<td>2 ± 0.2 mm</td>
</tr>
<tr>
<td>Foaming ratio</td>
<td>1:3</td>
</tr>
<tr>
<td>Double Lap shear strength (Al/Al) at 25° C (kgf/cm²)</td>
<td>50-70</td>
</tr>
<tr>
<td>TML-WVR (%)</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>CVCM (%)</td>
<td>&lt; 0.1</td>
</tr>
</tbody>
</table>

**Application(s)**

EFA-4330F foam adhesive is used for fabrication of light-weight honeycomb structures for satellites / launch vehicles and will find wide applications in other industries involved in fabrication of honeycomb structures.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed pressure sensitive adhesive, which finds wide application in bonding of subsystem packages and equipment panels in space industry. The adhesive is a Acrylate based two part system.

Part A: Butyl Acrylate, Acrylic acid and Methyl methacrylate co-polymer

Part B: Butyl acrylate and Glycidyl methacrylate co-polymer

**SALIENT FEATURES**

- Peel Strength (Kapton to Kapton) > 5 N/cm
- TML < 1%.
- CVCM < 0.1%

**APPLICATION(S)**

The adhesive is extensively used for bonding of subsystem packages and equipment panels of satellites, solar panel yokes and solar panel connectors of satellites, Multi Layer Insulation (MLI) in satellite etc. The adhesive may also find wide applications in other industries dealing with similar products.
EPNA-07 EPOXY ADHESIVE

Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed EPNA 07, a solventless, rubber toughened, two component epoxy adhesive. EPNA 07 is a room temperature curing, inherently polarized rubber toughened epoxy adhesive system enabling good bonding between the rubber metal interfaces. The adhesive system consists of a cycloaliphatic epoxy resin, a polarized natural rubber formulation as the toughening agent with suitable reinforcing fillers and an amine based hardener system.

PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lap shear strength at RT, ksc, (SS/neoprene rubber)</td>
<td>25-30</td>
</tr>
<tr>
<td>900 Peel strength at RT, Kg/cm, (SS/neoprene rubber)</td>
<td>4-7</td>
</tr>
</tbody>
</table>

SALIENT FEATURES

The synthesis of conventional adhesive systems includes many processing steps, incorporation of reinforcing additives, and use of hazardous tackifying resins. The conventional process also renders a non-eco friendly atmosphere during bonding operations for rubber-metal bonding applications. EPNA 07 adhesive system is a solventless, eco-friendly, simple and less complicated system with good performance characteristics. The other features include ambient temperature curing, high shear/peel strength room temperature curing and capability of bonding natural rubber.

APPLICATION(S)

The adhesive will find application as solvent free adhesive for metal-vulcanized rubber bonding.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed HST EP 700, a high strain tolerant, low modulus, room temperature curing two-part toughened epoxy formulation for bonding substrates with low surface energy such as polyethylene or polypropylene. The specialty of the system is that the material is highly compatible with polyethylene and thereby imparts good adhesion. Part-A is modified epoxy and Part-B is mixture of modified amines.

**PROPERTIES**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lap shear strength (Al/Al) at 25°C (kgf/cm²)</td>
<td>50-60</td>
</tr>
<tr>
<td>Lap shear strength (PE/PE) at 25°C (kgf/cm²)</td>
<td>20-25</td>
</tr>
<tr>
<td>Tensile strength at 25°C (kgf/cm²)</td>
<td>50-70</td>
</tr>
<tr>
<td>Tensile modulus at 25°C (kgf/cm²)</td>
<td>15-25</td>
</tr>
<tr>
<td>Tensile elongation at 25°C (%)</td>
<td>600-700</td>
</tr>
</tbody>
</table>

**SALIENT FEATURES**

- Ambient temperature curing
- High strain and low modulus epoxy formulation
- Suitable for bonding polyethylene

**APPLICATION(S)**

HST EP-700 will find application for bonding polyethylene to polyethylene or polyethylene to aluminum.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed HTV EP 411, a high temperature vulcanizing epoxy formulation suitable for bonding metal to EPDM rubber.

**PROPERTIES**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lap shear strength (Al/Al) at 25°C (kgf/cm²)</td>
<td>80-100</td>
</tr>
<tr>
<td>Lap shear strength (Al/Al) at 100°C (kgf/cm²)</td>
<td>10-15</td>
</tr>
<tr>
<td>Tensile strength at 25°C (kgf/cm²)</td>
<td>80-100</td>
</tr>
<tr>
<td>Tensile modulus at 25°C (kgf/cm²)</td>
<td>200-250</td>
</tr>
<tr>
<td>Tensile elongation at 25°C (%)</td>
<td>100-120</td>
</tr>
<tr>
<td>180° Peel strength (EPDM/15CDV6) at 25°C (kg/cm)</td>
<td>2.1-2.6</td>
</tr>
</tbody>
</table>

**APPLICATION(S)**

HTV EP-411 is useful for bonding EPDM in motor cases used in launch vehicles, as thermal protection system.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed a wide range of shape memory polymers with transition temperatures (shape recovery temperature) ranging from 50-180°C using casting/compression moulding. The Shape Memory Polymers exhibit shape retention and shape recovery capability above 95%. The recovery speed ranges from seconds to minutes (tunable) according to application (both fast and slow recovery shape memory polymers). Elastic memory composites also are developed in selected cases with actuation temperatures in the range of 70-90°C.

**SALIENT FEATURES**

- High shape recovery property
- High shape fixity features
- Tunable shape recovery temperature
- Tunable shape recovery time
- Easy processability
Glass filled nylon nozzle closure developed by Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) is fabricated using 30% glass filled nylon-6 by injection molding. Glass fiber reduces the coefficient of thermal expansion (CTE). It enhances the adhesion with copper using adhesive ENC-3030 M.

**SALIENT FEATURES**

Low thermal expansion co-efficient of glass filled nylon ensuring better margin of safety.

**PROPERTIES**

<table>
<thead>
<tr>
<th>Material inspection using X-ray</th>
<th>No defects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, MPa</td>
<td>65-75</td>
</tr>
<tr>
<td>Tensile Elongation %</td>
<td>80 maximum</td>
</tr>
<tr>
<td>CTE in Axial direction /°C</td>
<td>90x10⁻⁶</td>
</tr>
<tr>
<td>CTE in Radial direction /°C</td>
<td>90x10⁻⁶</td>
</tr>
<tr>
<td>CTE in Hoop direction /°C</td>
<td>25x10⁻⁶</td>
</tr>
</tbody>
</table>
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed technologies for processing and application of different types of paint and coatings with tailored properties to meet various mission/application requirements.

Non conductive White Paint is an acrylic based paint developed for satellite applications, as a thermal control coating with excellent out gassing resistance. It has low solar absorptivity (<0.22) and high IR emissivity (>0.88) characteristics. The paint has been used extensively in spacecraft components like reflectors, antennae and passive coolers.

GCC 50 is an advanced anti static coating system. This coating has a comparatively lower solar absorptivity and high emissivity, yet maintaining the anti static properties.

This is suited for coating insulated surface of the cryogenic stage components in launch vehicles to prevent static electricity build up.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed technology for processing of Polyimide Films.

These films are highly thermally stable, possess higher mechanical and dielectrical properties.

**SALIENT FEATURES**

- Processed in a batch process
- Sizes up to 1m X 2.5 m
- Excellent thermal, mechanical and dielectrical properties

**APPLICATION**

Polyimide films will find wide applications in:

- Solar panel
- Multi Layer Insulation (MLI) blankets
- Li-ion cells
- Moisture barrier film layers in camera structures of satellites
- Photo etched Copper Cladded films can be used in reflectors of antenna
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed Polyimide pipelines. These find application in the pneumatic hydraulic feed system of cryo stages used in ISRO launch vehicles. Pipelines perform critical stage functions such as tank chilling, propellant filling and draining, thermal conditioning and propellant level correction. A helical tape winding technique to realize the polyimide pipelines has also been developed.

**SALIENT FEATURES**

- Polyimide is a unique material, which can be used both in cryogenic as well as high temperatures
- Polyimide pipelines possess many advantages over conventional metallic pipelines such as low specific gravity (1.30), low stiffness, ability to retain higher percentage elongation at cryogenic temperature, withstanding thermal shock and inherently flexible
- 27 profiles of pipelines with 30mm to 80mm dia with straight, single bend and double bend configurations and 35 different profiles of various sizes ranging from 60 to 130 mm dia to withstand pressure rating of 3 to 36 kg/cm²
ELECTRONICS
V BAND LOW NOISE AMPLIFIER

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

TYPICAL APPLICATIONS

- EW Receivers
- Weather & Military ultra wideband radar applications
- Ultra wideband communication networks

SALIENT FEATURES

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

<table>
<thead>
<tr>
<th>Frequency GHz</th>
<th>Gain (dB)</th>
<th>Noise Figure (dB)</th>
<th>P1dB (dBm)</th>
<th>DC Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-60</td>
<td>8.5dB ± 1.5dB</td>
<td>5</td>
<td>14</td>
<td>3V, 80mA</td>
</tr>
</tbody>
</table>
Space Applications Centre of ISRO has developed an integrated 6-bit GaAs MMIC digital phase shifter featuring two MMIC dies catering to 1024ps 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.

Typical Applications
- EW Receivers
- Weather & Military ultra wideband Radars
- Beam Forming Modules

### Salient Features
- 6 bit TTD-Phase Shifter
- Wide Dynamic range: 1024 ps
- Fine Resolution: 16ps
- Novel Topology of self switched band pass network for 256ps delay bit
- DC power consumption: 80mA, 3V
- Novel topology of compensated network for 512ps delay bit

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>Max. Insertion Loss (dB)</th>
<th>Delay Range (ps)</th>
<th>I/O Return Loss max. (dB)</th>
<th>Max. RMS Error (ps)</th>
<th>Control Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.25 ± 0.125</td>
<td>15</td>
<td>16 to 1024</td>
<td>12</td>
<td>8</td>
<td>0/-5V</td>
</tr>
</tbody>
</table>
C BAND DC BIAS I/Q MIXER

Space Applications Centre of ISRO has developed a DC biased IQ mixer designed to operate at C band. It is fabricated in size of 1inch x 1inch on 25 mil alumina. Same circuit can be realized as is on TMM10i/RT6010 substrates. The novel use of DC biasing provides reduction of local oscillator (LO) power to 4 dBm as compared to 10 - 15 dBm of conventional I/Q Mixers. The circuit provides low conversion loss and low amplitude and phase imbalance. It can be used as a single sideband modulator and demodulator with very low LO power requirement.

Typical Applications
- EW Receiver / Transmitter
- Weather & Military Radars
- Single sideband modulator and Image Rejection Mixers

Salient Features
- C Band IQ mixer with DC biasing for low power requirement
- Low conversion loss
- Good amplitude and phase balance
- Planar topography
- Realization amenable to Conventional Photo lithographic patterning on soft & hard substrates

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>Conv. Loss (dB)</th>
<th>LO to RF Isolation (dB)</th>
<th>Amp. Imbalance</th>
<th>Phase Imbalance</th>
<th>Typical LO Power (dBm)</th>
<th>DC Bias (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.15 ± 0.250</td>
<td>10 ± 0.5</td>
<td>&gt; 25</td>
<td>0.3 dB (rms)</td>
<td>5 deg (rms)</td>
<td>4</td>
<td>0.3 - 0.7</td>
</tr>
</tbody>
</table>
SAC has developed an On Board Controller (OBC) Application Specific Integrated Circuit (ASIC) for central and distributed controllers of various microwave remote sensing payloads. OBC ASIC architecture is based on DW8051 microcontroller core. It contains a rich set of serial interfaces. It also contains parallel ports with a unique feature of event programmability, which makes I/O deterministic and reduces load of software for I/O task.

**SALIENT FEATURES**

- DW8051 (8 bit microcontroller) core
- 4 UARTs, 3 Timers and 5 Interrupts
- 3 synchronous serial Tx/ Rx
- 4 Ports (32 bits) for parallel I/O
- 6 Event Programmable ports (48 bits)
- 6 Programmable Timing Signals
- Auxiliary Data Interface (256 Bytes)
- Two 8 bit Delta Sigma ADCs (with external R,C & comparator)
- Watchdog Time
- Programmable Combinational Logic Module (similar to FPGA CLB)
- On chip monitor program for ICP
- JTAG boundary scan chain
- 0.6μ CMOS RadHard Digital Tech.
- Supply : 5 Volts for Core & I/O
- Package : CQFP 256 pins
- I/O : 5V CMOS compatible with 4ma/8ma drive (total 224 I/Os)
- Clock Frequency: 16 MHz (Max)
- 300K NAND2 equivalent gates
- QML-V Qualified
- ESD sensitivity: 2KV
- Radiation Performance
  - TID ≥ 100Krad (Si)
  - LET (no latchup) ≥ 128 MeV - cm²/mg
  - SEU rate ≤ 1.6 x 10⁻¹⁰ errors/ bit day
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.

**TECHNOLOGICAL FEATURES**
- Thick film technology
- SMT technology
- Planar Magnetics
- Magnesium alloy for weight reduction
- Hybrid Micro – Circuits

**SALIENT FEATURES OF PCPU**
- Powers a pair of V&H TR Modules and a TRC unit
- 10 outputs: 8 pulsed + 2 continuous
- 59W pulse output power
- 9.1W average output power
- High BW pulse modulators for fast rise & fall times on pulsed outputs
- In-built EMI filter isolates the satellite bus from the pulsed load transients.
Space Applications Centre of ISRO has developed seven types of MMICs flown in RISAT – 1. These MMICs are used for the development of Transmit Receive modules. ISRO offers to license this technology of these MMICs 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.

**SPACE QUALIFIED C-BAND MMIC’S**

**6-BIT DIGITAL ATTENUATOR**
- 5350 ± 125 MHz
- 31.5dB dynamic range
- 6-bit, 0.5 dB step
- Insertion Loss: 4.5 dB

**6-BIT DIGITAL PHASE SHIFTER**
- 5350 ± 125 MHz
- 360 deg dynamic range
- 6-bit, 5.625 deg step
- Insertion Loss: 7 dB

**SPDT SWITCH**
- 5350 ± 125 MHz
- Insertion Loss: 2.5 dB
- Isolation: 30 dB
<table>
<thead>
<tr>
<th>Amplifier Type</th>
<th>Frequency Range</th>
<th>Gain</th>
<th>Power</th>
<th>Noise Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medium Power Amplifier-1</strong></td>
<td>5350 ± 125 MHz</td>
<td>32 dB</td>
<td>15 dBm</td>
<td></td>
</tr>
<tr>
<td><strong>Medium Power Amplifier-2</strong></td>
<td>5350 ± 125 MHz</td>
<td>15 dB</td>
<td>25 dBm</td>
<td></td>
</tr>
<tr>
<td><strong>Small Signal Amplifier</strong></td>
<td>5350 ± 125 MHz</td>
<td>25 dB</td>
<td>13 dBm</td>
<td>4 dB</td>
</tr>
<tr>
<td><strong>Low Noise Amplifier</strong></td>
<td>5350 ± 125 MHz</td>
<td>2.6 dB</td>
<td>25 dB</td>
<td></td>
</tr>
</tbody>
</table>
Space Applications Centre of ISRO has developed a transmit receive (TR) module which is very useful for radar applications. Here, both transmit and receive chains are accommodated in a single small housing for achieving good noise figure in receive path and power in transmit path. 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>5350 GHz</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>225 MHz</td>
</tr>
<tr>
<td>Phase Control</td>
<td>6 bits, 360 deg range/ 5.625 deg step</td>
</tr>
<tr>
<td>Gain Control</td>
<td>6 bits, 31.5 dB range/ 0.5 dB step</td>
</tr>
<tr>
<td>Coupling of Coupler</td>
<td>20 dB</td>
</tr>
</tbody>
</table>

### Transmit Path Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power</td>
<td>-10 dBm</td>
</tr>
<tr>
<td>Peak Output Power</td>
<td>10W</td>
</tr>
<tr>
<td>Transmit Pulse Duration</td>
<td>20µs, 10% duty</td>
</tr>
</tbody>
</table>

### Receive Path Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise Figure (NF)</td>
<td>4 dB</td>
</tr>
<tr>
<td>Gain @ 0 dB Attenuation</td>
<td>30 dB</td>
</tr>
<tr>
<td>SPST Isolation</td>
<td>35 dB</td>
</tr>
</tbody>
</table>
Indian Space Research Organisation (ISRO) at its Space Applications Centre (SAC) has developed an Amplitude Tilt Active Equalizer for frequency and temperature compensation of microwave systems. The equalizer is having octave bandwidth performance and is used for the developed broadband ALC channel amplifiers and linearizers at Ku-Band frequency for GEOSAT payload projects.

**SALIENT FEATURES**

- Capable to generate positive, negative or zero slope over frequency by varying the control voltage
- Suitable to optimize gain flatness of any microwave circuit/system over frequency of operation
- Capable for temperature compensation of microwave circuits/systems

**APPLICATION(S)**

- Electronically controlled gain slope over frequency up to ± 8 dB
- Gain control of microwave system with adjustable slope over frequency.
- Gain control of microwave system with adjustable slope over temperature
- Development of broadband microwave subsystem such as receivers, channel amplifiers, linearizers
Indian Space Research Organisation (ISRO) at its Space Applications Centre (SAC) has designed, developed and qualified an Automatic Level Control (ALC) Driver Amplifier. The system has been used in ISRO’s GEOSAT payload projects.

**SALIENT FEATURES**

- Frequency: 11.45 GHz to 11.7 GHz
- 3rd order IMD: <-30 dBc
- Mode of Operation: Fixed Gain or ALC
- Gain (FGM): Commandable from 24 dB to 44 dB
- Dynamic Range: 20 dB
  (input from -44 to -24 dBm)
- Output Power: Commandable from 0 to -20 dBm

**APPLICATION(S)**

- ALC Driver Amplifier contributes nearly 44 dB transponder linear gain and also provides required input drive to the TWTAs. Its commandable gain setting feature is used to control the transponder overall gain and drive level of the TWTA.
- This driver amplifier also can be used in any system where commandable/adjustable gain from 24 dB to 44 dB is required with the provision of ALC system. The performances of the driver amplifier are temperature compensated over the temperature range of -10 to +60 deg C.
Indian Space Research Organisation (ISRO) at its Space Applications Centre (SAC) has designed and developed a HAMUX-64 HMC, a 64 channel analog multiplexer using multilayer thick film hybrid technology. This 64 channel analog multiplexer will find special applications.

**SALIENT FEATURES**
- 64 channel with ESD & Over voltage protection
- Provision for Internal / External reference voltage
- Buffered (Op-amp) and Un-buffered (Mux) output
- Cascadable up to 256 channels
- Compliant as per ISRO-PAS-206
- Radiation: TID upto 100K Rads (Si)
- Inter-channel Cross talk: 35db (Max)@50KHz

**APPLICATION(S)**
- It can be used for housekeeping of analog information for LEO and GEO payload and video signal multiplexing for multispectral instruments at low rates. The multiplexer has ESD and over voltage protected inputs
Indian Space Research Organisation (ISRO) at its Space Applications Centre (SAC) has developed a Microwave Linearizer. The technology is related to diode based pre-distortion linearizer to be used with power amplifiers (TWTAs or SSPAs) to improve nonlinear performance and efficiency of a communication system over broadband frequency and over very wide operating temperature range.

**SALIENT FEATURES**

- **Frequency Band**: L, S, C, Ku
- **Gain Expansion**: up to 10 dB
- **Phase Expansion**: up to 55 deg Gain
- **Output Power**: 10 to 27 dBm
- **Operating Temp. Range**: -10°C to +60°C

The linearizers are capable to compensate gain and phase nonlinearity up to 10 dB and 55 degree with any combination. Linearizer is used to operate the high power amplifier at near saturation or at less power back off condition with improved non-linear performance and improved DC to RF efficiency of the communication system. Diode based pre-distortion type linearizers are popularly used for its compactness and low power consumption.
Indian Space Research Organisation (ISRO) at its Space Applications Centre (SAC) has developed a C/Ku Ortho Mode Transducer (OMT) for combined C/Ku receive feed system. Such an Ortho Mode Transducer permits combination of separate C and Ku terminals into a single system thereby effecting cost savings.

**SALIENT FEATURES**

- **Frequency Bands**
  - C Band : 3.7 GHz – 4.2 GHz
  - Ku Band : 10.95 GHz – 12.75 GHz

- **Polarization**
  - Dual Linear (Lin V / Lin H)

- **VSWR**
  - C Band : 1.65@ 3.7 – 4.2 GHz
  - Ku Band : 1.4@ 10.95 –12.75 GHz

- **Insertion Loss**
  - C Band : 0.5 dB @ 3.7 – 4.2 GHz
  - Ku Band : 0.7 dB @ 10.95 – 12.75 GHz

- **Isolation**
  - C Band Lin V to Lin H : 35 dB min
  - C Band to Ku Band : 70 dB min
  - Ku Band Lin V to Lin H : 35 dB
  - Ku Band to C band : 70 dB
A Device for Compensating the effect of Temperature Variation on the Brightness of Light Emitting Diodes (LEDs).

Indian Space Research Organization (ISRO) has developed a device for compensating the effect of temperature variation on the brightness of LEDs, which will find wide commercial and special applications. It is required to achieve temperature invariant brightness of LEDs for different instruments and automobile applications. However, brightness of the LEDs changes exponentially with the change of operating temperature of the diodes. The driver circuit will provide temperature compensated voltage / current to the LEDs to compensate the brightness changes with temperature.

**SALIENT FEATURES**

- The LED driver circuit will provide bias to the LEDs to provide temperature compensated brightness without using any temperature sensors
- No temperature sensor is required, since properties of the diodes themselves are used to achieve the temperature compensation performance
- Temperature controlled bias voltage/current generated according to the junction temperature of the LEDs, any temperature gradient will not affect the temperature compensation
- Temperature changes induced by power dissipated within the diodes are also compensated
- No trial and error method is involved to optimize the circuit performance

**APPLICATION(S)**

- Camera calibration
- Colour printer application
- Applications in traffic light, signal light etc.
- LED displays in different instruments
C-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.

**SALIENT FEATURES**

- Can calibrate individual Like and Cross–Polarised C-band SAR Channels; VV, HH, VH, HV & Circular Polarisation using two ARC Rxs.
- Dual Polarized broadband (7%) multilayer microstrip antenna of 23 dB gain and cross polarization better than -40 dB.
- Antenna protected by radome using inverted patch.
- Receiver Input Signal range: -25 to -60 dBm, Max Tx signal: + 20dBm.
- Each Channel contains Selectable Gain with Digital control (Step: 1dB) & 6 bit Digital Phase Control in steps of 5.625 deg.
Space Applications Centre has developed a 15WC Band SSPA that can handle from twelve to twenty-four numbers of Normal C-Band SSPAs. The growing demand for band width to support such applications is calling for a large number of transponders to be deployed in the coming years. 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 scope of the proposed technology transfer consist of fabrication, optimization, testing and delivery of the RF Assembly.

The SSPA consists of RF Assembly and an Electronic Power Conditioner [EPC] Assembly.

**ATTENUATORS**

- The SSPA has two PIN attenuator circuits. One is a two-section commandable attenuator providing up to 24dB of attenuation for on-board gain control. The second attenuator is used for compensation of gain variation against temperature. Each attenuator section employs 3dB Lange couplers with two PIN diodes.
- The commandable attenuator is externally controlled through serial commands. These commands are processed with in 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.
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 15Watts (41.8dBm) in the specified operating frequency band. Nine amplifier stages provide the required 86dB 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 coaxial cable. The Power Section houses the MGF38V and MGF44V devices, the latter being a 25Watt output device from Ms/Melco. The space between the low power and high power sections is occupied by inter connections and harnessing.

Overall Block Diagram of SSPA
Indian Space Research Organisation (ISRO) has developed a driver circuit for stepwise temperature invariant performance of diode-based RF circuits such as p-i-n and Schottky diode-based attenuator, phase shifter, linearizer etc which will find wide commercial and special applications.

It is frequently required that some electrical parameters (such as attenuation, phase shift, gain, etc) of a diode based RF circuit be controlled in a stepwise manner according to a digital signal command. RF resistance of the RF diodes is very sensitive to the temperature of the circuits and also RF performance. This driver circuit provides temperature-controlled bias to the RF diodes in such a way that the stepwise RF performance of the diode based RF circuits will remain temperature invariant.

**SALIENT FEATURES**

- The driver circuit will provide bias to the RF diodes to provide temperature compensated RF performance without using any temperature sensors
- No temperature sensor is required, since properties of the diodes themselves are used to achieve the temperature compensation performance
- The temperature controlled bias voltage/current generated according to the junction temperature of the RF diodes themselves, thus any temperature gradient will not affect the temperature compensation
- Temperature changes induced by RF energy dissipated within the diodes are also compensated
- No trial and error method is involved to optimize the circuit performance

**APPLICATION(S)**

- Electronically controlled RF attenuators for various RF/Microwave instruments
- Electronically controlled RF phase shifters for RF/Microwave instrument and digital beam forming networks
- Gain control of RF/Microwave amplifiers for on-board and ground based instrument
- RF Linearisers for TWTAs, SSPAs
TWO CHANNEL MONOPULSE TRACKING RECEIVER

The Indian Space Research Organisation (ISRO) has developed a Two Channel Monopulse Tracking Receiver which will find applications in large earth stations for tracking both GEO and LEO satellites.

The two channel monopulse tracking receiver is one of the subsystems of auto track system in large earth stations. The tracking receiver receives two signals at IF corresponding to the sum channel and error channel of the feed assembly. It uses AGC and coherent demodulation to derive output voltages proportional to azimuth and elevation errors. These output voltages are used by antenna control unit to correct off pointing.

SALIENT FEATURES

- Wide tracking range: 70 MHz ± 250 KHz
- Wide dynamic range: 70 dB
- Low input C/No threshold: 40 dB-Hz
- Selectable loop BW: 300 Hz, 1 KHz & 3 KHz
- User friendly operation from local and remote
- Save / recall configuration for different satellites
- Programmable sweep range and sweep rate
- 19” rack mountable 3U chassis

CURRENT INSTALLATIONS

- Master Control Facility (MCF), Hassan, India

APPLICATION(S)

- This tracking receiver is useful in large earth stations for tracking both GEO and LEO satellites. It meets the stringent requirements of large earth stations at lower cost.
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed a technology for Miniaturized High Frequency DC-DC Converter which will find applications where weight and volume is a constraint, especially in aerospace applications.

The DC-DC converter provides regulated and isolated voltages for powering various avionics packages with input voltage ranging 16-40V and delivering 15 watts of total output power with output voltage of +5V, ±7.5V, ±5V and ±15V.

The DC-DC converter developed is highly efficient to provide regulated output voltages and the switching frequency is 400 KHz. The DC-DC converter is miniaturized to the size of 9.7x4.4x2.45 cm³, weighs only 100 gm and is economically cost effective.

SALIENT FEATURES

- High efficiency, reliability, small size and lower mass
- Use of surface mount technology to give reliable assembly at reduced cost
- As a substitute for imported MIL qualified DC-DC Converter
- Feed forward technique to achieve excellent audio frequency rejection
- Built in EMI filter configured to meet the requirements of MIL-STD-461C
- Wide input voltage range and amplitude modulated feedback system
- Lead lag compensation to achieve loop bandwidth of 12KHz and better load transient response

APPLICATION(S)

- The miniaturized high frequency DC-DC converter can be used for any application where volume and weight is the main constraint. It may find wide application in aerospace, avionics systems and high reliable applications
INTRINSIC SAFE MODULE

Indian Space Research Organisation at its Satish Dhawan Space Centre (SDSC-SHAR) has developed an Intrinsic Safe Module, which can be used in hazardous (explosive) area for electrical control applications.

Intrinsic Safe Module ensures that electrical energy available in the electrical actuators and interfaces present in the hazardous area are limited to a level such that it will not cause any ignition.

The Intrinsic Safe unit is designed such that the voltage and current supplied from the circuit is limited to safe level in case of component failure or any problem in the field.

The Intrinsic Safe power unit consists of a bridge rectifier and a transistor, zenor diode combination for voltage and current control, one more same set is provided for redundancy and one transistor resistor combination is used for final current limiting and incase of failure of all these components an high speed fuse will act to protect the entire system.

**Specifications**

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating voltage</td>
<td>10V dc</td>
</tr>
<tr>
<td>Max. current output</td>
<td>85mA</td>
</tr>
<tr>
<td>Safety fuse rating</td>
<td>100mA</td>
</tr>
<tr>
<td>Relay rating</td>
<td>10.2mA, 1000 Ω</td>
</tr>
</tbody>
</table>

**APPLICATION(S)**

- EOT cranes control circuit in hazardous area
- Electrical Motor operation in hazardous area
Indian Space Research organization at its National Remote Sensing Centre has developed a 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. 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 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.
SALIENT FEATURES

- Entire Demodulation functionality with single FPGA
- Reference carrier generation in the same FPGA
- Implementation of Multi demodulation schemes (BPSK, QPSK)
- Different Data rates selection
- Simultaneous Demodulation and Bit Synchronization

<table>
<thead>
<tr>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling frequency (Fs)</td>
</tr>
<tr>
<td>Carrier frequency</td>
</tr>
<tr>
<td>Data Rates (Fb)</td>
</tr>
<tr>
<td>Low pass filters used</td>
</tr>
<tr>
<td>FIR sampling frequency</td>
</tr>
<tr>
<td>FIR Cutoff frequency</td>
</tr>
<tr>
<td>Loop filter used</td>
</tr>
<tr>
<td>Loop filter cutoff frequency</td>
</tr>
</tbody>
</table>

APPLICATION(S)

- High Data rate demodulation for remote sensing data reception system
Indian Space Research Organisation at its National Remote Sensing Centre has developed a 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 functional block diagram of IF Switching Matrix with all the support interfaces is as shown below.
**SALIENT FEATURES**

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

**APPLICATION**

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

**CURRENT INSTALLATION**

- National Remote Sensing Centre, Earth Station, Shadnagar

---

**Specifications**

**Electrical**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Range</td>
<td>DC - 4 GHz</td>
</tr>
<tr>
<td>Matrix Size</td>
<td>8 (Inputs) X 10 (Outputs)</td>
</tr>
<tr>
<td>Matrix Type</td>
<td>Non-Blocking</td>
</tr>
<tr>
<td>Insertion Loss</td>
<td>20 dB (aprox.)</td>
</tr>
<tr>
<td>Port to Port Isolation</td>
<td>&gt; 90 dB</td>
</tr>
<tr>
<td>VSWR</td>
<td>1.2 : 1</td>
</tr>
<tr>
<td>Key Pad</td>
<td>3 x 3 Matrix type</td>
</tr>
<tr>
<td>LCD screen</td>
<td>240 x 128 Graphics LCD</td>
</tr>
<tr>
<td>Remote interface</td>
<td>Ethernet and RS-232</td>
</tr>
</tbody>
</table>

**Environmental**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature</td>
<td>+5° C to +40° C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-10° C to +60° C</td>
</tr>
</tbody>
</table>

**Power supply (external)**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Power Supply</td>
<td>230V +/- 10% AC @ 50Hz +/- 3Hz</td>
</tr>
<tr>
<td>Operating voltages</td>
<td>+5V ,+15V and +24V</td>
</tr>
</tbody>
</table>
Indian Space Research Organization at its ISRO Satellite Centre (ISAC) has developed Microwave Passive Devices.

Microwave Frequency Devices like Frequency Filters and Waveguide Pressure Windows for application on RF checkout operation on spacecraft have been developed. These are of general purpose use in nature and can be used for commercial application in terrestrial communication.

These devices have been developed / fabricated using in-house developed software calculation programmes. The realized designs have also been validated using the international standard simulation tools, fabrication through in-house / external fabrication facilities and subsequent performance characterization using in-house test set ups.

As commercially available software design and simulation tools are very costly and may not be affordable for the budding entrepreneurs in the country, these programmes can help them establish commercially viable RF & Microwave Products.
<table>
<thead>
<tr>
<th>Device Type</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evanescent Mode Filter</td>
<td>For small size, bandwidth 1 to 10%, frequency of operation L-band to Ku-band</td>
</tr>
<tr>
<td>Post Coupled Filter</td>
<td>For Low Insertion Loss, bandwidth 4 to 10%, frequency of operation S-band to Ku-band, high power applications</td>
</tr>
<tr>
<td>Iris Coupled Filter</td>
<td>For Low Insertion Loss, bandwidth 4 to 10%, frequency of operation S-band to Ku-band, high power applications</td>
</tr>
<tr>
<td>Waveguide Pressure windows</td>
<td>For TVAC applications, frequency of operation S-band to Ka-band, high power applications</td>
</tr>
</tbody>
</table>
Indian Space Research Organisation at its Satish Dhawan Space Centre (SDSC-SHAR) has developed a set of D.C. field coils indigenously in collaboration with BHEL, Hyderabad, for use with the 16 t force capacity water cooled shakers. These field coils are used for generating the high intensity magnetic field inside the electro-dynamic shaker.

**PRINCIPLE OF OPERATION**

The D.C. field coils are made of copper tubes, which can take 400A DC current and 230V voltage. Each field coil comprises 9 copper coils brazed with manifolds at inlet and outlet to supply the cooling water. Each of the 9 copper coils is covered with insulation tape (fiber glass) and bonded with epoxy layer. Finally, the coil assembly is encapsulated by potting with room temperature epoxy resin.
SALIENT FEATURES

- Capability to draw the 400A and 230V DC power for generating the required magnetic field inside the electro-dynamic shaker
- The field coils are wound with special care to reduce the stray magnetic fields and all the individual fields are exactly aligned with each other to generate high intensity magnetic field
- The field coils can withstand a temperature of up to 90degC

APPLICATION(S)

Use in electro-dynamic shaker and similar systems. These field coils generate the DC magnetic field which in turn aid in the generation of dynamic force. The electro-dynamic shaker system is needed for qualification vibration testing of launch vehicle and spacecraft related components and sub-assemblies. Electro dynamic shaker used in heavy industries can use the invention for generation of dynamic force.
Indian Space Research Organisation (ISRO) at its Space Applications Centre has developed a novel and versatile true time delay phase shifter circuit which is realized on a Gallium Arsenide based Monolithic Microwave Integrated Circuit (MMIC). It caters to variable differential delay requirements of 16psec to 1008psec, in response to a 6 bit digital control signal for phased array antenna application.

This time delay circuit is suitable for a network which produces time delayed microwave signals for large instantaneous bandwidth systems to provide antenna beam patterns which are substantially constant over the bandwidth of the system. RF and microwave industries involved in the design and development of TR modules, airborne and space radar systems will benefit from this invention.

**SALIENT FEATURES**

- Wide dynamic range : 16psec -1008psec @ 1.25 GHz over 20% bandwidth
- Fine resolution : 16ps
- 6 bit TTD-Phase Shifter
- Small size

**APPLICATION(S)**

- For Phased Array Antenna application
- Beam Forming Modules
Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed a Safety Ohm Meter. This is an instrument for accurate resistance measurement over wider resistance range, especially for the safe and reliable squib resistance measurement of electrically initiated pyro devices used in Aerospace, Automobile and other industries.

**SALIENT FEATURES**

- Measures very small resistance, especially squib resistance of electro explosive devices, where safety is mandatory.
- Operates on 1.5V DC, thus restricts the energy for the squib to ignite even at inadvertent failures.
- Total circuit current monitoring, thus confirming safety limits before proceeding with measurements and during measurement.
- Resistance measurement up to 10kΩ, which enables isolation measurements also with the same equipment.
- Reduced power, low voltage operation and highest reliability – Uses only passive electronic and mechanical components
- Uses Null indication method which is independent of the characteristics and calibration of the null indicator.
- Fail safe operation.
- Mechanical monitoring and display devices
- Enclosed in an electrostatically safe enclosure.
- Confirms to MIL-STD-1576, method 201.

**APPLICATION(S)**

Safe and reliable squib resistance measurement of electrically initiated pyro devices used in Aerospace, Automobile and other industries.
Indian Space Research Organisation at its Space Applications Center (SAC) developed a Solid State Recorder (SSR) based on non-volatile flash memory for applications requiring high speed data recording and large storage capacity. Industry standard NAND flash has been used due to property of increased density and cost reduction. These SSRs make an ideal data capture media for airborne sensors as well as other applications requiring high data ingest rate and capacity (including applications ground testing and archival of data). The architecture has been specially optimized for mass, volume and power. Various input connectivity options allow these recorders to be readily applied with most of the data heavy sources. The highly scalable and flexible architecture allows augmentation to high storage densities.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustained Input Data Rate</td>
<td>1.2 Giga Baud</td>
</tr>
<tr>
<td>Storage Capacity</td>
<td>Up to 16 Tb</td>
</tr>
<tr>
<td>Temperature Range</td>
<td>-40°C to +75°C</td>
</tr>
<tr>
<td>Storage Medium</td>
<td>NAND Flash</td>
</tr>
<tr>
<td>Mass</td>
<td>&lt; 1.0 Kg</td>
</tr>
<tr>
<td>Power</td>
<td>&lt; 10 Watts</td>
</tr>
<tr>
<td>Data Retrieval</td>
<td>USB / Ethernet</td>
</tr>
<tr>
<td>Input Interface</td>
<td>Serial 8/10b encoded data on copper/ Optical connectivity (LVDS / RS422 serial/parallel and RS232 serial data at correspondingly lower speeds)</td>
</tr>
<tr>
<td>Operational Voltage</td>
<td>5-12 Volts (non-isolated)</td>
</tr>
<tr>
<td></td>
<td>9-36/18-72 Volts (Isolated)</td>
</tr>
<tr>
<td>Package Size</td>
<td>220mm X 150mmx25mm</td>
</tr>
<tr>
<td>Operator Interface</td>
<td>Custom Utility (Win based)</td>
</tr>
</tbody>
</table>
SALIENT FEATURES

- NAND Flash based multiple chips
- Scalable and flexible design
- High performance
- Optimized for mass, power and volume
- Bad Block identification and management

APPLICATION(S)

- Imaging data recording
- High speed sensor data acquisition
- Airborne applications
- Ground testing and data archival
MECHANICAL AND MATERIALS
METHOD OF WELDING THIN WIRE

Indian Space Research organization at its Vikram Sarabhai Space Centre (VSSC) has developed method of welding thin wires of thickness ranging between 25 to 100 microns, especially used for aerospace applications. During the welding of thin wires having very small diameter, most of the conventional welding techniques fail and suffer due to inaccessible weld locations. The conventional welding techniques are having various limitations in terms of precision, quality and the life of weld.

The method of welding developed by us is suitable for welding thin wires used for aerospace applications. It is based on the principle of metal joining by fusion using pulsed laser beam. The laser power and spot size is reduced with an aperture, to spot weld the thin bridge wire. A needle fixture is developed to hold the thin wire in position during the welding process.

The welding method allows for eliminating the wire necking generally observed in the welding process by forming swelled portions of apprx. Three times the wire diameter at either end of wire and subsequent swell flattening. The resultant weld has improved level of quality with sufficient mechanical strength for aerospace applications. The needle fixture holds the wire over inaccessible locations during the spot welding process. The improved method of welding process achieves high quality micro welding using a moderately high power laser welding station with the help of a power reduction aperture.
Indian Space Research Organisation (ISRO) at its Space Applications Centre (SAC) has developed a Precision Tapping Attachment which will find applications for precision tapping in mechanical packages. This attachment is useful for tapping highly precise M1.2 screws and above with accuracy.

**SALIENT FEATURES**
- Useful for highly precise M1.2 screws and above with accuracy
- To ensure for perfect and precise tapping with perpendicularity
- Ensuring tapping up to proper depth
- No jamming or breaking of tapping tool
- Even unskilled worker can use it
- Increase in productivity

**SPECIFICATIONS**
- Tapping Capacity: Starting from highly precise M1.2
- Overall Size: 345 mm x 300mm x 330 mm height
- Swiveling of arm: 360°
- Vertical Adjustment: Easily possible up to 300 mm
- Tapping Operation: Manual
- Gross Weight: 9 kg
- Tools: Standard tools can be used
- Horizontal Adjustment: In range of 50 mm, Max. Distance 215 mm
- Extension: Extendable for Helicoil insertion and semi-automation for vertical feed and lubrication
DK18 is a MgTiO$_3$ based ceramic, which is widely used as Patch Antenna substrates in Satellite and GPS communication systems. This dielectric, medium permittivity material, possesses extremely low dielectric loss ($\tan\delta\sim10^{-5}$) in microwave frequency ranges.

Electronic ceramics with high permittivity ($\varepsilon_r>20$) and low dielectric loss ($\tan\delta<10^{-3}$) has a number of applications in microwave devices like filters, oscillators, multiplexers etc in terrestrial as well as Space communication systems ranging from UHF to mm band frequencies. In such devices, it is desirable that the ceramics has high $\varepsilon_r$ to confine the electromagnetic waves near them. However, when applications like antennas and substrates are considered, $10<\varepsilon_r<20$ 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 $\rho$, only about a half that of tantalates.

### Typical properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Light cream</td>
</tr>
<tr>
<td>Bulk density (g/cc)</td>
<td>$3.7\pm0.15$</td>
</tr>
<tr>
<td>Open Porosity</td>
<td>Nil</td>
</tr>
<tr>
<td>Closed Porosity</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>Resistivity (Ω.cm)</td>
<td>$10^{13}$</td>
</tr>
<tr>
<td>Coeff. of Thermal Expansion ($10^{-6}$/K)</td>
<td>9.2</td>
</tr>
<tr>
<td>Dielectric constant ($\varepsilon_r$)</td>
<td>19±1.5</td>
</tr>
<tr>
<td>Quality factor (Qu @ GHz)</td>
<td>12,000 (6.5)</td>
</tr>
<tr>
<td>Loss factor ($\tan\delta$, $10^{-5}$)</td>
<td>8.4</td>
</tr>
<tr>
<td>Temp. coeff. of frequency (tf, ppm/K)</td>
<td>0 ± 5</td>
</tr>
<tr>
<td>TE01δ resonator size at 5 GHz (D=2L, mm)</td>
<td>14</td>
</tr>
</tbody>
</table>
Indian Space Research Organisation at its Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram has developed various kinds of 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 millimetre 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.

<table>
<thead>
<tr>
<th>Typical properties</th>
<th>(Target)</th>
<th>(Achieved)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density</td>
<td>$&lt; 8 \text{ g/cm}^3$</td>
<td>$7.45 \pm 0.1 \text{ g/cm}^3$</td>
</tr>
<tr>
<td>Dielectric constant (er)</td>
<td>$25\pm 3$, $24\pm 1$</td>
<td></td>
</tr>
<tr>
<td>Unloaded Q-factor (Qu)</td>
<td>$15,000 @ 5.6 \text{ GHz}$</td>
<td>$28,000 @ 5.6 \text{ GHz}$</td>
</tr>
<tr>
<td></td>
<td>$22,000 @ 7.5 \text{ GHz}$</td>
<td></td>
</tr>
<tr>
<td>Unloaded Q-factor (Qu)</td>
<td>$8,000 @ 10 \text{ GHz}$</td>
<td>$20,000 @ 10 \text{ GHz}$</td>
</tr>
<tr>
<td>Temp. coeff. of freq. (tf)</td>
<td>$&lt; 7 \text{ ppm/K}$</td>
<td>$6 \pm 1.0 \text{ ppm/K}$</td>
</tr>
</tbody>
</table>
SILICA FIBRE

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

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

FIBRE SPECIFICATIONS

- Composition : Silica (99.5%)
- Diameter : 1-20 µ
- Length : 5-20 mm
- Aspect ratio : 500 – 20,000
- Morphology : Amorphous (1400°C)
- Heat Treatment : Up to 1400°C
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 subsequent firing using microwaves. They can be used for high temperature insulation up to 1250°C. Since they are hollow and weigh less, they can also be used as filler materials for paints, polymer/metal and ceramic matrices to reduce density and improve thermal properties.

**PRODUCT SPECIFICATIONS**

- **Product Composition**: SiO₂ (99.5%)
- **Diameter**: <2 mm
- **Bulk Density**: <0.35 g/cc
- **Morphology**: Hollow, Fibrous & Amorphous
Indian Space Research Organization (ISRO) at its Liquid Propulsion Systems Centre has developed a novel pressure regulator which will find wide industrial and commercial applications.

**PRINCIPLE OF OPERATION**

This device has two single stage regulators working independently arranged in reverse cascaded way with only one regulator functioning at a time. The open mode failure or leak of first regulator initiates the second regulator to carry out regulation. The regulators are in a single housing and thus overall envelope and weight is reduced as in comparison to two independent regulators.

**SPECIFICATIONS**

- **Inlet pressure**: 15 to 0.5 MPa
- **Outlet pressure range**: 0.05 to 0.15 MPa
- **Regulation band**: +0.002 MPa (both regulators)
- **Working fluid**: Xe, GHe and GN₂
- **Operating temperature**: 288 to 328 K
- **Maximum flow rate**: 5 mg/s of Xe
- **Internal leak tightness**: < 1 x 10⁻³ sccs of GHe
- **External leak tightness**: ≤1 x 10⁻⁶ sccs of GHe
- **Operating life**: 10 years
- **Cycle life**: 5000 cycles
- **Weight of valve**: ≤ 1.4 kg

**ADVANTAGES & SALIENT FEATURES**

- Operates in Space environment
- Low envelope and weight.
- Improved life and redundancy compared to single stage regulators.
- Compact design, simple in construction, robust in operation, easy to manufacture in large scale, industrially viable

**APPLICATION(S)**

- Aerospace / satellite industries
Indian Space Research Organisation at its Satish Dhawan Space Centre (SDSC-SHAR) has developed a technology for upgradation of Vertical Turning Milling machine. The technology is developed to retrofit and upgrade the machine with state of art control systems and suitable interfaces, so that the useful life of the machine can be successfully extended by many years and high quality of machining is assured.
The upgradation involves dismantling old control systems, motors, panels, laying of new cables, installation of new CNC and electrical panels, junction boxes, design, fabrication and fixing of all mechanical interfaces, positioning and aligning the servo motors and spindle motors with shafts, powering the systems, integration, drive checks, panel checks, PLC checks, machine operations and functions checking, axes calibration with laser source, cutting trials, machining trials with Insulation specimens, software installation and training, familiarization and training on operations, interfacing old mechanical systems with new control systems and recommissioning the machine.

**APPLICATION(S)**

- This technology will help the industries to augment/upgrade their existing machines.
Indian Space Research Organization (ISRO) at its Liquid Propulsion Systems Centre has developed a novel normally closed inline pneumatically actuated valve that has low weight and envelope (when compared to conventional actuator valves) for usage in low temperature application.

**PRINCIPLE OF OPERATION**

The usual way of achieving high equivalent port for a valve is by providing an actuating device capable of giving high seat lift required for achieving the required flow area. The actuating device, i.e. Bellows should have large lengths which inturn increases the envelope and weight of valve.

In this valve design the high seat lift is achieved by tandem movement of two actuating bellows which are arranged in series. One bellow is housed inside another, thus resembling a telescopic arrangement. The overall weight & envelope of valve is reduced by arranging the bellows in telescopic fashion.

**SPECIFICATIONS**

- Inlet pressure : 0.3±0.01 MPa
- Working fluid : GH², GHe and GN²
- Operating : 120 K to ambient temperature range
- Command pressure : 5 ± 0.3 MPa
- Pressure drop : ≤ 0.02 MPa across the valve
- Internal leak tightness : < 1.0 sccs of (Inlet or outlet GHe pressurised condition)
- Minimum command : 3.5 MPa pressure to open the valve fully
- Weight of valve : < 7.5 kg
ADVANTAGES & SALIENT FEATURES

• Low temperature and high flow rate application
• Low pressure drop due to telescopic arrangement of actuating bellows
• Compact, simple in construction, robust in operation, easy to manufacture in large scale, industry viable.

APPLICATION(S)

• Aerospace industries
• Low temperature gas handling in industries
• Steel manufacturers
• Food industry using cold $N_2$ freezing techniques
Indian Space Research Organisation (ISRO) at its Liquid Propulsion Systems Centre has developed a novel check valve which has low envelope and also avoids system failure caused by chattering phenomenon usual in check valves.

**PRINCIPLE OF OPERATION**

Conventionally, redundancy for a check valve is achieved by adding another check valve or poppet, in series. This arrangement will not help avoiding the failure mode called chattering because if one poppet chatters it gets coupled to the second instantaneously. This check valve has double poppets arranged telescopically ensuring chatter free operation for inner poppet. The sealing plain for 1st and 2nd poppets are arranged in such a manner that during closing the 1st poppet will move away from 2nd and during opening it will go inside the 2nd. Another important specialty of the valve is its pressure drop less than the cracking pressure. This valve can be used for both liquid and gaseous medium.

**SPECIFICATIONS**

- Cracking pressure : 0.35 MPa
- Reverse seal leakage : $1 \times 10^{-4}$ sccs of GHe at 0.11 MPa at outlet
- Pressure drop : $\leq 0.25$ Mpa
- Flow rate tested : $4.67$g/s of GN2 at 0.56 MPa inlet pressure with a pressure drop of 0.22 MPa
ADVANTAGES & SALIENT FEATURES

- Chatter free operation of 1st poppet.
- Lesser envelope for valve and thus lesser weight due to telescopic arrangement of poppets.
- Pressure drop lesser than cracking pressure.
- Redundancy built in the valve
- The valve is simple in construction, robust in operation, easy to manufacture in large scale, industry viable

APPLICATION(S)

- Aircraft / Aerospace industry
- Petroleum industry
- Valve manufacturers
- Fluid power machine manufacturers
- Mining industry
Indian Space Research Organisation (ISRO) at its Liquid Propulsion Systems Centre has developed a novel pilot operated command valve which has a compact envelope and offers better leak tightness compared to conventional command valves.

**PRINCIPLE OF OPERATION**

This valve is basically used to give command pressure to various control packages used in Liquid propulsion Systems. The main valve has 6 mm port and is pilot operated command valve which is commanded by a pilot valve of 1.2 mm port.

The main valve is a pneumatically operated 3 way valve with bellow as the actuator element and employs self aligning poppets mechanism for improving its leak tightness in the circuit. Evidently, this design feature improves the valves reliability to a larger extent compared to conventional ones. On the other hand, the Pilot valve is a 1.2 mm port, direct acting, 3 way solenoid valve which gives pneumatic command to the main valve. In addition, both pilot valve and main valve uses soft poppets to achieve added protection against leak. It may be noted that both the valves are integrated on a common body to have a compact envelop thus saving considerable weight when used in larger numbers.
**SPECIFICATION**

- **Type**: Electro pneumatic, 3 way valve
- **Working fluid**: Ambient gas
- **Valve port size, mm**: 6
- **Inlet & outlet dia., mm**: 6
- **Operating pressure, bar**: 35-50
- **Operating**: Ambient temperature, K
- **Internal leakage**: <1.5 x10^-2 scc/ at 50 bar, sec of GN2
- **External leakage**: < 1x10^-6 scc/ at 25 bar, sec of GHe
- **Supply voltage, VDC**: 28+4
- **Pull in volt at 50 bar,**: 21 VDC max.
- **Drop out volt at**: 4 VDC min. no load condition
- **Response time at 50 bar and 28 VDC, msec Opening**: 90
- **Closing**: 90
- **Storage life, years**: 7

**ADVANTAGES & SALIENT FEATURES**

- Minimum leakage of the valve.
- Lesser envelope for valve and thus lesser weight.
- The valve is simple in construction, robust in operation, easy to manufacture in large scale, industry viable.

**APPLICATION(S)**

- Aircraft / Aerospace industry
- Valve manufacturers
- Petroleum industry
- Fluid power machine manufacturers
- Mining industry
Indian Space Research Organisation at its Satish Dhawan Space Centre (SDSC-SHAR) has developed a technology for fabrication of In-line Disc Filters.

**SALIENT FEATURES**
- Disc filter involves unique procedure to be followed for fabrication
- The disc filters can be installed in between two flanges with gaskets
- The filters are of cleanable type and can be tested & reused

**APPLICATION(S)**
- Industry with filtration requirement of 10/30 micron.
- These filters can be accommodated in between flange joints with gaskets
- These filters can be used for Liquid and Gas application
Indian Space Research Organisation at its Satish Dhawan Space Centre (SDSC-SHAR) has developed a novel CAN type kerosene-air based gas generator system, specifically for use in small scale R&D testing involving supersonic internal and external flows.

**PRINCIPLE OF OPERATION**

Ignition source is obtained through the well mixed sustainable proportion of Acetylene and air mixture through a mixing tube. This premixed gas goes through a burner, where is it is ignited using a high voltage spark generator. Once flame is generated for the ignition of main fuel, viz., Kerosene-Air mixture atomized through a three injector manifold and a flame holding device with primary, secondary and tertiary air distribution system in annular mode. Instantaneous generation of high pressure and high temperature, very fuel lean hot gas thus is produced and it goes through a zig-zag mixing tube for obtaining uniform temperature pattern.

**ADVANTAGES & SALIENT FEATURES**

- Remote operation
- Simple in operation
- High output
- Suitable for R&D applications

**APPLICATION(S)**

- Suitable for R&D applications in space related sub systems testing. It provides driving fluid for all internal and external supersonic scale model testing with quick turn around time. Safer and remote operation is ensured as it involves high pressure and high temperatures.
Indian Space Research Organisation at its Satish Dhawan Space Centre (SDSC-SHAR) has developed a thick walled pneumatic vibration isolators of 150 kg and 2500 kg capacity.

**PRINCIPLE OF OPERATION**

The equipment to be protected is mounted on the isolators. The number of isolators are selected based on the weight of the equipment and stability requirements. The pressure is adjusted to level the specimen within +/- 5 mm of the nominal height. The rubber body and air column enclosed in it support the load. Generally the air pressure in the isolator offers the significant portion of the isolation capacity of the isolator. For shock application, the top surface initially deflects and then the shock loads are transferred to the outer wall. This type of isolator will be able to support and isolate the load even if the air leaks out in some exigencies, with slight reduction in the efficiency of isolator.
### Specification

<table>
<thead>
<tr>
<th></th>
<th>150 kg</th>
<th>2500 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>150 kg</td>
<td>2500 kg</td>
</tr>
<tr>
<td>Base Plate size</td>
<td>140mmx140mmx10mm</td>
<td>500mmx5000mmx20mm</td>
</tr>
<tr>
<td>Overall height</td>
<td>105mm</td>
<td>120mm</td>
</tr>
<tr>
<td>Operating pressure</td>
<td>3.5 bar</td>
<td>3 bar</td>
</tr>
<tr>
<td>Isolator diameter</td>
<td>130 mm</td>
<td>478 mm</td>
</tr>
<tr>
<td>Rubber</td>
<td>Neoprene</td>
<td>Neoprene</td>
</tr>
<tr>
<td>Reinforcement in shell region</td>
<td>Steel wire of wire diameter 2mm</td>
<td>Steel wire of wire diameter 5mm</td>
</tr>
<tr>
<td>Weight</td>
<td>2.9 kg</td>
<td>57.9 kg</td>
</tr>
<tr>
<td>Natural frequency (with air)</td>
<td>5 Hz</td>
<td>5 Hz</td>
</tr>
<tr>
<td>Natural frequency (without air)</td>
<td>10 Hz</td>
<td>10 Hz</td>
</tr>
</tbody>
</table>

### ADVANTAGE AND APPLICATION(S)

- The thick walled pneumatic vibration isolator is ideally suited to conditions requiring high deflection with low natural frequency and good lateral stability. This type of isolators requires less free height than conventional mounts.
- Automobiles, Air Compressors, Motor Generator and in Machineries
Umbilicals are extensively used in the fields of aviation, space technology as well as automotives. 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.

**PRINCIPLE OF OPERATION**

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

The ground segment has got a pack of Belleville disc springs to which gives designed sealing load & take up longitudinal deflections. A twin spherical ball mechanism is provided to transfer disc spring load to ground segment and accommodate assembly misalignments & vehicle sway. Moreover, the system employs push open type check valves on flight segment which enables transfer of fluid in mated condition and acts as redundant seal in case of a system component failure.
SPECIFICATION

- Accommodate vehicle sway of ±1mm
- Accommodate vehicle longitudinal deflection of 2mm in downward direction
- 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 in flight
- External leak in mated condition ≤ 1x10^{-3} SCCS of GN₂ at Room Temperature

ADVANTAGES & SALIENT FEATURES

- Compact design
- No complex locking and separating mechanism
- Simple concept of self sealing connectors
- Minimum assembly and test time required at launch pad
- Provides complete testability & serviceability at launch pad
- Easy fabrication, assembly and testing

APPLICATION(S)

- Servicing of aircrafts
- Launch vehicle
- Oil rigging operations
- Automobile industry
- Chemicals and fertilizer industry handling toxic chemicals
- Locomotives
- Commercial gas (LPG) filling center
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 its Vikram Sarabhai Space Centre (VSSC) has developed a technology for processing NiTi base 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.

**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 on impurities
- Achieves economy in cost and labour 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
APPLICATION(S)

• 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.
ELASTO MAGNETIC ABRASIVE SPHERES FOR SUPER FINE FINISHING

Development of a multipurpose, flexible, simple and cost effective approach for applying fine abrasives to finish surfaces without using slurry or altering the form of the surface is an ideal approach for meeting many challenging industrial applications.

Indian Institute of Space Science and Technology (IIST), Department of Space has developed a novel, simple and cost effective method for the preparation of Resilient Elasto Magnetic Abrasive Spheres for Fine Finishing of Surfaces. These elasto magnetic abrasives can be used as simple loose abrasive balls for fine finishing of complex and difficult to access surfaces using custom made simple setups, as per the end user requirement. Because of magnetic characteristics, these can also be used directly for magnetic abrasive finishing. The novel method developed involves a simple approach to prepare elasto magnetic abrasive spheres of varying size ranges for fine finishing of different types of surfaces and class of materials, with the help of simple custom made setups.

SALIENT FEATURES

- Simple, cost effective and direct chemical approach of preparing high resilient elasto magnetic spheres.
- Size of spheres, size and type of embedded abrasive grains, and elastic and magnetic characteristics are easily controllable
- Usage for fine finishing of surfaces (typically to achieve Ra value <0.1µm)
- The elastomeric nature, that can be controlled, makes the spheres deform itself in conformity to work surface to achieve fine finishing without changing its form.
- Environmentally safe, chemically inert and reusable (with a possibility of re-embedding the abrasive grains on the elastomeric spheres) under normal working conditions.
APPLICATION(S)

Elasto-magnetic abrasives can be applied for fine finishing applications with the help of custom made setups, as per the application requirements. Finishing of surfaces in many precision components including but not limited to dies, moulds, valves, bearing sleeves and similar intricate internal/external surfaces (including internal circumferential grooves).

TARGET INDUSTRIES

- Industries involved in the development of moulds, dies, fixtures, precision valve units, highly finished bushes, bearing sleeves etc.
- Industries involved in fine finishing of internal tubes, hollow specimens, high aspect ratio bores, EDM surfaces, intricate external surfaces, free form surfaces.
- R&D organisations / industries for ultra fine finished surfaces for precision engineering applications.
- Abrasion / erosion based finishing systems

PRE REQUISITES FOR PROSPECTIVE LICENSEES

Industries interested in know how transfer of the technology shall have adequate expertise, qualified manpower and prior and proven experience in the successful development of products for aforementioned manufacturing sectors.
Carbon foams are next generation advanced structural materials, made up of cellular carbon. These foams possess low density, good specific strength and tuneable thermal properties making them suitable for applications in high temperature thermal protection, ablative materials, acoustic materials, EMI shielding and as an electrode materials in batteries and bipolar plates in polymer membrane fuel cells.

Indian Institute of Space Science and Technology (IIST), Department of Space has developed a novel, simple and cost effective method for the preparation of carbon foams from sucrose and carbon powder. The conventional preparation process is based on fossil fuel derived precursors. The novel method uses naturally available renewable precursors for the preparation of carbon foams.

**SALIENT FEATURES**

- Natural, renewable and cheap precursors
- Environment friendly process with no evolution of toxic by-products
- Foam properties controlled by foaming temperature and carbon powder concentration
- Relatively good mechanical strength
- Low thermal conductivity

**SPECIFICATION**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density</td>
<td>0.1 to 0.3 g/cc</td>
</tr>
<tr>
<td>Cell size</td>
<td>0.5 to 2 mm</td>
</tr>
<tr>
<td>Specific BET surface area</td>
<td>200 to 500 m²/g</td>
</tr>
<tr>
<td>Thermal conductivity</td>
<td>~0.1 W/m. K</td>
</tr>
<tr>
<td>Compressive strength</td>
<td>0.1 to 3 MPa</td>
</tr>
<tr>
<td>CO₂ adsorption capacity</td>
<td>2.5 mmols/g</td>
</tr>
</tbody>
</table>

**ADVANTAGES OVER CONVENTIONAL SYSTEM**

Conventional system uses aqueous based process for the sucrose and carbon powder where 50% water in the resin medium requires more energy for evaporation. Also, agglomeration and sedimentation of particles in low viscous medium result in non uniform foam structure. Molten based technique of the proposed method overcomes these disadvantages of the aqueous system.
APPLICATION(S)

- Standalone foam structure for thermal insulation.
- Sandwich structure for structural application.
- Electrode in fuel cells.
- CO$_2$ scrubber.
- EMI shielding.
- Target Industries: Aerospace, ship building, battery and fuel cell manufacturers.
Indian Space Research Organisation (ISRO) at its ISRO Satellite Centre (ISAC) has developed a novel Mechanism for Dual Range Mass and Centre of Mass Measurement Machine technology. The technology is useful for highly accurate measurement of mass and centre of gravity.

**SALIENT FEATURES**

- The novel mechanism allows dual range measurement of mass and centre of gravity in a single setup
- Eliminates the need for multiple machines for measurement of varying mass of specimen
- Automated functioning of the machine and reduced human efforts in measurement and changeover
- Combines measurement of both mass and centre of gravity in a single setup, thereby avoiding additional handling for two independent measurements especially for delicate measurements

**APPLICATION(S)**

Mass and centre of gravity measurements in automobile industry, aerospace industry, turbine blades and rotating machinery etc.

**TARGET INDUSTRIES**

Aerospace, Turbo Machinery, Wind Energy and Research Institutes.
Indian Space Research Organisation (ISRO) at its Space Applications Centre (SAC) has developed a novel Vibration Management Solution. The system is based on wire rope mounts that provide inherent damping by virtue of relative motion between wire strands. Delicate electronic and optical systems vulnerable to vibration and shock can be protected using this system. The system is ideal for solving vibration and shock difficulties encountered during transportation in space and ground environment. Wire rope isolators accommodate large deflections without danger of bottoming and plastically deforming, thereby offering wide range of isolation for variety of applications.

**SALIENT FEATURES**

- All metal construction
- High inherent damping
- Wide temperature range 100-200 deg C
- Maintenance free
- Corrosion resistant
- Multidofs

**TECHNICAL SPECIFICATION**

<table>
<thead>
<tr>
<th>Type</th>
<th>Supported Mass (Grams)</th>
<th>Frequency Range (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVMS Quad-Fed</td>
<td>400-3000</td>
<td>5-2000</td>
</tr>
<tr>
<td>VMS Tri-Fed</td>
<td>&lt;18</td>
<td></td>
</tr>
<tr>
<td>SVMS Hex-Fed</td>
<td>&lt;65</td>
<td>20-2000</td>
</tr>
<tr>
<td>SVMS Platform</td>
<td>&lt;240</td>
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</tr>
</tbody>
</table>
TYPES
SVMS Quad-Fed, SVMS Tri-Fed, SVMS Hex-Fed, SVMS Platform

POTENTIAL APPLICATION AREA
- Space mission payload systems and instruments
- Delicate system suspension in planetary landers
- Air/Road/Sea transportation
- Equipment foundation
- Chemical processing equipment
- Seismic isolation

Realised AVS Approaches
Indian Space Research Organisation at its Satish Dhawan Space Centre (SDSC-SHAR) has developed a high pressure seeder which can generate 3 to 5 micron size liquid droplets and can be used for seeding high speed gaseous flows. These spherical liquid droplets can scatter the light (Mie Scattering). Based on the light scattering both qualitative and quantitative flow visualization like Particle Image Velocimetry (PIV) can be carried out.

PRINCIPLE OF OPERATION

The equipment employs suitable nozzles which are immersed in the liquid from which the seeding particles are to be generated. Preferably, vegetable oil like olive oil can be used. Once the air supply is given to the nozzles, required liquid droplets is generated in the diameter range of 3 to 5 microns. In order to carry the generated seed particles at high pressure, a high pressure bleed nozzle is also provided. This will act as carrier flow and carry the generated seed particles to the main flow and insert the seeding particles in the required flow where experiments are to be carried out. In order to prevent larger droplets to be picked by the carrier flow, an impact plate is also placed inside the chamber. The system is designed for remote operation for experiments with high pressure system.
SALIENT FEATURES

- The operating pressure can be varied from very low pressure <1 bar to a high pressure of 50 bar.
- Ideal for supersonic and hypersonic flow visualization and diagnostic experiments for both open and confined flows.
- Very simple operation with remote operation capability.
- The seed generation can be varied for suiting high and low mass flow rates by valve adjustment.
- Contamination with the inlet gas flow for seeded particle generation is very less.
- Since the seeder is using oil like olive oil, seeding particle will not cause any irritation/allergy to the operating personnel.

APPLICATION(S)

- Ideal for supersonic and hypersonic flow diagnostics experiments with Particle Image Velocimetry (PIV).
- The equipment is designed for a vast range operation. The seeder can be used for better flow visualization with gaseous flows.
Indian Space Research Organisation at its ISRO Satellite Centre has developed Heat Pipes which are highly efficient heat transfer devices. Heat Pipes use the continuous evaporation/condensation of a suitable working fluid for two-phase heat transport in a closed system. Since the latent heat of vaporization of the working fluid is very large, heat pipes transport heat at small temperature difference, with high rates. Heat pipes are sensitive to gravity.

Performance of a heat pipe is specified by Heat Transport capability which has a unit of Watt-meter.

Axially grooved, constant conductance, Aluminum-Ammonia Heat pipes are extensively used in thermal management of ISRO satellites. Heat pipes of different shapes, lengths and configurations are developed and being used for indigenously built satellites. These heat pipes operate in the temperature range of -40°C to 60°C.
APPLICATION(S)

Due to a variety of advantages, axially grooved heat pipes have found wide applications in space industries where satellites operate under micro-gravity environment.
Indian Space Research Organisation at its Satish Dhawan Space Centre (SDSC-SHAR) has developed a Hydrogen Peroxide based Gas Generator using Hydrogen Peroxide as the oxidizer, Ethanolamine as the fuel and Copper II Chloride as the metal salt catalyst. The hypergolic nature of the fuel and oxidizer is studied and the de-composition delay has been characterized using open cup drop tests. A pilot scale Gas Generator has been conceived, designed, realized and tested.

**PRINCIPLE OF OPERATION**

A premixed Ethanolamine (Fuel) and Copper II Chloride (Catalyst) are stored in a tank which is pressurized along with Hydrogen Peroxide (with 50% concentration) using nitrogen cylinders and pressure regulation system. An injector has been used in the Gas Generator for injecting fuel and oxidizer into the combustion chamber. Due to the hypergolic nature a spontaneous reaction occurs and the de-composed gases are expanded through the perfectly expanded C-D type nozzle.
**TEST MATRIX AND RESULTS** (% of metallic catalyst)

<table>
<thead>
<tr>
<th>Test Sl. No.</th>
<th>Configuration</th>
<th>Results</th>
<th>Duration of test (Seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;2&lt;/sub&gt; (bar)</td>
<td>Ethanolamine Pressure (bar)</td>
<td>CuCl&lt;sub&gt;2&lt;/sub&gt; Concentration (%)</td>
<td>P&lt;sub&gt;0&lt;/sub&gt; (bar)</td>
</tr>
<tr>
<td>1</td>
<td>18</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>15</td>
<td>5</td>
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<td>2</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>18</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>18</td>
<td>15</td>
<td>1</td>
</tr>
</tbody>
</table>

**Flow Rates Through the Injector**

**Ethanolamine and Hydrogen Peroxide**

<table>
<thead>
<tr>
<th>INJECTION PRESSURE</th>
<th>MASS FLOW RATE ACHIEVED (Kg/s) (Through 2 injector ports for fuel)</th>
<th>MASS FLOW RATE ACHIEVED (Kg/s) (Through 6 injector ports for Oxidiser)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Ksc</td>
<td>0.055</td>
<td>0.21</td>
</tr>
<tr>
<td>4 Ksc</td>
<td>0.075</td>
<td>0.3</td>
</tr>
<tr>
<td>6 Ksc</td>
<td>0.085</td>
<td>0.36</td>
</tr>
<tr>
<td>8 Ksc</td>
<td>0.113</td>
<td>0.41</td>
</tr>
</tbody>
</table>

*Process and Instrumentation Layout for Hydrogen Peroxide Gas Generator*

*Hydrogen Peroxide Gas Generator Injector Components*

*Hydrogen Peroxide Based GG in Operation*
SENSORS
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.

**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 S.S AISI 304/316/Inconel. The sensor uses unique construction techniques to obtain noise immunity and high response.
SPECIFICATION

Temperature Range : -196 ºC To +250 ºC
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/ ºC
Accuracy : 0 to 100 ºC ± 3 ºC; 0 to -196 ºC ± 7 ºC
Mass : 210 grams
Electrical interface : Multi pin hermetically sealed connector

ADVANTAGES & SALIENT FEATURES

• Fast response
• Wide temperature ranges
• Less weight
• Shock & vibration resistance
• Highly linear

APPLICATION(S)

• Space application
• Process industries
• R&D Laboratories
• Oil & Gas Industries
Cryogenic fluids such as liquid Nitrogen, liquid Oxygen, liquid hydrogen and liquid Helium find extensive application in Aviation, Space Technology and Scientific Research. Indian Space Research Organisation (ISRO) at its Liquid Propulsion Systems Centre in collaboration with Indian Institute of Science (IISc) has developed a novel ‘Fibre Optic Liquid Level Detector’, which will find wide industrial and commercial applications.

**PRINCIPLE OF OPERATION**

A number of Liquid Vapour (L-V) and Liquid-Liquid (L-L) interface sensing methods are used to facilitate liquid level measurements, especially related to difficult to handle fluids such as liquid nitrogen, oxygen, hydrogen and helium. The traditional methods rely upon differences in resistance, the capacitance, the acoustic impedance or the viscous dampening in order to sense the location of L-V interface. However, they have their own limitations.

Fibre optic devices sense the liquid level, frequently, through principles of reflection/refraction and they facilitate non-invasive level detection at an extremely high speed. The innovative “Fiber Optic Liquid Level Detector” developed by ISRO-IISc utilizes a ‘hollow prism’ that contains a leak tight hollow space trapped between a pair of ‘dielectric members’. When one of these dielectric members is arranged at an inclined angle to other, an optical beam launched onto the said hollow prism exhibits a ‘novel refractive behaviour’, which constitutes the basis for the working principle of the new level detector and is stated as under.

The optical beam emerging from the hollow prism remains either undeviated from the direction of optical beam that is entering into the hollow prism or suffers a deviation, depending upon whether the surface of the hollow prism from which optical beam exits is in air or immersed in liquid respectively.
SPECIFICATIONS

Medium : Any liquid that is transparent to the incident light
Mode of detection : Discrete detection of the L-V interface
Mounting resolution : Customer Specified upto 0.5 mm
Accuracy : Upto ± 0.1 mm
Maximum Operating : Upto 10 bar Pressure
Operating Temperature : Anywhere range between 320 K to 4.2 K
Materials in contact : User selectable with the media depending upon the chemical and thermal Properties of the media under measurement

ADVANTAGES & SALIENT FEATURES

• With the use of hollow prism, the level detection process depends only on the refractive index of the liquid and not on liquid temp. and pressure, which change dynamically in cryo liquid environment.
• Simple in construction, robust in operation, easy to manufacture in large scale, industrially viable. Suitable for a variety of fluids and very fast responses.
• The product does not require optical surfaces of high accuracy.
• Elimination of recalibration whenever a liquid under test is changed.
• Identical response-time for liquid level detection, during the filing as well as the draining operations.
• Traditional methods with high cost, slow response, heavy weight and potential “electric spark hazard”, pose several questions on their reliability, especially when used in detection of the liquid levels in fuel tanks in aerospace industry
APPLICATION(S)

“Fiber Optic Liquid Level Detector” with little or no modification will find wide commercial and industrial applications in aerospace, aviation, pharmaceutical, chemical, petrochemical industry and in scientific research:

- The product can be used to detect the liquid level of any transparent fluid.
- Measurement of fuel and oxidiser levels in large tanks of the cryo system is crucial, particularly when application area involves sensing and regulation of complex instrumentation tasks in a coordinated manner.
- The device will find application as “Green Monitoring Device”, in a variety of areas especially for sensing and controlling the quality and quantity of fuels, thereby contributing towards monitoring for environmental pollution control.
- Handling of petrochemical and chemically harsh liquids during storage and bulk transportation.
- “Built in device” in tanks of various sizes for detection of quantity of residual fuels in a more accurate manner.
- Optical approach ensures an electrically passive and inherently spark free sensing operation. In explosive environment, such features help to realize a safe operation with increased efficiency and reduced maintenance loads.
- Reliable monitoring of fluids quantitatively during filling or emptying of tanks at high flow rates.
ULTRASONIC LIQUID LEVEL SENSOR

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.

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.

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.
SPECIFICATION

Immersion Length : 125mm (Approx)
Level detection : 75 mm below mounting flange
Working liquids : N₂O₄, UDMH, water and any fluid with high density difference between vapour phase and liquid phase.
Fluids pressure : 10 bar (Abs)
Test pressure : 15 bar (Abs)
Operating Temperature : 0 to 70ºC
Material : SS 304 L
Vibration Resistant : 13.5g, 20-2000 Hz Random
Electrical interface : Multipin electrical connector
Mechanical interface : Threaded connection

ADVANTAGES & SALIENT FEATURES

• Miniature/low cost
• Less Weight
• High output
• Low hysteresis
• Shock and vibration resistant
• High dynamic response

APPLICATION(S)

• Automotive
• Oceanography
• Vacuum pressure measurement
• Process and chemical Industries
• Automatic weather stations
• Space applications
Indian Space Research Organisation (ISRO) at its Liquid Propulsion Systems Centre has developed temperature sensor, which will find wide industrial and commercial applications.

**PRINCIPLE OF OPERATION**

Accurate and reliable measurement of temperatures in high pressure gaseous and liquid media requires dedicated and specialized sensors. 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 ºC and encapsulated with S.S AISI 304/316/Inconel material. The sensor uses unique construction techniques to achieve noise immunity and high response.

**SPECIFICATION**

- **Temperature Range**: -196ºC to 250ºC
- **Time Constant**: ≤ 3.0 s
- **Material of Sheath**: AISI 304L/Z2 CN 18-10 (S.S.)
- **Sensitivity**: 0.39 µV / ºC
- **Accuracy**: 3.92±0.3×10⁻³ / ohm/ºC
- **Resistance at 0ºC**: 100.0± 0.25 ohms
- **Mass**: ≤ 100 g
- **Max. Pressure**: 300 Bar
- **Electrical interface**: Multi-pin hermetically sealed connector
ADVANTAGES & SALIENT FEATURES

• Accurate
• Reliable Measurement
• Linear
• Rugged
• Less weight
• Can withstand high flow rate
• Stable

APPLICATION(S)

• Space application
• Process Industries
• R&D Laboratories
• Oil & Gas Industries
Differential Pressure Transducer

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

**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 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. Any failure of the sensing element will be contained within the sensor and no catastrophic damage is caused to the system outside.
SPECIFICATION

Differential : ± 3, ± 5, ± 7,
pressure range  ± 10, ± 15
Line pressure  : 65 bar
Safe overload  : 75 bar
Excitation     : 10 V ± 5 mV
Output         : 10mV ± 1 mV
Non Linearity + : ≤0.5% F.S.O Hysteresis
Hysteresis     : ≤0.3% F.S.O
Sensitivity    : ±1mV/V
Zero & F.S.O drift : ±2 x 10^-4 in temperature/F.S.O/°C
Noise due to vibration : ≤1% F.S.O
Mass           : ≤950 gms
Maximum current : 28 mA @ 10 V.D.C
Wetted parts   : Stainless steel, 316L/304L
Mechanical interface : M14 x 1.5 male 2 nos.
Electrical interface : Multi-pin hermetically sealed electrical connector

ADVANTAGES & SALIENT FEATURES

• Rugged
• Hermetically Sealed
• Vibration resistance
• Compatible with corrosive fluid environments

APPLICATION(S)

• Aerospace
• Process Industries
• Air and Gas Compressors
• Oil and gas industry
Indian Space Research Organization (ISRO) at its Liquid Propulsion Systems Centre has developed 21 NA Pressure Transducer, which will find wide industrial and commercial applications.

**PRINCIPLE OF OPERATION**

21NA Pressure transducers is space qualified and is compact, accurate and light weight. 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 industry, wind tunnel studies etc.
SPECIFICATION

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 ± 5 mV Safe over load
For 0-3 to 0-20 bar : 2X Nominal pressure
For 0-30 bar : 40 bar
For 0-50 to 0-200 bar : 2X Nominal pressure
For 0-300 to 0-330 bar : 500 bar
Full Scale Output (FSO) : 20 to 21 mV For 10 Volts Excitation
Non Linearity + Hysteresis
For 0-30 to 0-300 Bar : ≤ 0.7% FSO
For 0-330 Bar : ≤ 0.85% FSO
Hysteresis : ≤ 0.5% FSO
Sensitivity : 2.01 mV/V
Zero & Nominal point : ≤ 2 X 10^-4 / drift in temperature FSO/ °C
Noise Due to Vibration : ≤ 1% FSO
Mass : ≤ 100 grams
Electrical interface : Multi-pin hermetically sealed connector

ADVANTAGES & SALIENT FEATURES
- Compact & Light Weight
- Hermetically Sealed
- Can withstand shock
- Vibration resistance upto 30grms
- High Dynamic Response
- Compatible with corrosive fluid environments

APPLICATION(S)
- Aerospace
- Process Industries
- Air and Gas Compressors
- Oil and gas industry.
- Automobiles
- Wind Tunnel Studies
- Oceanography
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.

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. One circular strain gauge is 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 custom designed 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.
SPECIFICATION

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 : Upto 800 Bar Containment Pressure
Nominal Excitation : 10 V DC nominal
FSO for 10 V Excitation : 20 mV +1 mV
Temperature drift of zero and FSO : < ± 2.0X10^-4/°C
Non linearity + : < ± 0.3 % FSO Hysteresis
Sensitivity : 2 ± 0.1 mV/V
Dimension / Mass : Φ 25 x 72 mm / 105 gms
Electrical interface : Multi-pin hermetically sealed connector
Mechanical interface : M14 x 1.5 Male / Nut and nipple

ADVANTAGES & SALIENT FEATURES

• Any range from 30 to 500 bar can be custom designed and manufactured.
• Compatible with corrosive & harsh fluid environments
• Full Stainless Steel Construction
• E.B welded and hermetically sealed
• Low Cost
• High Accuracy
• Rugged
• Shock 50gm
• Vibration resistance upto 30grms
• High dynamic response
• Fast response

APPLICATION(S)

• Space industry
• Oceanography
• Oil and gas industry
• Automobile
• Biomedical engineering
• Mining safety and process industry
Indian Space Research Organisation at its Satish Dhawan Space Centre (SDSC-SHAR) has developed a sensor for measuring temperature of Propellant Slurry in the Mixer Bowl.

During Propellant Mixing Process, Temperature of Slurry is to be closely maintained to realize proper product mix. For this measurement of Slurry Temperature inside the bowl is to be done accurately in a safe manner. For this special mould assembly with resin for the thermocouple sensors is conceived and fabricated. The sensors proved to be efficient, reliable and sturdy and have facilitated delicate and special process instrumentation requirement.

**SALIENT FEATURES**

- Flushes with the inside surface of the bottom of bowl and do not protrude into the mix since the clearance between blade-blade and blade-bowl is very minimum
- Intrinsic safe
- Fast response and does not create any conduction errors by its very existence
- Better performance, reliable and less expensive

**APPLICATION(S)**

- All chemical industries, process plants, refineries, production centers, where precision and reliable temperature measurement with safe methods are needed
Indian Space Research Organisation at its Satish Dhawan Space Centre (SDSC-SHAR) has developed Thyristor based temperature control system for hardware and propellant processing programmes to achieve fine temperature control with minimum spatial variation in autoclaves, hot air oven, curing hot air circulation system and curing hot water circulation system.

**PRINCIPLE OF OPERATION**

For effecting Temperature Control Strategy, process controllers are employed. For example, in main curing ovens which are using On/Off Control Strategy, the higher capacity heater banks 1 & 2 will be set, with lower temperature set points at 40 Deg C and 55 Deg C to bring up the temperature quickly within 45 minutes. The third bank will be set at 59.5 Deg C. This will be maintained throughout the process, to achieve 60 Deg C inside ovens with Rocket Segment. With On/Off Control Systems, the response achieved is cyclic and also dispersion will be more. Though this system is simple and straightforward, the final agreement of process value with set point will be having appreciable differential. Since entire Heater bank load is switched on and off, every time, when set point is crossed, the oven will have huge heat quantity inside and hence will result in process parameter oscillations, continuously and it will be difficult to achieve process values close to expected set value. In order to reduce oscillations in temperature, Thyristor is introduced in the process.

The Thyristor will be driven by proportional analog signal from a PID Controller or from a PLC/PAC based system. The analog output will be programmed and configured to vary according to the differential of PV & SP, from maximum value to minimum value. Thyristor, triggered by the analog signal, will fire in proportion to this and energise the heaters accordingly. The Thyristor power output will also vary from maximum value to minimum value, just as the analog output signal does and can be suitably regulated by parameters configuration. This step ensures that, heaters deliver heat load, in progressive fashion into the system and does not create conditions for oscillations, as in On/Off control.
SALIENT FEATURES

• By using ON/OFF Control strategy, the spatial variation observed is +/- 2 Deg C. After using Thyristor Control system, the spatial variation, achieved, is +/- 0.5 Deg C. The precise control established, is very beneficial to curing process and helps turn out quality product, with remarkable repeatability.
• Process value dispersions, inaccuracies and cyclic effects minimized, ensuring better product quality and enhanced process performance.
• User friendly design of the system, enables users, to carry out the operations, smoothly, with convenience and also helps monitoring the important parameters well.
• Compatibility and interfaceability of the system for upward integration.

APPLICATION(S)

• This technology will be beneficial for Industries where fine temperature control is needed.
ANTENNA
DUAL POLARIZED, S&X BAND MONOPULSE FEED FOR TRACKING LEO SATELLITES

Indian Space Research Organisation at its National Remote Sensing Centre (NRSC) has developed a dual polarized S/X Band feed 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). 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 feed system has been integrated with a reflector of 7.5 m diameter in Cassegrain configuration. 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.
SALIENT FEATURES

- 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.
- 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.
- 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.
- Instead of using conventional four horns or five horns as feed element, dielectric rod radiating elements with high aperture efficiency, rotationally symmetric beams with low side lobe levels, have been used.
- 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.
- 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, capable of tracking in both orthogonal polarized mode.

APPLICATION(S)

The feed system has been integrated with a reflector of 7.5 m diameter in Cassegrain configuration and the system is being used 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.
MULTI-LAYER PRINTED ANTENNA TECHNOLOGY

Space Applications Centre of Indian Space Research Organisation at Ahmedabad has developed multilayer printed antenna array technology and delivered antenna for various ISRO’s projects. The salient feature of technology includes 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 new type of light weight low dielectric constant material for high radiation efficiency, low surface wave propagation, low cross polar suppression.

The development include 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.

APPLICATION(S)

- Mobile Communication
- VSAT Terminals
- Electronic controlled Active Phased Array Antenna
- MSS Type C and D
- GPS and GPR
TERMINAL SPECIFICATIONS

Antenna Type : Planar
Cross Polarization : Better Than -30 dB
Beam width and Gain : As per specification (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 micron
Inspection : 10 micron
Repeatability : 5 Micron
Curing Chamber : 1.3 M X 1.3 M
Magnification : 50 X / 100 X
Clean Room : Class 1 lac
Drilling Speed : 40,000 rpm
Adhesive : Prepreg
NEAR FIELD TEST RANGE FACILITY (NFTR)

There are numerous applications in the field of Radars and Communications that use Phase Array Antenna. One of the major concerns for the Design Engineer is to validate the far field pattern of the Antenna.

Indian Space Research Organisation (ISRO) has developed the near field measurement processing instrumentation & software to measure and process the near field Antenna measurement data. This facility includes electronic hardware, mechanical system and software.

SALIENT FEATURES

- Near field data processing software has no frequency limitations
- All the systems required for Defence / Space for various Radars can be completed in less time
- Ability to measure Antenna pattern using time gating approach and does not need elaborate anechoic chambers. In this way it is amenable for in situ pattern measurements
- The system can be used for active array Antenna measurements with bidirectional test facility and passive Antenna measurements.
- The radar hardware can be utilized to measure the radar antenna pattern without any external signal and recording sources, provided the radar is operating with pulse compression
- The present system can measure the composite antenna pattern over the systems complete bandwidth in one shot

APPLICATION(S)

- Active array Antenna measurements with bidirectional test facility and passive antenna measurements.
- To measure the Radar Antenna pattern without any external signal and recording sources.
Indian Space Research Organisation (ISRO) at its Space Applications Centre has developed a focal plane helix feed array antenna. It is capable of handling high power of the order of 250 Watts per element. Helix feed array is designed and realized with materials and processes which are passive inter modulation free. Measured passive inter-modulation level is below -200 dBc.

SALIENT FEATURES

- Waveguide ridge transformer for impedance matching & High power handling
- Helix machined in single piece along with the ridge transformer
- Low mutual coupling

APPLICATION(S)

- Feed array antennas in multiple beam antennas
- Elements in array antennas and as a feed in reflector antennas
Indian Space Research Organisation (ISRO) at its Space Applications Centre has developed a Unified Hybrid Horn Antenna for transmitting/receiving electromagnetic waves and more particularly; as feed for reflector antenna and also as stand-alone antenna.

The novel configuration of the horn comprises mainly three sections:

- Linear/non-linear smooth-walled taper or stepped section at throat
- Variable slot depth/width axial corrugated section in the mid section
- Single-depth spline-profiled or dual-depth spline-profiled or multi-section/piece-wise linear radial corrugated section or multi-nonlinear profile toward aperture side.

This design approach provides flexibility to design a variety of hybrid horn antennas with different edge taper at semi-subtended angle or peak gain with excellent RF performances for different size of reflector antenna or stand-alone applications. RF and microwave industries involved in the design and development of TR modules, airborne and space radar systems will benefit from this invention.
SALIENT FEATURES

- The proposed configuration provides greater flexibility for the design of tailored high electrical performance like cross-polar level, return loss, edge taper, aperture efficiency, gain, phase center stability etc.
- Reduction in axial length and aperture size.
- Ease in fabrication.
- Compact size.

APPLICATION(S)

Feed system for reflector antenna and stand-alone direct radiating horn antenna for Spacecraft antenna, Ground antenna and VSAT antenna.
APPLICATION TECHNOLOGY
**GROUND PENETRATION RADAR**

Indian Space Research Organisation at its Space Application Centre has developed Ground Penetration Radar (GPR), which is a high resolution electromagnetic imaging technique that works on the principle of scattering of electromagnetic waves to locate buried objects. It is used primarily to investigate subsurface profiles of the earth or planetary surface. GPR is a method that finds applications in environmental, engineering, archeological, and other shallow investigations.

GPR operates by transmitting high frequency waves directing down into the ground via a wideband antenna. When the transmitted signal enters the ground and reaches objects or mediums with different electrical and dielectric properties, part of the signal is reflected off. This reflected energy is then sensed by the receiver antenna. Ground penetrating radar relies on several factors for target detection:

(i) Efficient coupling of electromagnetic radiation into the ground
(ii) Adequate penetration of the radiation through the ground with regard to target depth
(iii) Obtaining from buried objects or other dielectric discontinuities a sufficiently large back scattered signal for detection at the ground surface.

**SALIENT FEATURES**

- Frequency : 250 - 750 MHz
- Polarization : Single Polarization
- Scan Speed : 1 m/s
- DC Power Requirement : <10W
- Volume : 20cm x 20cm x 10cm(ht)
- Mass : 1 kg
- Penetration Depth: 6 m
- Depth Resolution : 0.3m
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.

**METHOD OF OPERATION**

- 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.
- 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.
- 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.

**POTENTIAL USERS**

All laboratories, research institutes, universities involved in marine & oceanographic research especially in the area of primary production by phytoplankton and fisheries.
ELASTIC RAMAN LIDAR (ERL)

A state-of-the-art low-cost Elastic Raman LIDAR (ERL) system has been successfully developed and demonstrated by ISRO at its National Atmospheric Research Laboratory (NARL) for remote sensing the atmospheric water vapour and aerosols in the boundary layer.

SPECIFICATIONS

- **Laser**: Nd:YAG, Third harmonic
- **Wavelength**: 355 nm
- **Laser energy per pulse**: 100 mJ
- **Repetition rate**: 10 Hz
- **Beam-divergence**: 0.5 mRad
- **Telescope**: 350 mm
- **Field of View**: 4 m Rad (Half-angle)
- **No. of receivers**: Three
- **Vertical resolution**: 7.5 m and multiples of 2
- **Range**: Lower atmosphere
- **Operation**: Night time for water vapour and Day and Night time for aerosols

Water vapor measurement accuracy: less than 1% in one hour measurement in the atmospheric boundary layer

PRINCIPLE OF OPERATION

The ERL system is an optical remote sensing instrument for investigations of the atmosphere and it uses the property of elastic and molecular Raman scattering. The ERL instrument transmits laser beam into the atmosphere, and a telescope collects the return signals, including direct backscatter, vibrational Raman signals at several wavelengths. The return signals are then detected and processed to obtain measurement of atmospheric structure and constituents. The intensity of a
vibrational Raman signal is directly proportional to the density of the scattering molecule and independent of other molecular species. The wavelength shift and narrow spectral width of the Raman return signal allows it to be distinguished from the other resources of elastically scattered radiation.

**COMPONENTS OF RAMAN LIDAR**

The major components of ERL are Laser unit for generating very fine laser pulses at UV wavelengths for probing the atmosphere, telescope to collect the laser backscatter from particles and gas molecules in the direction of laser probing, optical units of Lidar system containing iris, wavelength separation mirrors, field and collimating lens, neutral density (ND) filters, interference filters and photomultiplier tubes. The other components include a receiver unit employing both analog and photon counting detection technologies. A computer system is used for auto controlling of receiver operation and for managing the data manipulation.

**SALIENT FEATURES**

- Simultaneously provides water vapor and aerosol data, both in analog and photon counting detection methods.
- Operation during day and night for profiling aerosol and clouds. This elastic channel data at 355 nm provides the aerosol and cloud backscatter data up to a height range of 17 km in daylight periods. However, during nighttimes it can go beyond 30 km
- Transmitter and receiver configured in a way to avoid need for optical alignment
- Monitoring the laser power through a beam sampler on continuous basis
- Near horizontal operation of lidar is possible
- Remote operation of LIDAR system using Ethernet control
- The Lidar data acquisition and controlling software enables for summation/averaging of lidar data, range height map generation, converting acquired data into ASCII format in real-time

**CURRENT INSTALLATION**

National Atmospheric Research Laboratory (NARL), ISRO, Gadanki, AP.
APPLICATION(S)

- ERL can be used for the measurement of water vapour, which is of great importance not only in the studies related to the meteorology, but also plays a key role in understanding the ecological change, green house effect and interaction between forest and atmosphere.

- ERL facilitates to understand the specific humidity effects on particle physical and optical properties and thus plays an important role in the measurement of altitude distribution of aerosol properties.

- Knowledge of water vapour distribution in the atmosphere is needed for improved understanding of atmospheric processes including atmospheric chemistry.

- ERL will find application in measurement of water vapour distribution, which has direct impact on natural disasters, such as cyclones, storms, low pressure systems etc. Water vapour has been found to be the main energy source for cyclones and water vapour measurement can aid in estimating cyclone strength and direction.

- Accurate determination of stable boundary layer is possible with altitude distribution of high resolution water vapor data, which is very important for modelling of stable boundary layer over land regions.

- Simultaneous measurement of Nitrogen molecular distribution along with water vapor and elastic backscatter provides an important climate related study of aerosol extinction in the atmosphere. ERL equipped with Nitrogen molecular channel provides an independent method of measurement of particle extinction in the boundary layer, which is vital for radiative transfer/climate related studies.

- Continuous measurement of elastic backscatter provides information on formation of stable, mixed and residual layers in the boundary layer.
Observations of wind velocity profiles are very important for studying meteorological phenomena and for weather forecasting. Radar Wind Profiler (RWP), a coherent-pulse-Doppler-radar, is one of the most suitable remote sensing instruments for observing height profiles of three components of wind velocity vector, including the vertical velocity, with high time and height resolutions without influence of weather conditions. The Lower Atmospheric Wind Profiling Radar (LAWP) developed by ISRO provides the data to study the dynamics of the lower atmosphere (upto 4-5 km).

**SPECIFICATIONS**

- **Frequency**: 1280 MHz
- **Technique**: Doppler beam Swinging
- **Antenna Type**: Microstrip Patch Array
- **Array Size**: 8x8 (1.4 m x 1.4 m)
- **Beam Width**: 90°
- **Beam Former**: Passive
- **Beams**: 25
- **Tx/Rx Type**: Solid State Transceivers (64)
- **Peak Power**: 0.8 kW
- **Duty Ratio**: Upto 10%
- **Pulse Width**: 0.25 – 8.0 µs
- **NCI**: 4 - 1000
- **NFFT**: 32 -1024
- **Range Bins**: 1-256
- **Receiver**: Super Hetrodyne
- **Detection**: Direct IF Digital
- **Dynamic Range**: 70 dB
- **Min. Height**: 100 m
- **Max. Height**: 3-5 km

**PRINCIPAL OF OPERATION**

Atmospheric radars derive information on the dynamical atmospheric phenomenon by making use of variations in amplitude and frequency of radio waves which are transmitted from radar system, back scattered by the atmosphere and again received by the radar system.

Radio wave propagation is affected by the refractive index of the atmosphere, which primarily depends upon the temperature, pressure and humidity. The atmosphere is in a constant state of agitation, which produces irregular, small scale variations in the temperature and moisture over relatively short distances. The wind, as it varies in direction and speed, produces turbulent eddies, which
produce variations in the refractive index of air that initiate scattering. As the irregularities in refractive index are carried by the wind, they prove to be good tracers of wind.

The electromagnetic pulse radiated by the radar is scattered due to the random irregularities present in the refractive index of the atmosphere. Back scattered echoes received by the radar are analysed for their intensity and Doppler shifts. The intensity and Doppler shifts measured in three (or more) radial directions are used to derive the wind vector of the atmosphere.

**CONFIGURATION OF RADAR**

LAWP Radar consists of a simplified active microstrip patch 8x8 array, solid state TR modules, a passive two dimensional beam forming network, which can generate 25 usable beams, a Direct-IF Digital receiver, a PC based Radar Controller. Entire wind profiler system is kept in an air conditioned shelter of 1.5m x 1.9m x 1.8m size. This profiler can be transported easily on a TATA ACE vehicle and can be deployed at different locations.

**SALIENT FEATURES**

- Simplified active aperture
- Solid state transmit receive modules
- Calibration free passive BFN
- Direct IF Digital Receiver
- Pulse compression
- Continuous operation capability
- Range resolution: 37.5 m
- Transportability

**CURRENT INSTALLATION**

National Atmospheric Research Laboratory (NARL), ISRO, Gadanki, AP.

**RESEARCH APPLICATION(S)**

LAWP radar is a potential tool to carry out research studies such as Atmospheric Boundary Layer (ABL) Dynamics (Winds, Turbulence structure), Seasonal and Inter annual variations, Interaction between the ABL and the free troposphere, Vertical profiles of precipitation, Bright band Characterization, Monitoring the height of the melting layer and the vertical extent of hydrometeors, Rain/Cloud drop size distribution etc.
OPERATIONAL APPLICATION(S)

Improved short-range forecasting, numerical weather prediction models, air pollution, civil aviation and flight planning, identification of atmospheric ducts, air pollution prediction, wind shear monitoring, temperature profiling in the radio acoustic sounding system (RASS) mode, rocket and missile launching etc.
PICO SATELLITE ORBITAL DEPLOYER (POD)

Indian Space Research Organisation (ISRO) at its Vikram Sarabhai Space Centre (VSSC) has developed the technology for a mechanism for ejection of box shaped satellite weighing up to 3 kg by remote command from an enclosure through the application of spring force. The mechanism includes holding and releasing the swing door of the enclosure, ejection of satellite after a delay from swing opening of door.

The system is designed, developed and qualified for aerospace applications. Effectiveness of the mechanism has been tried out through a large number of functional tests and on one of the PSLV flights.

This technology—Nano Satellite Ejection System is now available for transfer to industries. In addition to ejection of satellites from launch vehicles, this technology can be utilized for other applications that require ejection of hazardous substances by remote command in a reliable and safe way.
DETECTION OF LANDSLIDES FROM HIGH RESOLUTION OPTICAL SATELLITE DATA

Indian Space Research Organisation at its National Remote Sensing Centre has developed a advanced technique for detecting landslides from high resolution satellite data.

Landslide is a major natural disaster in India or countries elsewhere where significant portion of landmass is in mountainous areas. A new technique using advanced object-based image classification method is developed to automatically detect landslides from satellite data. This technique imitates the human interpretation process in identification of landslides.

THE PROCESS OF LANDSLIDE DETECTION

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.

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.
MULTI-SCALE CLASSIFICATION

Inherent scales in the satellite data depending upon the sizes of the landscape features are identified objectively. This helps to eliminate landslide false positives (e.g. river sand, barren land, buildings, roads, uncultivated agricultural land etc.) accurately thereby increasing the accuracy of landslide detection process.

[Agricultural lands (AL), generally of larger size in comparison to roads (Rd) were accurately identified using a larger scale factor (left image) where as roads were classified with a small scale factor (right image)]
SALIENT FEATURES

• The technique combines spectral, shape, texture, morphometric and contextual information derived from high resolution satellite data and DEM for the preparation of new and historical landslide inventories
• selection of landslide diagnostic parameters and their use in the comprehensive characterisation of different types of landslides, a concept which is addressed for the first time for detection of landslides in an object-based environment
• 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

APPLICATION(S)

This technology can be used to create routine landslide inventories 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 of landslides.
The Indian Space Research Organisation (ISRO) has developed an INSAT based Distress Alert Transmitter (DAT), which will find wide commercial and special applications.

INSAT based Distress Alert Transmitter (DAT) is used to transmit emergency conditions and position location to a central HUB station via UHF transponder of INSAT for rescue operation. It can be easily installed in boats or other vehicles. In case of emergency, user just needs to switch on the DAT unit. User is required to select a message (eg: fire in boat / boat sinking / medical help / other emergency) by pressing the corresponding switch provided in the system. The DAT combines the message with position of the boat obtained through GPS, and transmits the same to a central HUB station. The DAT will repeat the message every minute for first five minutes and then every five minutes till it is switched off manually or until the battery life gets over.
SALIENT FEATURES

- Low cost and therefore affordable to fishing community
- In-built GPS to give position and time information
- Transmits emergency signal on manual activation
- Test transmission facility
- Continuous transmission on activation for 24 hrs at 5 minutes intervals
- Omni directional antenna suitable for fishing fleet
- Available with bracket suitable for pole/canopy mounting
- Receives time of activation, type of emergency, vessel ID and position along with audio alarm at Maritime Rescue Coordination Centre (MRCC) of Indian Coast Guard
- Light weight & floatable

APPLICATION(S)

- Intended for emergency message communication transmission for all type of sea going vessels
- Satellite based disaster management
Indian Space Research Organization at its National Atmospheric Research Laboratory (NARL) has developed a cloud and aerosol LIDAR technology for atmospheric measurements. The LIDAR technology enables atmospheric profiling at high spatial and temporal resolution continuously during day and night. The built in LIDAR software provides real time range information on cloud and aerosol layers in the atmosphere.

SYSTEM DESCRIPTION

The Cloud and Aerosol LIDAR (CAL) employs a laser source, a telescope, detector unit with receiver optics and data acquisition unit controlled by laptop/computer. The system is housed in two compartments. The steerable compartment contains transmitter and receiver optics. Data acquisition unit is positioned in non movable compartment controlled by laptop/computer through Ethernet link.

SYSTEM SPECIFICATION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter</td>
<td>Pulsed laser, 20 Hz, 15 mJ per pulse</td>
</tr>
<tr>
<td>Wavelength</td>
<td>1064 nm</td>
</tr>
<tr>
<td>Receiver</td>
<td>150 mm telescope optics</td>
</tr>
<tr>
<td>Detector</td>
<td>Avalanche photodiode</td>
</tr>
<tr>
<td>Data acquisition</td>
<td>Single channel type, analog mode of signal acquisition through software control</td>
</tr>
<tr>
<td>Mode of operation</td>
<td>Slant path direction (vertical optional)</td>
</tr>
</tbody>
</table>
SALIENT FEATURES

- Continuous day and night operation without pause
- 20 km daytime range during clear sky conditions
- 35 km night time range during clear sky conditions
- Single wavelength operation using Avalanche Photodiode
- Data acquisition in analog mode
- Enables receiver data collection in 7.5 m, 15 m, 30 m, 60 m, 120 m, 240 m and 480 m range bin settings. The LIDAR can be operated at one second time sampling mode for high resolution atmospheric measurements in the above bin settings.
- LIDAR operational software provides real time range information of atmospheric targets. Data presentation in RTI maps.
- LIDAR operation in slant path direction.
- Operation in clear sky, convective, cloudy and rain periods in slant mode.

APPLICATION(S)

- Continuous monitoring of clouds in atmosphere
- Convective boundary layer growth
- Wind drifted aerosol structures
- Slant range visibility measurement for aircraft landing operations
SOFTWARE
Internet connectivity for any organisation is inevitable for vital applications like email, surfing, downloading content and application/patches. Although organisations implement high level security at perimeter, server and desktop levels like Firewall, IDS/IPS, Antivirus etc., it is highly prone to attacks from malicious users both within and outside. As a result, large number of organisations dealing with confidential data refrains from connecting to internet.

Indian Space Research Organisation (ISRO) at its Space Applications Centre (SAC) has developed and patented “Phantom Network Toggling Technique”. The system comprises of an organisational network (intranet), third party network (internet), a phantom server with intermediate data storage and a toggling mechanism to isolate the organisational network from third party network. It permits secured data communication between organisational network and third party network without connecting to them.

**SALIENT FEATURES**

- Providing extremely high security to organizational network against external and internal threats
- Complimentary to existing IT applications
- Easy, low cost, highly reliable, automatic and high speed
- Script based network toggle through parallel/USB/Ethernet interfaces

**APPLICATION(S)**

- Users can send and receive emails to/from external world without connecting organizational network with internet directly
- Providing thin client based surfing facility with the feature of copying users download data from internet to intranet without connecting them
The Indian Space Research Organisation (ISRO) has developed Satellite Photogrammetry Software for Indian Remote Sensing Missions – Cartosat-1 (SAPHIRE-C) which can process Cartosat-1 satellite stereo data products to generate Digital Elevation Model (DEM) and Orthoimage for the user interest area. SAPHIRE-C is available on Linux & Window platform.

The software accepts the Cartosat-1 stereo-pair products and Ground Control Points (GCP) as inputs. It allows user interaction for choosing the optimum model errors and generates DEM and Orthoimage as output. The software has been tested on a variety of regions from plain to highly hilly terrain and is utilized in various remote sensing application projects.

**SALIENT FEATURES**

- Graphical User Interface for User Interaction.
- Processes Cartosat-1 stereo-pair products
- Generates DEM and respective Orthoimage
- Model uses the sensor geometry thus improving the end product accuracies
- Supports SOI Map-index grid for user geographical area selection
- DEM provided in ASCII formats
- Orthoimage generated in GeoTiff format
- Report generation on processing parameters
- Database support for archiving processing history
• Handles multiple stereo-pair product processing
• Output Product evaluation, Supports WGS84 and Everest Datum
• Supports UTM and Polyconic Map Projections
• Archival of GCP ground coordinates with image chips in database is possible.
• Provision for DEM Visualisation in vector and raster form.
• DEM editing in vector form.

APPLICATION(S)

• SAPHIRE-C is used for generation of DEM and Orthoimage of user defined area in varying scales and resolution using Ground Control Points. The DEM thus generated gives precise three dimensional ground coordinates which include the terrain height for specific points in the given area. The DEM can be used in applications like extraction of drainage patterns, contour line generation, terrain visualisation and generating Orthoimage. The Orthoimage can be used for topographic mapping applications. This also gives a bird’s eye view of the terrain undulation of the given area to an appreciable accuracy.
LDPCC Code for GNSS Application

The Indian Space Research Organisation (ISRO) has developed a MATLAB and C++ model of the Low Density Parity Check (LDPC) and LDPC Convolutional Code (LDPCCC) for use in Global Navigation Satellite System (GNSS) respectively.

Global Navigation Satellite System (GNSS) are under planning / being implemented by the US, Russia, Europe, China, Japan, India, Nigeria and many other countries in the frequency bands 1559-1610 MHz (L1 band), 1215-1300 MHz (L2 band) and 1164-1215 MHz (L5 signal). The signal and data structure for each of these systems is different. Data rates ranging from 25 bits/sec to 500 bits/sec and Forward Error Correction (FEC) techniques from rate = ½, k = 7 convolutional code to Low Density Parity Check (LDPC) codes have been proposed for various signals.

Application of LDPC / LDPCCC

- These models can be used for developing FPGA netlist or IP Core RTL product for LDPC or LDPCCC as applicable to GNSS. For telecom and other applications the software can be modified to suit a given application. FEC technology using Advanced Coding Techniques is useful in deep space missions, fibre communication, computer to computer communication links etc.

Advantages of LDPC Block Codes

- These are suited for implementations that make heavy use of parallelism. Consequently, error-correcting codes with very long code lengths are feasible.
- The quasi-cyclic LDPC codes presented show a comparable decoding performance to the randomly constructed LDPC codes with the advantage of a significantly reduced encoding complexity.
- QC-LDPC codes have encoding advantage over conventional LDPC codes and their encoding can be carried out by shift register with complexity linearly...
proportional to the number of parity bits of the code.

• No tail bits are required for block coding providing additional bits for data transmission.

ADVANTAGES OF LDPC Convolutional Codes (LDPCCC)

• LDPCCC are simple to encode, since the original code construction method yields to a shift register based systematic encoding.

• LDPC convolutional codes are suitable for transmission of continuous data as well as block transmissions in frames of arbitrary size where LDPC can transmit block of fixed length only.

• For a given complexity LDPC convolutional codes have better performance than LDPC block codes.

• LDPCCC has excellent BER performance under AWGN.

• LDPCCC is extremely useful for large values of data bits N. However, they can be used with good BER performance for shorter number of data symbols such as in GNSS navigation data.

• LDPCCC architecture is more amenable to pipelining because of feed forward architecture. Hence, it may achieve higher clock speeds and continuous decoding.

• VLSI implementation of LDPCCC is based on replicating identical units called processors. A complete decoder can be constructed by concatenating a number of these processors together. The convolutional structure of the Tanner graph aids VLSI implementation.

• For comparable BER performance, the size of an LDPCCC processor could be an order of magnitude less than that for LDPC block code. Hence the routing complexity within a processor is also an order of magnitude less than that for a block code.
LDPC CC ALGORITHM

- Use of LDPC Convolutional Codes (LDPCCC) for navigational data structure in a conventional medium earth orbit or geostationary orbit satellite navigation system is yet to be proposed. For finite block lengths, a systematic comparison of these codes is not proposed in the literature so far.

- The LDPC and LDPCCC algorithms have been subjected to Failure Mode effect analysis (FMEA) testing.
Virtualisation of Software for Expert Display

Indian Space Research Organisation at its Satish Dhawan Space Centre (SDSC-SHAR) has developed a novel PLC based display system, which will find wide industrial application.

**PRINCIPLE OF OPERATION**

The parameters from PLCs are received through network and processed in the server. The output (processed packets) is received by the Native Software and the communication is made to host software through virtual network adapter (VNA). The Native operating system which is normally Microsoft Windows is configured with a fixed IP address, which is a registered IP for communication in the server. The Host software (SCADA software) is configured to directly receive the packets for analysis. The analyzed information will be displayed on screen as one directional communication, as per protocol of safety. Further the performance tuning activity is carried out and the update/refresh time is reached in few milliseconds.

**ADVANTAGES/APPLICATION(S)**

- Already a proven way to overcome the legacy systems, limitation of proprietary industrial PCs can be discarded by using this configuration and the same work can be performed by normal systems.
- These activates can be recorded in compressed video format compatible to any standard media player for playback.
- Safety critical systems where few milliseconds refresh rate is required
Indian Space Research Organisation at its Satish Dhawan Space Centre (SDSC-SHAR) has developed a technological concept, for interfacing and integrating number of individual Data Acquisition System data, to present summarised, concise and quick look parameter information, to Maintenance Team and Chief Executives during live Propellant Processing Programmes.

SALIENT FEATURES
Integration of digital systems with suitable interfaces and networking, facilitates development of centralised data screens, with proper GUI packages and presentation of summarised process data display.

APPLICATION(S)
• This concept will be beneficial for Industries, with well spread out facilities, for instant monitoring.
• Tool for Process, Maintenance and Management Personnel.
e-SMART is an online software tool to automate and provide seamless end-to-end workflow management from designer to delivery…
### Advanced Technologies from ISRO

#### Feature Benefits

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>End-to-end workflow management</td>
<td>All departments like Designers, Planning Engineers, Workshop Engineers, Cutting-Store Personnel, Inspection Engineers and Management Personnel work on same platform.</td>
</tr>
<tr>
<td>Simple and intuitive interface.</td>
<td>Easy to train manpower</td>
</tr>
<tr>
<td>Web based Scalable architecture</td>
<td>Saves on infrastructure costs. Remote facilities can be connected</td>
</tr>
<tr>
<td>User-level Authorization and authentication</td>
<td>Responsibility and accountability</td>
</tr>
<tr>
<td>Provision for Data-warehousing and automated daily-backup</td>
<td>Data protection</td>
</tr>
<tr>
<td>3D Visualization of fabrication parts in web browser.</td>
<td>No commercial/paid CAD/CAM software required</td>
</tr>
<tr>
<td>Thumbnails (small images) of fabrication parts facilitate in quick visualization and identification.</td>
<td>Increases productivity</td>
</tr>
<tr>
<td>More than 60 online reports can be generated and exported in multiple formats like .rpt, .xls, .doc, .xml</td>
<td>Critical Information for decision-making can be obtained</td>
</tr>
<tr>
<td>Back traceability of a part</td>
<td>Complete history of a part can be obtained</td>
</tr>
<tr>
<td>Paperless operations</td>
<td>Saves on cost and delays due to movement of papers</td>
</tr>
</tbody>
</table>

- 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.
Indian Space Research Organization at its National Remote Sensing Centre (NRSC) has developed and implemented software for automating the Business Process Workflows. The processes involved in the assembly line are seamlessly combined into a workflow through an asynchronous network message driven invocation calls. Prominent features include an indigenously developed job prioritization algorithm and a resource driven workload distribution methodology. The software is currently operational for automating the remote sensing data product generation workflows. However, it can be customized for meeting the requirement of other users.

**SALIENT FEATURES**

- Developed using Java and can be deployed on any high end computing platform
- Supports different file formats as inputs to the system
- Mechanism to store the business rules into a knowledge base
- Asynchronous message driven interfaces between the processes involved in the workflow
- Automatic job prioritization to reduce the overall turnaround time
- Efficient Job distribution methodology taking into account the available computational nodes
- Improved throughputs from systems due to efficient job loading methodology
• Workflow history maintenance and tracking of orders
• Operator interfaces in case of emergencies
• In process monitoring and analytics
• Predictable timelines for delivery of products

APPLICATION(S)
• Business process automation
• In process monitoring, visualization and analytics

POTENTIAL USERS
• State and Central Government organizations involved in providing services to citizens
• Private organizations carrying out business in publishing, health care, logistics and other services involving workflows
• Manufacturing companies required to carry out complex processes to accomplish a product
Indian Space Research Organisation at its Vikram Sarabhai Space Centre has continually developed the indigenous structural analysis software FEAST SMT, which is based on finite element method.

Many problems pertaining to solid and fluid mechanics domain that find applications in aerospace, civil and mechanical engineering are solved numerically. The solutions of large order problems are possible due to availability of digital computers. Finite element method is a popular numerical method, which has found wide range of applications to solve real-life problems, especially in solid and structural mechanics. The software utilizes Substructure and Multithreading (SMT) concepts for high performance. FEAST SMT is supported by PreWin, a graphical user interface (GUI) based pre/post processor. PreWin provides state-of-the-art capabilities for modeling and visualization. This software can work on UNIX, LINUX and Windows operating systems. PreWin and FEAST SMT are available as an integral software for the users.

The software is available in modular form for academic and commercial usage. The Basic Module consists of: Linear static, Free-vibration and Buckling analysis. Advanced modules are: Transient, Frequency, Random, Fluid-Structure Interaction, and Base Excitation. Advanced modules can be bundled with basic modules as per user requirement. These capabilities are supported by a rich element library comprising beam, shell, solid, axisymmetric, spring, rigid-links, gap etc. and material models viz., isotropic, orthotropic, incompressible and layered orthotropic. The software is updated regularly by considering user feedbacks and capability augmentation. A downloadable demo version along with tutorials is available at http://feast.vssc.gov.in
Indian Space Research Organisation (ISRO) at its Space Applications Centre (SAC) has developed a MIL-STD-1553 Remote Terminal IP. MIL-STD-1553 bus is a robust control communications bus being used in aerospace applications. A large number of Remote Terminals (RTs) can communicate with a Bus Controlling Unit (BCU) as well as among themselves under the control of the BCU.

In today’s digital world, almost all systems contain high density logic devices like FPGAs, abundant in logic resources, where the remote terminal functionality can eminently be integrated. This eliminates the use of an external protocol IC on the PCB with attendant advantages.

The MIL-STD-1553 Remote Terminal Intellectual Property Core implements a full functionality Remote Terminal portable into an FPGA device. Implementation of the IP is free from any vendor specific logic that gives it an added benefit of being used with any FPGA or ASIC devices.

RESOURCES
Utilization for Xilinx Virtex-5 FX130T Device:
4098 Slices out of total 81920 slices- 5%

SALIENT FEATURES
- Validated as per RT Validation Test Plan MIL-STD-HDBK, Nov 1988
- Operates on 12 MHz clock
- Supports dual redundant MIL-STD-1553B bus
- Generic architecture portable on any FPGA or ASIC devices
- 16-bit external memory interface
- 16-bit register interface to in-house register bank
- Word size BIT word register for debugging
- Bus waveform conditioning
- Supports Single buffer and circular buffer memory management modes
• DDC Mini ACE compatible look up table based memory management
• Internally resets the core on reception of a new command
• 800 us Fail Safe timer to recover from the babbling transmitter condition
• Separate Manchester decoder, command decoder and message validator chain for both the channels.

RT ARCHITECTURAL FEATURES
• Supports MIL-STD-1553 B Notice 2
• Complete RT Functionality implemented in a Modular Architecture
• External Memory and host processor Interface
• Register access through Host Processor
• RT Status Word Control Bits: Subsystem Flag, Terminal Flag, Service Request Bit
• RT Vector Word Programmability through Host Processor/ Subsystem
• Supports all the 10 Message Formats of MIL-STD-1553 protocol
• Capable of handling Superseding Commands on both the channels
• Separate Receiver chain for handling messages on both the channels

AUTONOMOUS BUILT-IN SELF TEST CAPABILITY
• BIT Word Generated For Every Message Processed
• Message Validity Check
• Fail Safe Capability
• RT-RT Transmitter Timeout Period: 55.5 us
• Interrupt Generation on Error Conditions For Every Message Processed
• High/Low Word Count Error, Parity Error, Biphase Error, Incorrect Sync, RT-RT No Response Timeout Error, etc. conditions registered on every message processed
• Message Length Error Detection

HOST AND MEMORY INTERFACE CONFIGURATIONS
• 16-bit External DPRAM Interface
• 16-bit register interface to internal register bank, 5-bit Register Addressing

APPLICATION AREAS
• All aerospace systems using MIL-STD-1553B and subsystems with FPGAs
• Space/ Rad Hard Applications
TECHNOLOGY TRANSFER FROM ISRO

ISRO is willing to offer the know-how of the technologies to entrepreneurs/industries in India. Capable industries interested in acquiring the know-how may write with details of their present activities, requirements and plans for implementation, infrastructure, technical expertise, own market assessment, if any, and plans for diversification to the relevant address given below.

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