MODULE 6-0

RUGGEDIZING DEVICES
Why Do We Want To Ruggedize Devices

- The bare boards and peripherals we use to build custom hardware isn’t ruggedized.
- Usually meant for lab or home
- Lots of tricks to ruggedize them for the field!
Why We Ruggedize Devices

Mechanical failures, through exposure to the elements are a common point failure in the field

- Dust and debris
- Water
- Animals
- General wear and tear

Ruggedization is a fight against mechanical failures!
How Do We Protect Devices

Areas to ruggedize devices
- Enclosures
- Bare circuit board
- Cabling
- Connectors
- User interfaces & visual indicators outside the enclosure
Ruggedized Enclosures

- IP ratings
- Seals and gaskets
- Screws
- Device access via latches or screws
# Ingress Protection Quick Guide

## Solids

<table>
<thead>
<tr>
<th>Number</th>
<th>Image</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><img src="image1.png" alt="Image" /></td>
<td>Solid objects greater than 50 mm, such as the back of a hand.</td>
</tr>
<tr>
<td>2</td>
<td><img src="image2.png" alt="Image" /></td>
<td>Solid objects greater than 12.5 mm, such as a finger.</td>
</tr>
<tr>
<td>3</td>
<td><img src="image3.png" alt="Image" /></td>
<td>Solid objects greater than 2.5 mm, such as a screwdriver.</td>
</tr>
<tr>
<td>4</td>
<td><img src="image4.png" alt="Image" /></td>
<td>Solid objects greater than 1 mm, such as a wire.</td>
</tr>
<tr>
<td>5</td>
<td><img src="image5.png" alt="Image" /></td>
<td>Limited ingress of dust. It must not interfere with the actuator operation.</td>
</tr>
<tr>
<td>6</td>
<td><img src="image6.png" alt="Image" /></td>
<td>No ingress of dust.</td>
</tr>
</tbody>
</table>

## Liquids

<table>
<thead>
<tr>
<th>Number</th>
<th>Image</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><img src="image7.png" alt="Image" /></td>
<td>Vertically falling drops.</td>
</tr>
<tr>
<td>2</td>
<td><img src="image8.png" alt="Image" /></td>
<td>Vertically falling drops over an actuator tilted 15°.</td>
</tr>
<tr>
<td>3</td>
<td><img src="image9.png" alt="Image" /></td>
<td>Sprays of water at any angle up to 60° from the vertical.</td>
</tr>
<tr>
<td>4</td>
<td><img src="image10.png" alt="Image" /></td>
<td>Sprays of water at any angle.</td>
</tr>
<tr>
<td>5</td>
<td><img src="image11.png" alt="Image" /></td>
<td>Water jets.</td>
</tr>
<tr>
<td>6</td>
<td><img src="image12.png" alt="Image" /></td>
<td>Powerful water jets.</td>
</tr>
<tr>
<td>7</td>
<td><img src="image13.png" alt="Image" /></td>
<td>15 cm-100 cm immersion during 30 min.</td>
</tr>
<tr>
<td>8</td>
<td><img src="image14.png" alt="Image" /></td>
<td>Immersion under harder conditions than in IPX7.</td>
</tr>
</tbody>
</table>

## Codification Example

```
IP54
```

- **Ingress Protection**
- **Solids**
- **Liquids**
Seals and Gaskets

• A metal sheet or moldable ring that fits in the small gap between the two surfaces to create a seal, and prevent liquid getting in
• conforms to uneven surfaces
• IP68 rated enclosures need a gasket
• Used in different scenarios such as o-ring on a dive tank, electronics, piping etc
Seals and Gaskets

- Typically used in enclosure lids, or any holes where cables come out
- Enclosures may not come with a gasket included
- Cable glands usually come with gaskets included
Seals and Gaskets

- Glue gasket in place using rubber cement or ‘Rubber and Gasket Adhesive’
Screws: Bare vs Plated vs Stainless

- Bare (uncoated) screws rust quickly
- Zinc plated screws are electroplated with a zinc layer. More protection against rust but the plate can wear off & then rust
- Stainless steel screws give most protection against rust
Latches vs Screws

Latches and screws both water and debris proof (may rust easily so check what they’re made from)

Latch-based enclosures
• usually more $$
• easier access (for anyone!)

Screw-based enclosures
• cheaper
• harder access, but can act as a deterrent
• Carry electric screwdriver with you!
Holes for other peripherals

ePTFE
  - PTFE = Teflon
  - Expanded PTFE = Gore-Tex
  - Microporous, water-resistant, sound permeable (let’s air through but not water)
  - fragile, needs to be handled gently

TPU
  - Thermoplastic PolyUrethane Film
  - Air, sound permeable also
  - Structurally stronger, stiffer
Bare Circuit Boards - Varnish

Waterproof with varnish
- PC board protector spray
- clear varnish paint
- nail polish (last resort, $$)

Avoid spraying or painting
- Connectors
- SD card slot
- moving parts
- removable cables

Use a stencil or tape over these parts
Bare Circuit Boards - Potting

Potting
- Protects against moisture and vibrations, shock
- Materials
  - Epoxy resin
  - Electronics grade silicone
  - Urethane
- Requires a mold
- More effort, more $$$
- Permanent. Once potted, circuit can’t be easily modified
Bare Circuit Boards – Heat Shrink Tubing

Heat shrink tubing
• Forms to circuit board
• Creates light, compact layer of protection
• Once done, can’t access bare board
• Easy to cut off and access circuit board
• Transparent (can see visual indicators on board)
• Available in different colours

To seal the tube, add hot glue or tape to the open ends
Inside the Enclosure - Condensation

Reusable silica gel absorbs excess moisture inside the enclosure

- put inside breathable fabric pouch
- recommend silica gel with color indicator to show when it’s saturated and no longer absorbing moisture.
- Can reuse by drying in microwave or oven
COMING UP

Module 6.1: Cabling, Connectors, Interfaces