SWARM- Sensor Withdrawn from a Remote Module

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"SWARM" – Sensor Withdrawn from a Remote Module

Aims:

- Aim 1: *Develop SWARM Host circuitry for communication with outlying sensors and integrate into a full module.*
  - Our team will develop the SWARM Host circuits, including those for enabling switching communication protocols and power output levels as well as a method for detecting failures between the Sensor and the Host. The Host module will be produced for testing in Aim 3.
- Aim 2: *Design and fabricate a SWARM IMU Sensor as a proof-of-concept*.
  - The team will generate the necessary circuitry for the IMU sensor and the necessary packaging, feedthroughs, and header for communication with the SWARM Host. The SWARM Sensor will be produced for testing in Aim 3.
- Aim 3: *Complete bench-top testing for a full SWARM System to generate data for an early feasibility study IDE submission.*
  - The Host and Sensor developed in Aims 1 and 2 will be tested to support research teams' IDE submissions for incorporating these components into their own implementations as well as their development of additional sensors for the SWARM within the COSMIIC ecosystem. Tests will include electromagnetic compatibility, current leakage during failure modes, and hermeticity tests.

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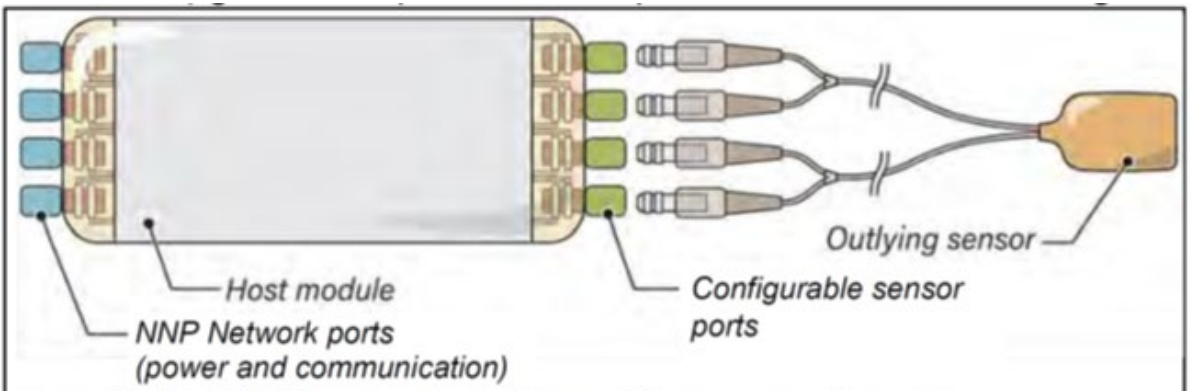

Figure SW-3: SWARM concept art with an outlying sensor with 8 cables

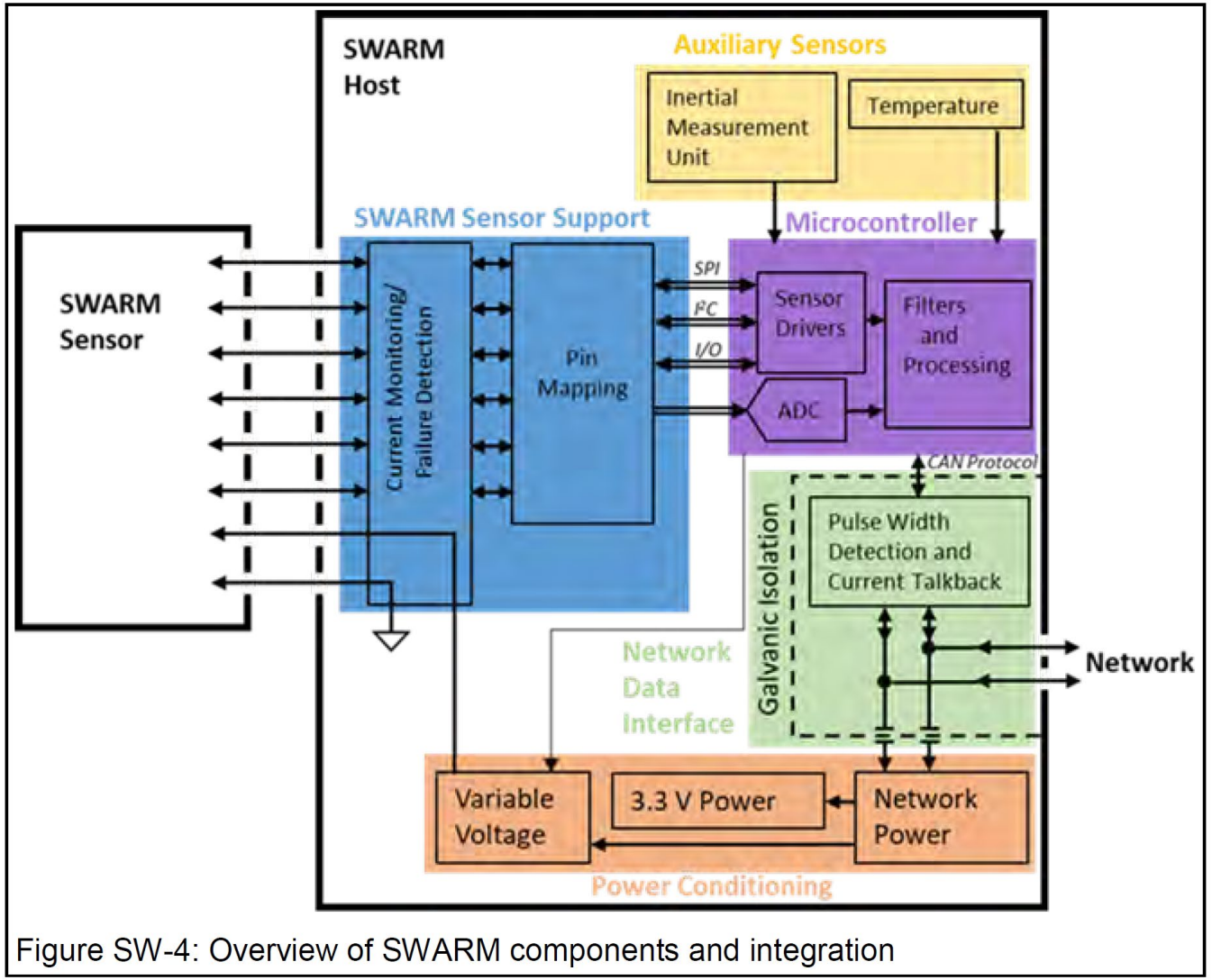

Figure SW-4: Overview of SWARM components and integration

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Specifications:

- Communication – shall support I2C, SPI, UART, analog sampling from outlying module
- Power - shall support up to 5V output
  - We haven’t defined current requirements
- Sampling – shall sample at at least 100Hz (IMU)
- ADC and filtering – requirements have not been defined
- Leakage current
  - Shall have leakage current less than 1uA
  - Shall have a method to detect if failure occurs and the cease current output
  - Outlying sensor can shall NOT be grounded and must be floating when the device is unpowered
- Pin mapping
  - Shall have configurable pin mapping
  - Should have programmable pin mapping
- Auxiliary Sensors
  - Shall have onboard IMU

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Plan:

- Evaluate whether the existing connector design supports DC powering safely
- Develop circuit for detecting failure modes
- Implement microcontroller and develop circuit for supporting two sensor modalities
  - IMU
  - Analog with a strain gauge (Steve Majerus work) – it is feasible and we have received responses
- Leave space on the circuit layout for other potential options

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Test 1: Impedance Measurements-Does the existing connector method provide safe DC Powering

- There may be current leakage through the connector ports
- Can we safely use the existing connector method or do we need to consider a redesign
- Additional tests will be done to evaluate potential current leakage
- This was NOT in the proposal, but necessary to verify we have something usable

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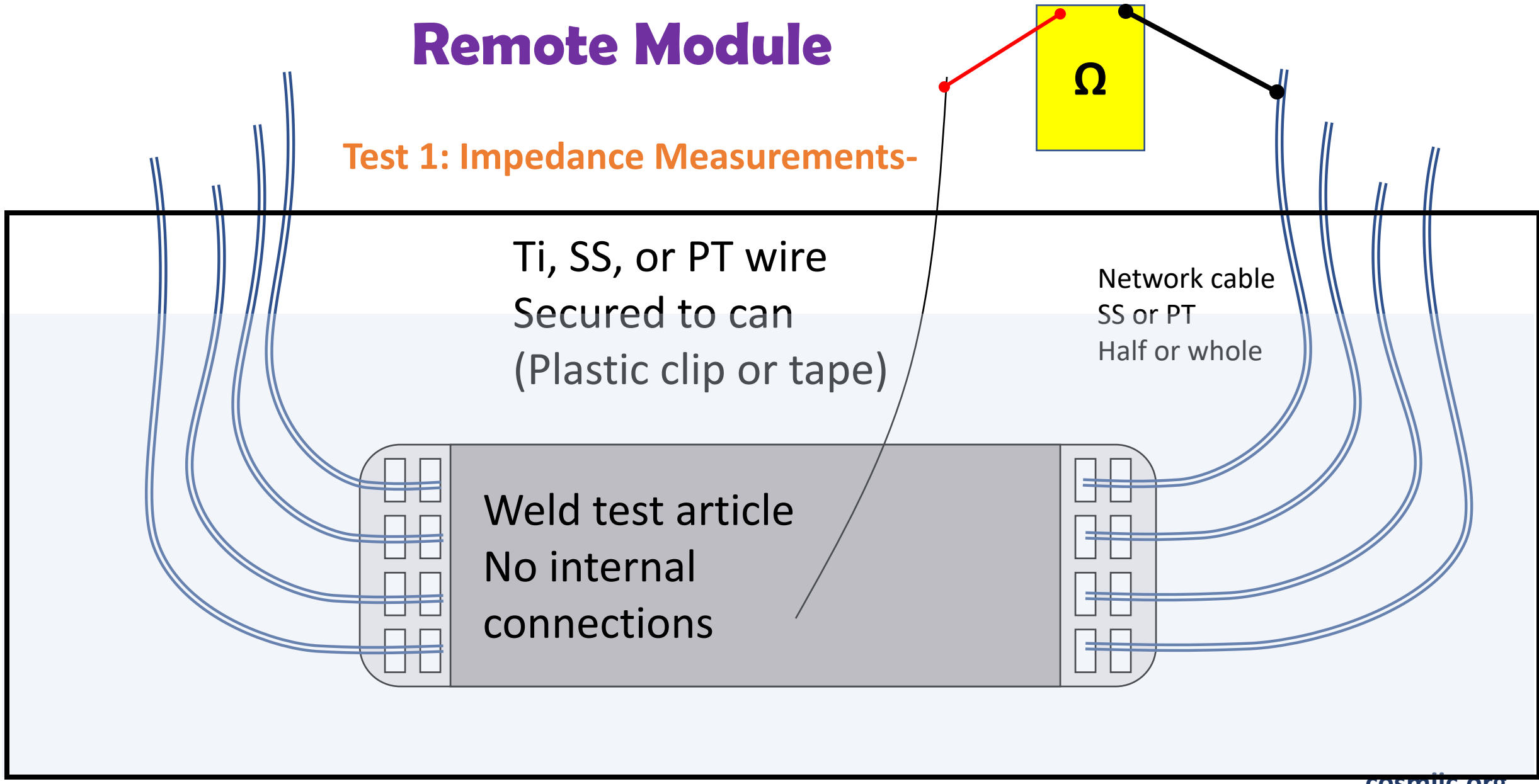
Test 1: Impedance Measurements-



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Test 1: Impedance Measurements-Results interpretation

- If measured resistances are <5Mohm, the seals are not sufficient to guarantee DC leakage < 1uA at 5V
- If measured resistances are <3.3Mohm, the seals are not sufficient to guarantee DC leakage < 1uA at 3.3V
- If measured resistances are <1.8Mohm, the seals are not sufficient to guarantee DC leakage < 1uA at 1.8V.
    - This is the required supply voltage for the ICM-20948 IMU we are planning to support as a first SWARM sensor

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Test 1: Impedance Measurements-Results discussion

- The DC resistance test is not sufficient to demonstrate longevity of the system, so it is just a preliminary test
  - If it fails to show >1.8Mohm for even the tip connectors, then we will have to use a different interconnect system or avoid DC
  - If it passes, then we need to do a long term test to demonstrate that maintained DC current is not degrading interconnect points
    - This likely requires a different setup with access to the internals of the RM can

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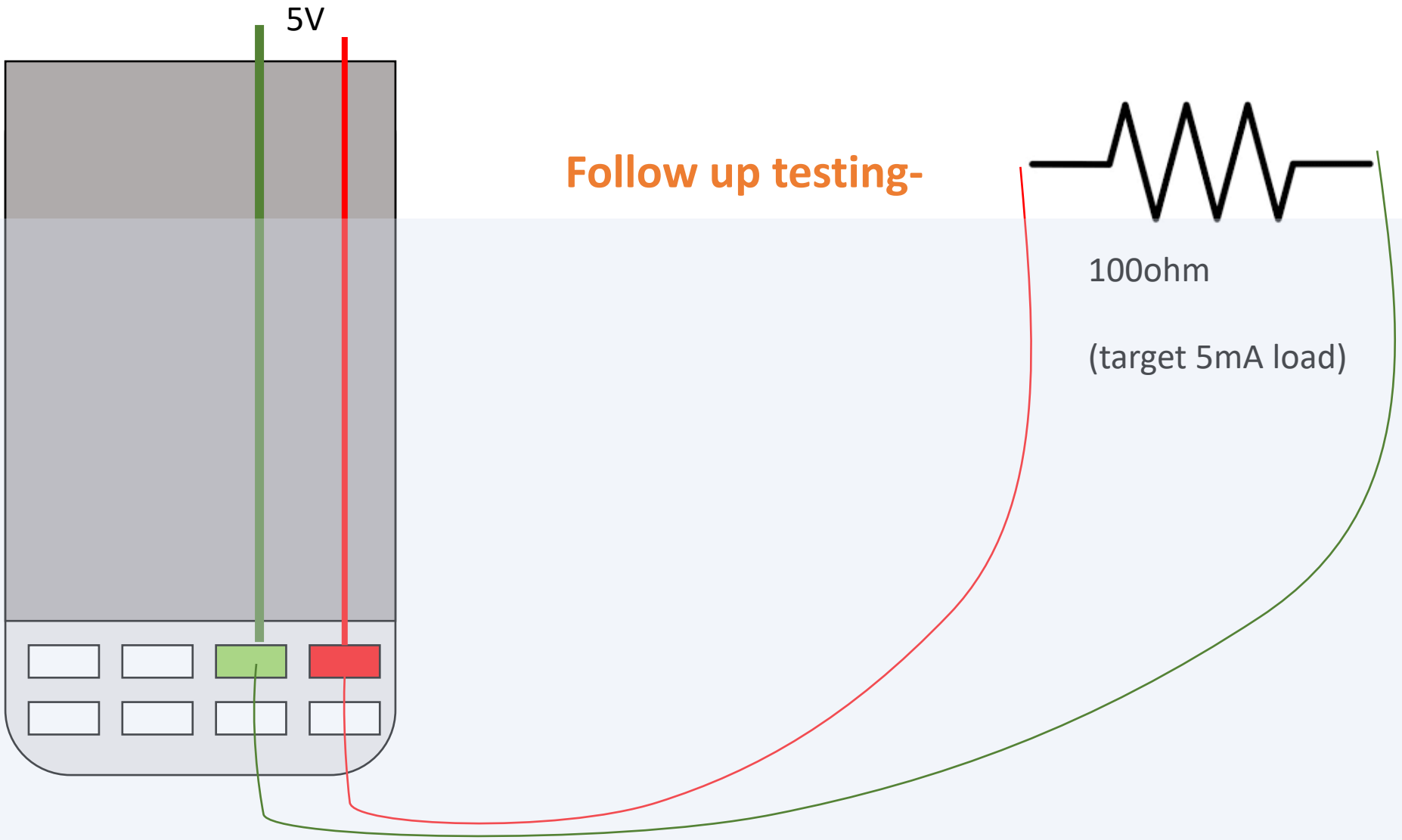

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Follow up testing-

- Active test continuously driving 5V, 5mA across connectors
- Monitor source current
  - Optional: monitor load current
- Look for discoloration and other visual signs of change
- Test different combinations of (ideally in parallel, not on same unit)
  - Inner,inner
  - Outer,outer
  - Inner,Outer (same port)
  - Outer,Inner with grounded can
- Should be done with Pt-Ir network cables, MP35N BalSeal housings
- Is there anything available?
  - Unlike weld test article, needs connection within module

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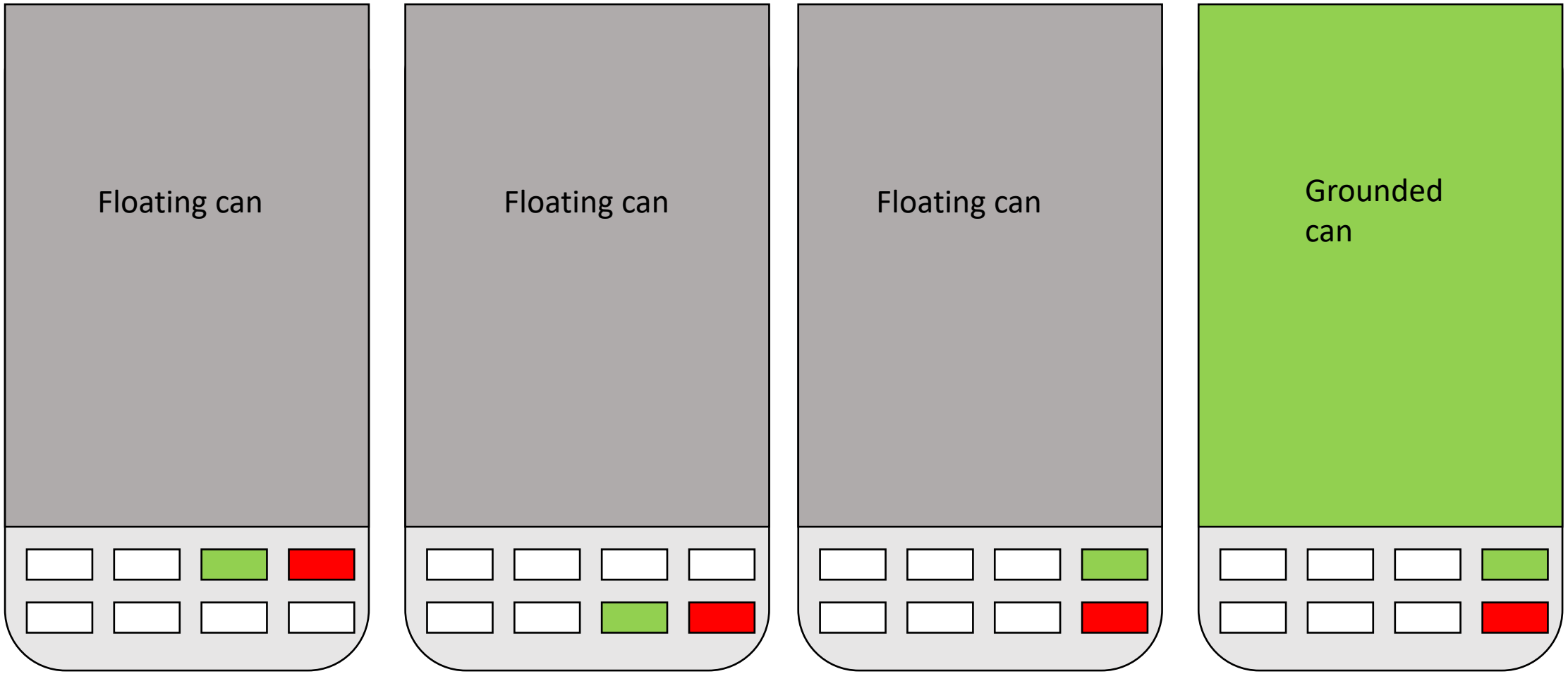
Follow up testing-



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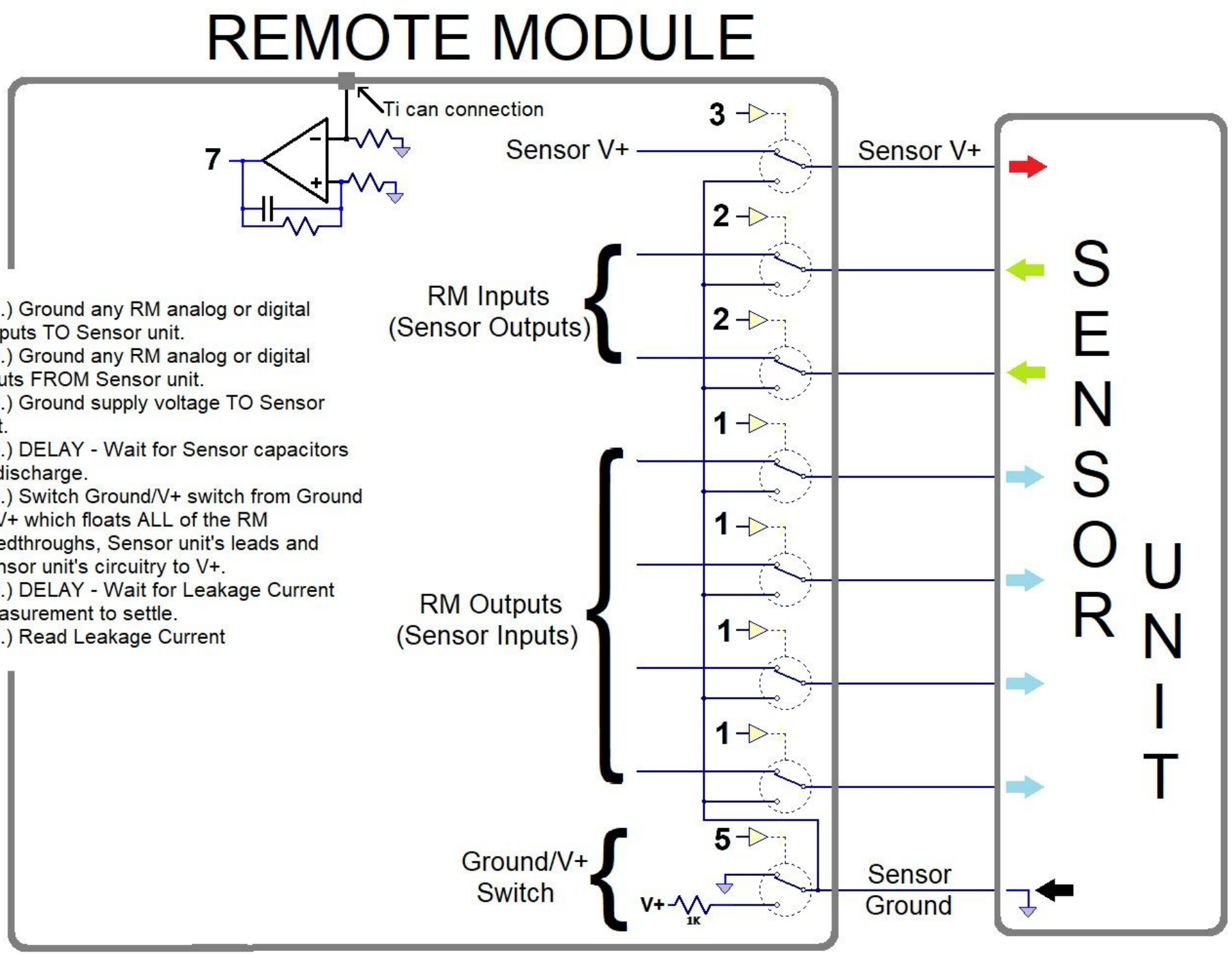
Failure Detection

- Goal is to determine whether there is a failure that could result in current leakage
- Then the module would be turned off
- Goal is NOT to determine what the exact problem is and where it is
- Digital switching approach proposed by Fred to identify current back through the enclosure



- Turn everything high to determine if current leakage through the body back to the can
- Does NOT identify wire breakage
- Requires pause in functional use of outlying sensor

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Sensing Implementation

- Microcontroller communicating with two IMUs
- To determine what is needed to support Steve Majerus strain gauge approach

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Open Questions

- Proposed diagnostic approach tells us IF there is a problem that causes risk to the user, not where it is or other potential problems – any objections to this approach?
- Outlying sensor enclosure cannot be grounded
- Are there other sensors we should definitely approach
- Is it alright to support up to 8 feedthroughs even if we don’t intend to support them all?
- How often does the test protocol need to be run?
- How important is it to support more than one sensor from a single host sensor?