Project Title	Adaptive Readout Interface for Wireless Implantable Sensors
Student	Breandán Gillanders
Supervisor	Dr. Adnan Elahi
Co-Assessor	
This Revision	Revision 1

Scope Statement

Battery-less implantable LC sensors enable continuous, real-time monitoring of physiological parameters by encoding changes in variables such as pressure or strain into shifts in their resonant frequency. However, long-term performance can be affected by biological factors such as fibrotic tissue encapsulation, which alters coupling conditions, increases losses, and degrades wireless readout accuracy. Maintaining reliable operation under these changing conditions requires adaptive circuitry capable of compensating for varying link efficiency.

This project aims to evaluate and improve an existing wireless readout circuit developed for passive implantable sensors. The system interrogates the implanted LC resonator via inductive coupling, measuring the reflection coefficient (S_{11}) to detect shifts in the resonant frequency of the sensor. Building on this foundation, the project will design and integrate a tuneable (reconfigurable) amplifier stage to dynamically adjust gain and stabilise performance as coupling conditions change, ensuring consistent and accurate resonance detection.

The scope of the project includes the following:

- Literature review on existing techniques for measuring S_{11} and resonant frequency detection.
- Circuit evaluation, schematic review, and performance benchmarking of the current system.
- Simulation (LTSpice/QucsStudio) of RF front-end and amplifier stages.
- Design, implementation, and tuning of a reconfigurable amplifier for adaptive gain control.
- Integration and experimental validation of the improved system.
- Evaluation of system stability and resonance tracking accuracy under variable coupling conditions.
- Documentation and presentation of design process, results, and future recommendations.

Stakeholder List

Stakeholder	Power	Interest	Concerns
Supervisor	High	High	Timely achievement of project milestones and solutions to project issues. Regular reporting & achievement of deliverables
Co-Assessor	Medium	Low	Achieve deliverables; clear documentation for assessment; overall project quality and completion
Student (me)	High	High	Technical feasibility, meeting project scope and deadlines; demonstrating competency and producing results
Translational Medical Device Lab	High	High	Functional prototype that aligns with their research goals; practical, scalable readout system design; documentation for future development; experimental data
Technical Officers	Medium	Medium	Safe and effective use of lab equipment; availability of components
EEE Department	High	Medium	Compliance with academic standards, successful and innovative project outcome
University of Galway	High	Low	Adherence to institutional research policies and procedures.
End Users	Low	High	Reliability, safety, non-invasiveness, and ultimate improvement in patient care and monitoring

Table of Contents

Deliverables

Fixed Deliverables

These are standard for all projects and should be incorporated into your Work Breakdown and Work Schedules below.

- Project Plan (working 'live' document)
- Progress Presentation (PPT document)
- Project Presentation/Poster/Demo
- **Final Project Report (Word document)**

Interim Deliverables

- Literature Review
- Existing circuit evaluation results
- Circuit Simulation Results
- Prototype circuits (reconfigurable amplifier circuit)
- Final wireless reader system
- Testing and validation results of final system

Work Breakdown

Work Package #1	Literature review and design requirements
Task #1	Review the underlying theory of resonant sensing systems.
Task #2	Perform a literature review on magnetic-resonant bioelectronic implants for cardiovascular monitoring, with emphasis on their readout circuitry. Additionally, review current techniques and circuit implementations for measuring reflection (S_{11}) and transmission (S_{21}) coefficients relevant to these systems.
Task #3	Investigate reconfigurable and programmable amplifier designs. Define design requirements for this application (e.g. operating frequency range, max transmitted power level etc.)
Linked Deliverables	
Expected Outputs	Literature review and design requirements

Commented [IS1]: This should be Task #2

Commented [IS2]: Move it to task #3 and change it to define the design requirements for the targeted application (e.g., operating frequency range, max. transmitted power level,…). Your literature review on existing readout circuits for smart stents will help you finding other design requirements

Work Package #2	Evaluation and refinement of the current readout circuit
Task #1	Review circuit schematics, PCB design and layout, and simulation models of current circuit design. Isolate and test each subsystem individually (DDS, phase shifter, phase detector, filters etc.) before performing full-system evaluation.
Task #2	Perform complete system testing after individual subsystem verification. Benchmark overall performance and compare with design expectations.
Task #3	Incorporate design improvements to the circuit as informed by system testing results and additional insights obtained from the literature review.
Linked Deliverables	
Expected Outputs	Existing circuit benchmark results and improved version

Commented [IS3]: This should be part of Task #1

Commented [IS4]: This should be Task #2. Also based on the testing of each subsystem and the complete circuit will find out what need to be improved in the current circuit version.

Commented [IS5]: Task #3 should be implementing the improvements you identified as needed in Task #2 and using the information you gathered in the literature review.

Work Package #3	Design of reconfigurable amplifier module
Task #1	Design the reconfigurable amplifier architecture based on design requirements (gain range, bandwidth etc.). Perform LTSpice simulations of the design to evaluate functionality and component selection.
Task #2	Translate the simulated design into a PCB using Altium/KiCad, ensuring RF design best practices are adhered to. Fabricate the PCB in the TMD lab. Solder components to PCB.
Task #3	Test the amplifier using a signal generator and an oscilloscope. Record metrics on the gain and phase response of the amplifier. Compare measured data with simulated results.
Linked Deliverables	
Expected Outputs	Validated amplifier design, PCB prototype board

Work Package #4	Reconfigurable readout circuit integration
Task #1	Integrate the reconfigurable amplifier module with the improved readout system to evaluate system-level performance and identify requirements for merging all components onto a single PCB. Update the firmware and implement a FreeRTOS-based framework to manage concurrent tasks, including communication with the DDS, ADC, and data processing.
Task #2	Develop a new PCB layout incorporating lessons learned from the existing device. Export Gerber files, BOM. Ensure components are readily available in the lab or can be easily sourced. Submit the finalized PCB design for fabrication. Procure all necessary components and assemble the revised board within the lab.
Task #3	Conduct validation and performance testing of the fully integrated PCB, comparing measured results with expected results and benchmarking the final system in terms of accuracy and reproducibility.
Linked Deliverables	
Expected Outputs	Integrated PCB design and updated firmware

Work Package #5	Final Report
Task #1	Document the full system, detailing the circuit and PCB design, firmware implementation, and experimental results obtained at each stage of testing.
Task #2	Identify limitations in the circuit design, determine areas for improvement, and compile a list of recommendations for the next design revision.
Task #3	Prepare the final project report and presentation, summarising the design process, results, and key findings. Incorporate the literature review, system documentation and suggestions for future work.
Linked Deliverables	
Expected Outputs	Final system testing results

Commented [IS6]: Task #3 should be part of Task #2

Commented [IS8]: Since our focus will be on the readout circuit design, it would be sufficient to validate and demonstrate its functionality in your presentation. If there's still enough time, we can test it within the test rig we have in the lab, but for now, it's better not to promise that.

Commented [IS9]: Task #1 should be documenting the full system, circuit and pcb design, firmware, experimental results

Commented [IS10]: Task #2 should be identifying what needs to be improved and prepare a list of recommendations for the next revision of this design

Commented [IS11]: Task #3 should be writing the final report and preparing the presentation

Work Schedule

Task Scheduling Table #1

WP #	Task #	Dependencies	Start Date	End Date	Deliverable	Notes
WP1		n/a	13/10/2025	17/11/2025		
	T1	n/a	13/10/2025	22/10/2025		
	T2	n/a	22/10/2025	31/10/2025	Literature Review	
	T3	n/a	03/11/2025	17/11/2025		
WP2			22/10/2025	01/12/2025		
	T1		22/10/2025	31/10/2025		
	T2		03/11/2025	17/11/2025	Benchmarking Results	
	T3		17/11/2025	01/12/2025	Circuit Improvements	
WP3			10/11/2025	08/12/2025		
	T1		10/11/2025	24/11/2025		
	T2		24/11/2025	01/12/2025		
	T3		01/12/2025	08/12/2025	Finalised Amplifer Design	
WP4			05/01/2026	02/03/2026		
	T1		05/01/2026	19/01/2026		
	T2		19/01/2026	16/02/2026	Wireless Reader System	Dependent on PCB manufacturing time
	T3		16/02/2026	02/03/2026	Validation Results	
WP5			19/01/2026	30/03/2026		
	T1		19/01/2026	16/02/2026		Can be done in parallel with PCB manufacturing
	T2		02/03/2026	09/03/2026		
	T3		09/03/2026	30/03/2026	Project Report	

Commented [IS12]: You need to update it according to the previous comments and the changes you make in the tasks.

Commented [IS13R12]: Set the start date on 22/10. WP1 and WP2 can run in parallel. WP 4 will take a lot of time because the final PCB will be prototyped externally, and there are always some problems in the integration. So you can dedicate some time to that.

Commented [IS14R12]: I think you can start running WP3 around the middle of WP2 because at this stage the readout and the amplifier are independent circuits (more or less, you will need some info from the readout to fine tunning your amp but half way through WP2 this requirements should be clear).

Task Scheduling Table #2

WP #	**Task #**	**Deliv #**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	Feb	**Mar**	**April**
WP1										
	T1			XX						
	T2			XX						
	T3				XX					
WP2										
	T1			XX						
	T2				XX					
	T3				XX					
WP3										
	T1				XX					
	T2				XX					
	T3					XX				
WP4										
	T1						XX			
	T2						XX	XX		
	T3							XX		
WP5										
	T1						XX	XX		
	T2								X	
	T3								XXX	

Communications Strategy

Name	Recipient(s)	Frequency	Medium	Contents
Status Reports	Supervisor	Weekly (Friday)	SharePoint	Bullet-point summary of weekly activities, issues encountered and planned next steps.
Supervisor Meetings	Supervisor	Weekly (Wednesday)	In-Person	Discussion of progress, review of challenges, and identification of solutions or required support.
Progress Presentation	Supervisor & Co-Assessor	Once (start of semester 2)	In-Person	Presentation summarising progress to date and outlining objectives and timelines for Semester 2.
Poster	All Stakeholders	Once (public event)	Poster Session	Presentation summarising progress to date and outlining objectives and timelines for Semester 2.
Final Project Report	Supervisor & Co-Assessor	Once (end of project)	PDF Document	Comprehensive final report detailing all project work, results, and conclusions.

Appendix A: Health & Safety Risk Assessments

Oscilloscope Risk Assessment

Person(s) at risk	Operator/instructor:	X	Students	X	Other	

Hazard(s)	**Likelihood** (Controls in place)	**Severity** (Controls in place)	**Controls** **(See over for more details)**
Electric shock	1	2	The equipment must be properly grounded.
Overheating of electronic components	2	1	Ensure that the component is not defective and all connections are as intended, no short circuit and all instruments are properly grounded. Use of heat sinks where needed.

Likelihood:
1= Very Unlikely/Yearly
2= Unlikely/During a Semester
3= Likely/Weekly
4= Very Likely/Daily

Severity:
1= Slight Harm
2= Moderate Harm
3= Extreme Harm

Likelihood \ Severity	1	2	3
1		x	
2	x		
3			
4			

Comments:
- **Place an "x" in the matrix for each hazard**

Risk Assessment **with** controls (Taken as the highest colour in matrix)	High		Medium		Low	X

Hierarchy of Controls: **Equipment:** Battery Powered Hand Drill
Engineering:

Training given for protocol, safety (PPE, spills, sharps, biohazards, waste).
PPE worn at all times.

Administrative/Procedural:
- Standard Operating Procedures in place
- Induction to lab safety provided before experiments commence
- Wear a lab coat depending on your sample type.

List any specific PPE required-

All experiments:

Lab Coat

General Rules:
- No Loose Hair, No Loose Clothes, No dangling Jewellery
- Adequate Footwear required (No open toes)
- Wash your hands after the laboratory session.
- No Eating or Drinking during laboratory sessions.
-Lab coat and gloves do not leave wet lab area.

Impedance Analyser Risk Assessment

Person(s) at risk	Operator/instructor:	X	Students	X	Other	

Hazard(s)	**Likelihood** (Controls in place)	**Severity** (Controls in place)	**Controls** **(See over for more details)**
Liquid spills/splashes	3	1	Electrical equipment is raised & splash guard between stations. Spill tray used with large volumes of liquid. PPE worn. Spill training given, and tools provided.
Contact/contamination with biological tissues	2	1	PPE worn. Clean station after use. Tissue preparation on disposable biohazard mat.
Blood spillage/splatter	4	1	PPE worn (goggles, gloves, coat). Splash guard between stations. Clean station after use.
Broken glass (beakers, etc)	2	1	Spill training given, and tools provided. Training given on accident protocol.
Sharps injuries	2	1	Use scalpel one time only – do not clean. Dispose in sharps bin. Training given on accident protocol.

Likelihood:
1= Very Unlikely/Yearly
2= Unlikely/During a Semester
3= Likely/Weekly
4= Very Likely/Daily

Severity:
1= Slight Harm
2= Moderate Harm
3= Extreme Harm

Likelihood \ Severity	1	2	3
1			
2	xxx		
3	x		
4	x		

Comments:
- **Place an "x" in the matrix for each hazard**

Risk Assessment **with** controls (Taken as the highest colour in matrix)	High		Medium		Low	X

Hierarchy of Controls: **Equipment:** Prototyping Hand Tools
Engineering:

Training given for measurement protocol, safety (PPE, spills, sharps, biohazards, waste).
PPE worn at all times.

Administrative/Procedural:

- Standard Operating Procedures in place
- Induction to lab safety and measurement protocol provided before experiments commence
- Clean Work surfaces after each lab session
- Hepatitis B vaccine and titre testing offered to all workers (risks and benefits detailed)

List any specific PPE required-

All experiments:


Gloves & Lab Coat

Experiments with Blood or chemicals that require eye protection:

Eye Protection

General Rules:
- No Loose Hair, No Loose Clothes, No dangling Jewellery
- Adequate Footwear required (No open toes)
- Wash your hands after the laboratory session.
- No Eating or Drinking during laboratory sessions.
-Lab coat and gloves do not leave wet lab area.

Risk Assessment **with** controls (Taken as the highest colour in matrix)	High		Medium		Low	X

3D Printer Risk Assessment

Person(s) at risk	Operator/instructor:	X	Students	X	Other	

Hazard(s)	Likelihood (Controls in place)	Severity (Controls in place)	Controls (See over for more details)
Contact with moving parts - Entrapment or entanglement	1	2	Enclosed system guarding around moving parts Training and SOP
Direct/Indirect contact with parts - Electric Shock	1	2	Training and SOP Repairs and maintenance by competent person only Regular maintenance & Electrical Inspection Test & Tag
Exposure to fumes and ultrafine particles - Potential health effects on respiratory system from long term exposure	2	1	Place the printer away from workstations Adequate ventilation and exhaust capability Training and SOP Use of personal protective equipment (mask, gloves etc.) Regular changing of High Efficiency Particulate Arrestance HEPA filters
Contact with particles generated from post processing (e.g. sanding) of printed object - Potential health effects on respiratory system from long term exposure	2	1	Training and SOP Use of personal protective equipment (mask, gloves, safety glasses etc.)
Contact with caustic bath or other chemicals during post processing - Burns	2	1	Training and SOP Use of personal protective equipment (mask, gloves, safety glasses etc.)
Heat from extrusion head - Burns, scalds and other injuries by possible contact with objects and materials while they are still hot	1	2	Guarding system that prevents user from touching the nozzle or the end product until it has cooled. Training and SOP
Unstable surface – Printer may fall	1	2	Appropriate setup
Printer catching fire due to electric fault	1	2	Repairs and maintenance by competent person only Repairs and maintenance by competent person only

Likelihood:
1= Very Unlikely/Yearly
2= Unlikely/During a Semester
3= Likely/Weekly
4= Very Likely/Daily

Severity:
1= Slight Harm
2= Moderate Harm
3= Extreme Harm

Likelihood \ Severity	1	2	3
1		xxxx	
2	xxxx		
3			
4			

Comments:
- **Place an "x" in the matrix for each hazard**

Risk Assessment **with** controls (Taken as the highest colour in matrix)	High		Medium		Low	X

Hierarchy of Controls: **Equipment:** Prototyping Hand Tools

Engineering:

Training given for measurement protocol, safety (PPE, spills, sharps, biohazards, waste).
PPE worn at all times.

Administrative/Procedural:

- Standard Operating Procedures in place
- Induction to lab safety and measurement protocol provided before experiments commence
- Clean Work surfaces after each lab session

List any specific PPE required-

All experiments:

Gloves **Lab Coat** **Eye Protection**

General Rules:
- No Loose Hair, No Loose Clothes, No dangling Jewellery
- Adequate Footwear required (No open toes)
- Wash your hands after the laboratory session.
- No Eating or Drinking during laboratory sessions.
-Lab coat and gloves do not leave wet lab area.

Risk Assessment **with** controls (Taken as the highest colour in matrix)	High		Medium		Low	X

Desk-Based Activities Risk Assessment

Hazard(s)	**Likelihood** (Controls in place)	**Severity** (Controls in place)	**Controls (See over for more details)**
Ergonomics of use	1	1	If using a computer habitually as a significant part of normal duty (for continuous spells of three hours or more daily) a DSE assessment must be completed. If using a laptop, a monitor should use be used with separate mouse and keyboard at your workstation. Place the laptop/notebook on a firm surface (not on the lap) at the right height for keying. Ensure that a suitable 5-star chair that is adjustable has been used to support your back.
Vision Fatigue	1	1	Ensure that frequent breaks and time away from the workstation for every hour of use. If glasses are required for computer work, ensure that they are been used
Slips, Trips and falls	1	1	Workstations should be kept clear of cables and other trip hazards

								
		P					P	
State standard of PPE:								
	Hard hat	Safety Glasses				Toe protector	Sharp protectio n	For all in vicinity

Risk Assessment Matrix

		Severity			
		1	2	3	4
Likelihood	1	xxxx xxxx	xxxxx xxxx xxx	x	
	2	xxxx xxx			
	3				
	4				

Risk Assessment **with** controls
(Taken as the highest colour in matrix)

High	Medium	Low
		X