

Implementation of Adaptive Position-Free Wireless Power Transfer

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Motivation and Background

- Wireless power transfer (WPT) technologies has been seeing significant growth in consumer markets in recent years
- Convenience has become more of an interest nowadays over practicality of cabled connections
- Thesis aim is to design and build a wirelessly powered wall while maximising efficiency, cost effectiveness, scalability and reliability
- The motivation behind this project is to improve the convenience of powering consumer electronics and lighting by reducing the need for additional wiring while also saving external wiring cost for homes and businesses.
- To achieve a loosely coupled system (not affected significantly by misalignment), magnetic resonance coupling (MRC) will be used as the WPT method

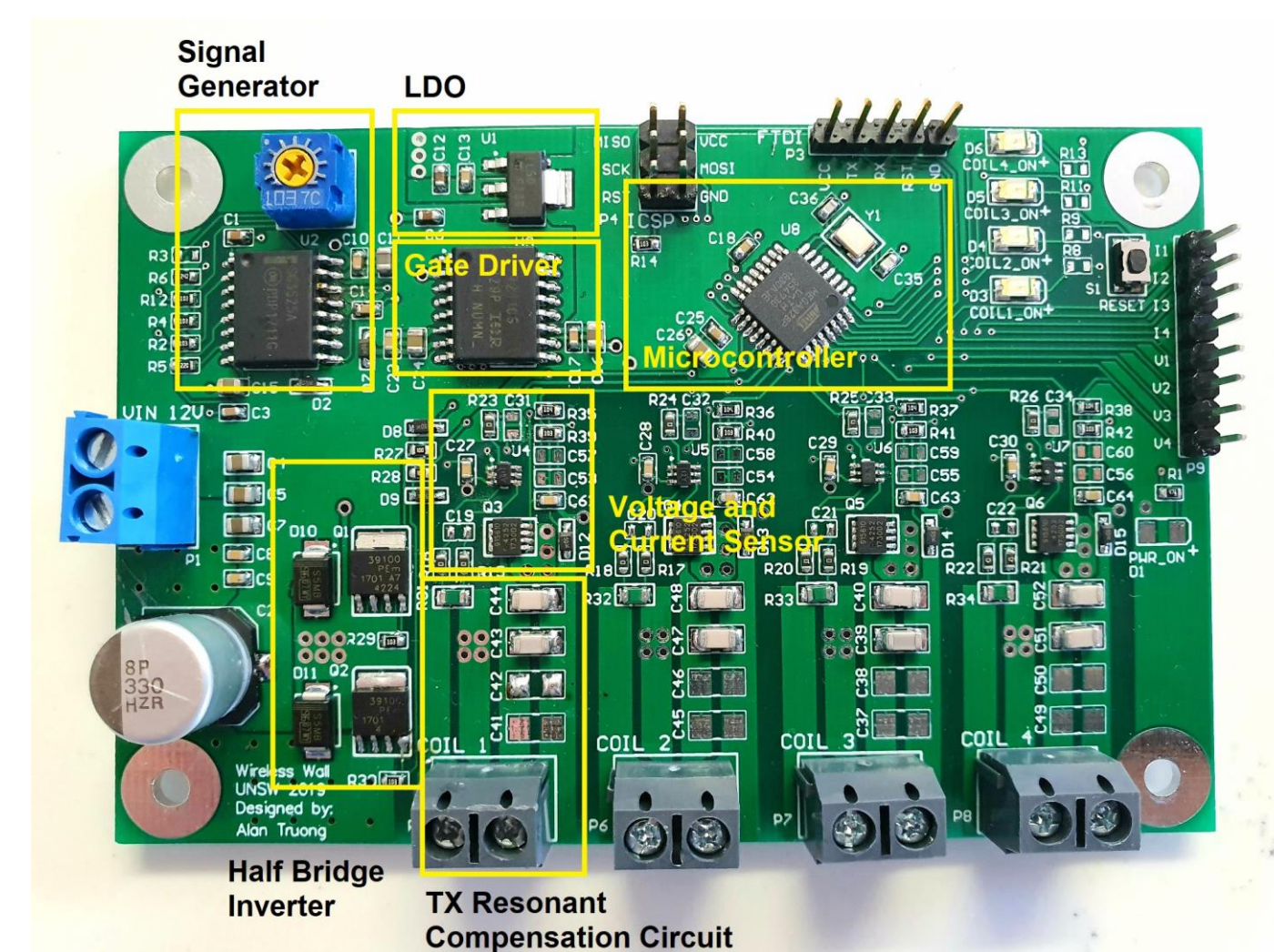
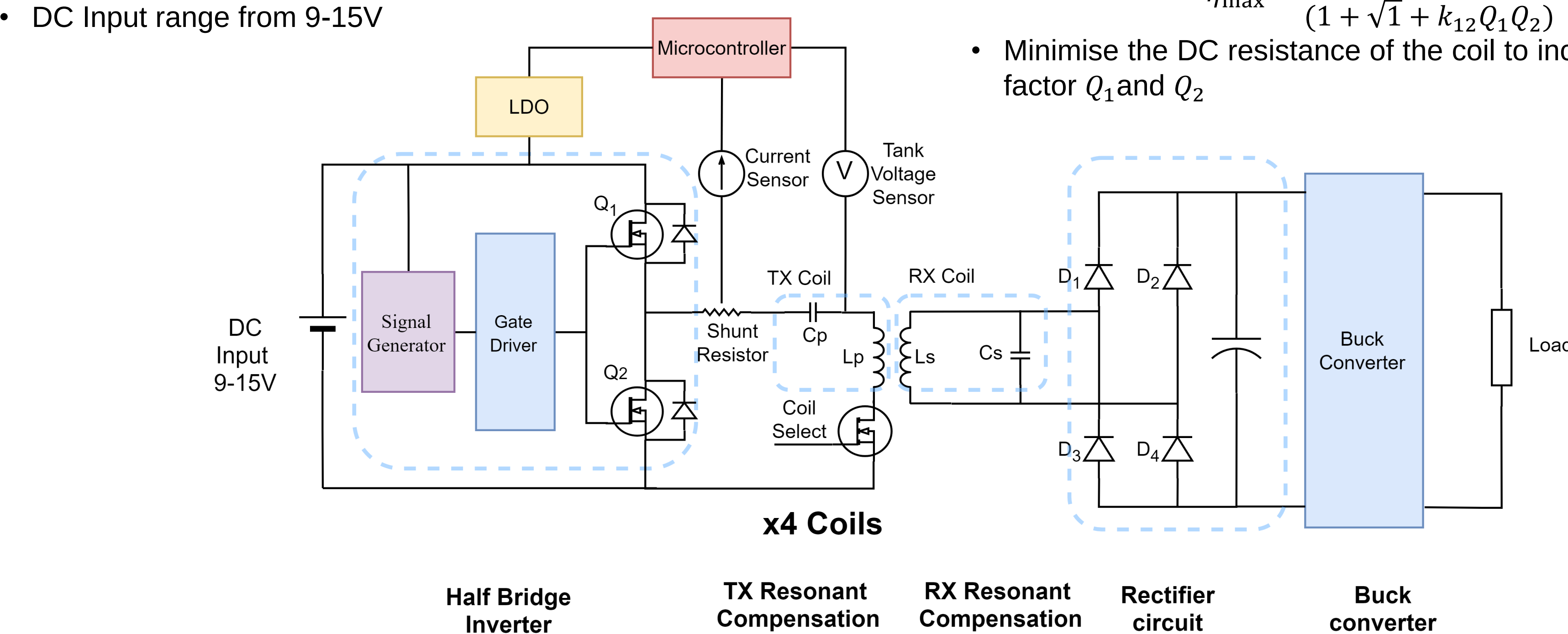
Proposed Design

Transmitter Circuit

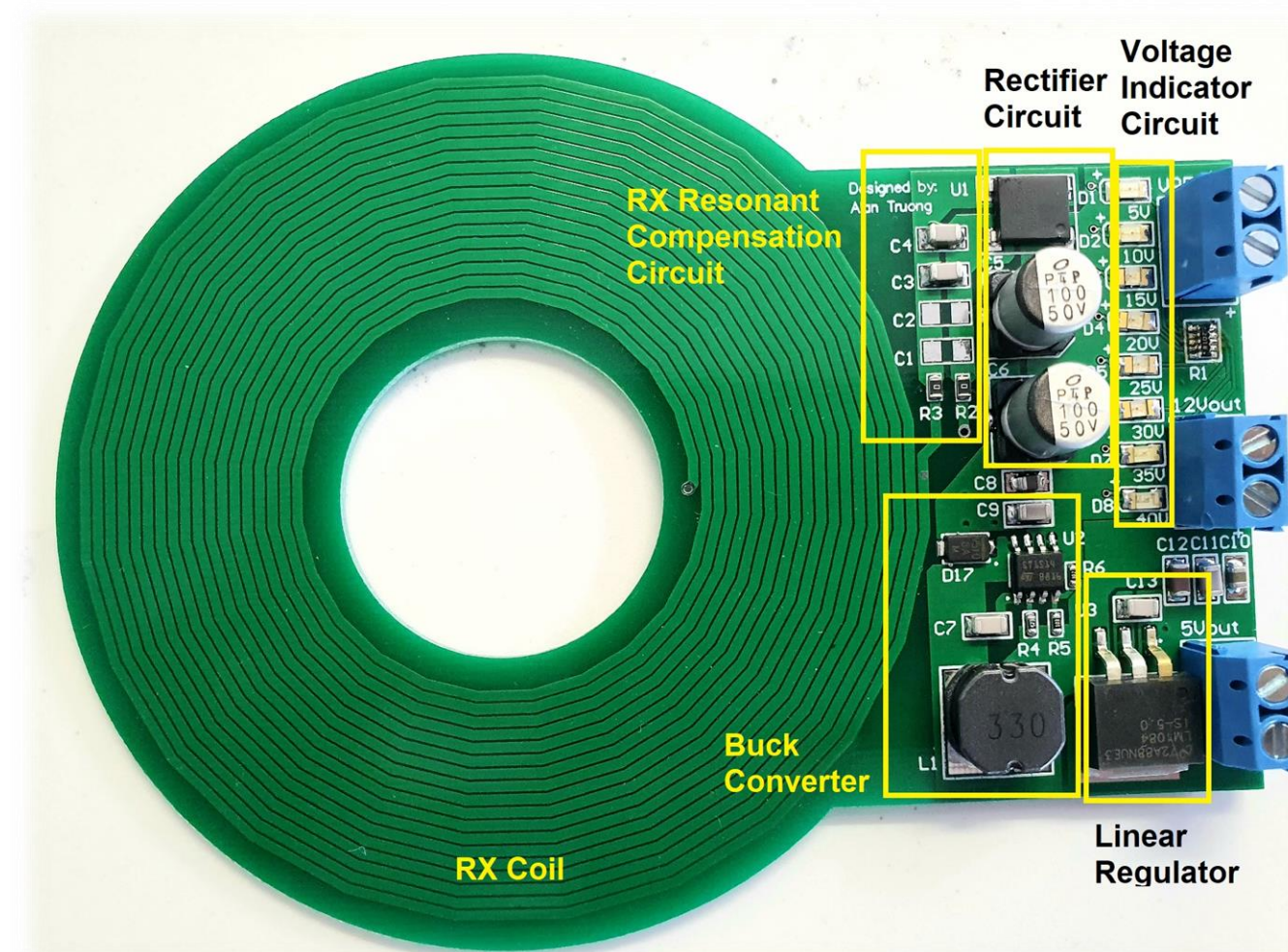
- The transmitter board features a half bridge topology
- One transmitter circuit drives 4 coils
- Current and Voltage sensing for RX coil detection and foreign object detection
- Power MOSFET to select which coils to enabled or disabled
- Series-Parallel compensation topology
- DC Input range from 9-15V

Receiver Circuit

- Proposed receiver coil designed as a custom FR4 PCB single layer coil with 23.5uH.
 - 3 outputs – Rectified voltage, 12V, 5V
 - To maximise efficiency, the Q factor of the TX and RX coil needs to be maximised, from equation
- $$\eta_{\max} = \frac{k_{12}^2 Q_1 Q_2}{(1 + \sqrt{1 + k_{12} Q_1 Q_2})}$$
- Minimise the DC resistance of the coil to increase the quality factor Q_1 and Q_2



PCB Layout for Transmitter



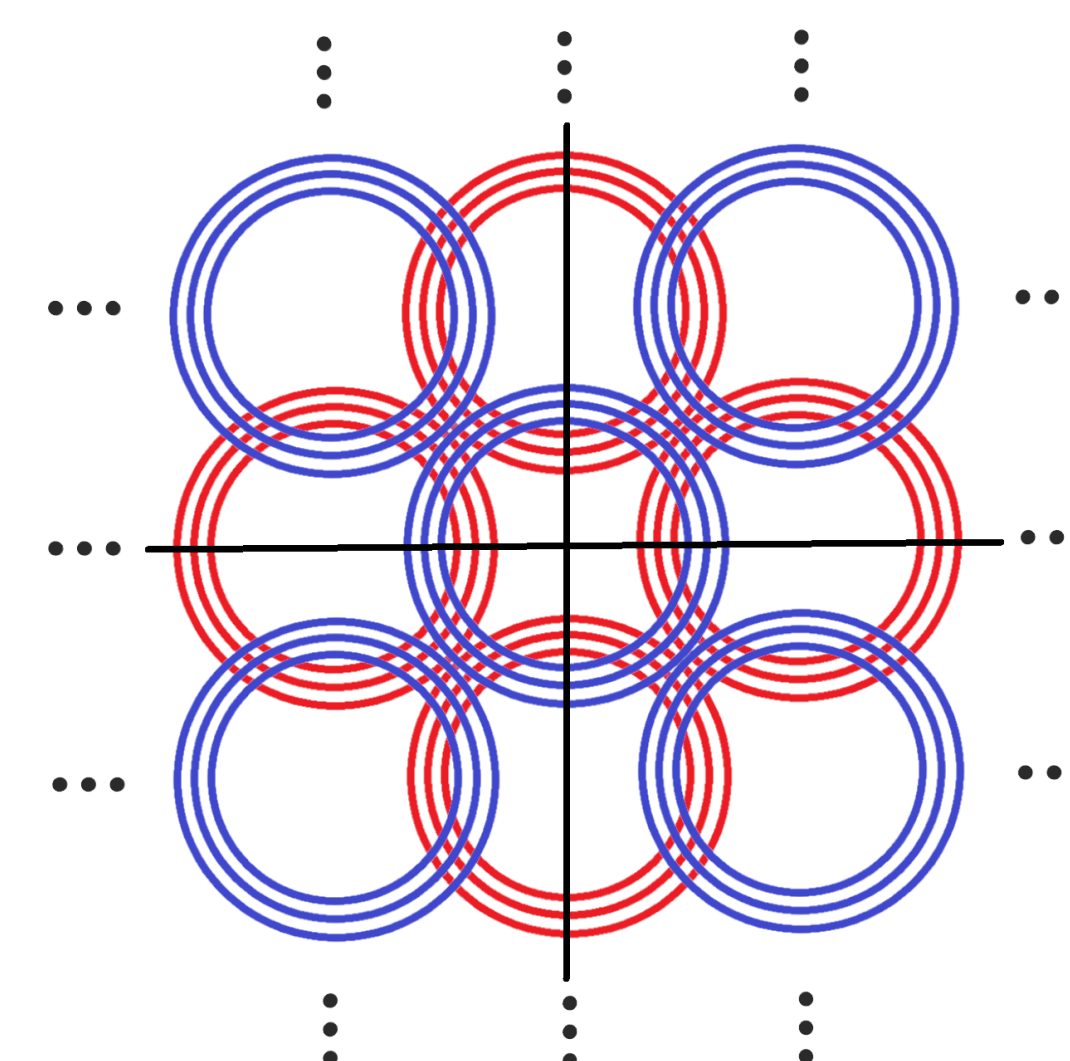
PCB Layout for Receiver

Parameter	Value
Inductance	23.96uH
Q factor @ 100kHz	8.38
DC Resistance	1.761
Turns	18
Diameter	8.5mm
Material	FR4 1 oz Cu
Trace width	40mil

Custom Wireless Wall Coil Parameters

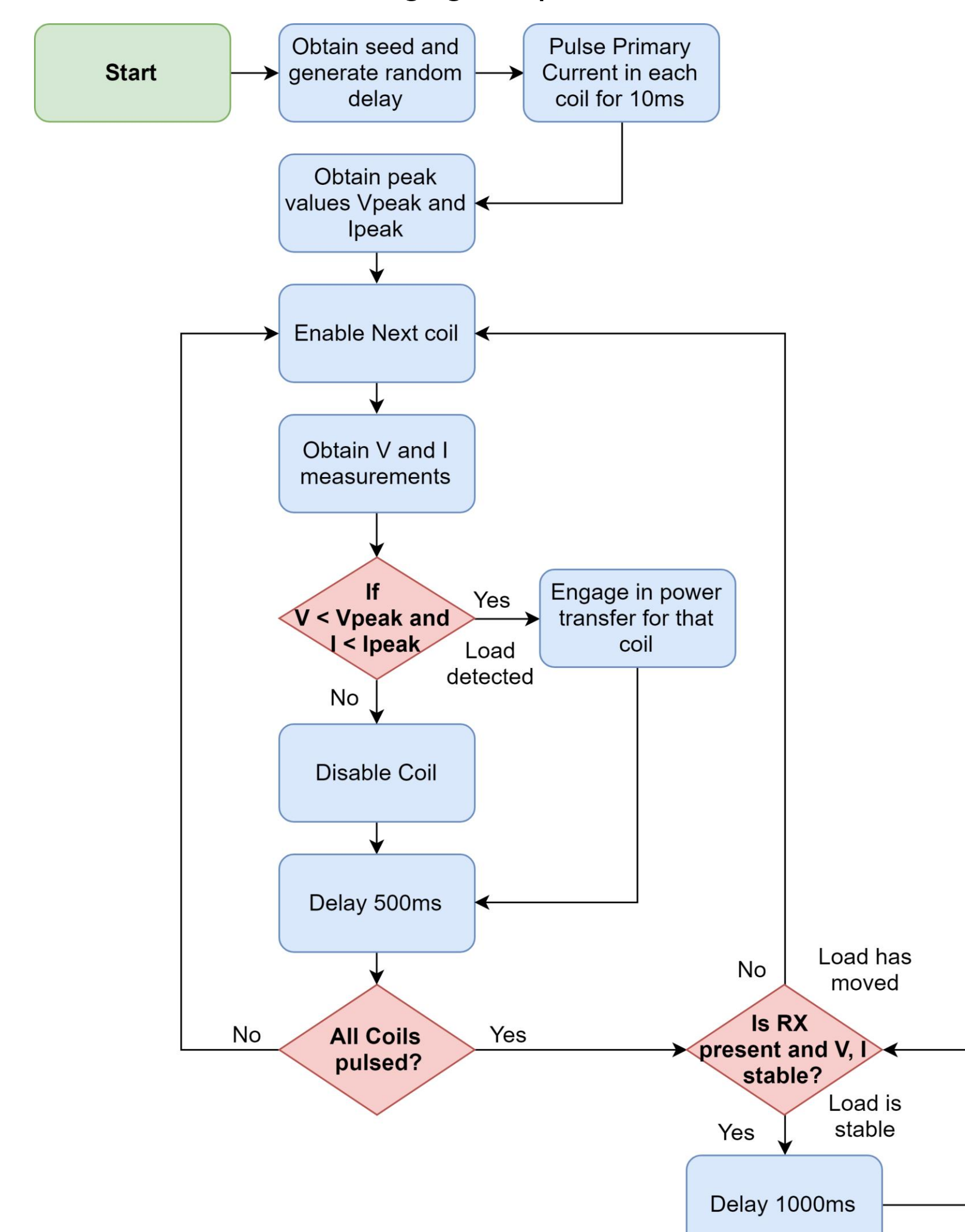
Transmitter Coil Array

- 2 Layer PCB (Blue – top, Red – bottom)
- Interlaced coils for increased field coverage
- Each transmitter coil board will contain 4 coils
- Prototype will include 9 transmitter boards



Coil Detection Algorithm

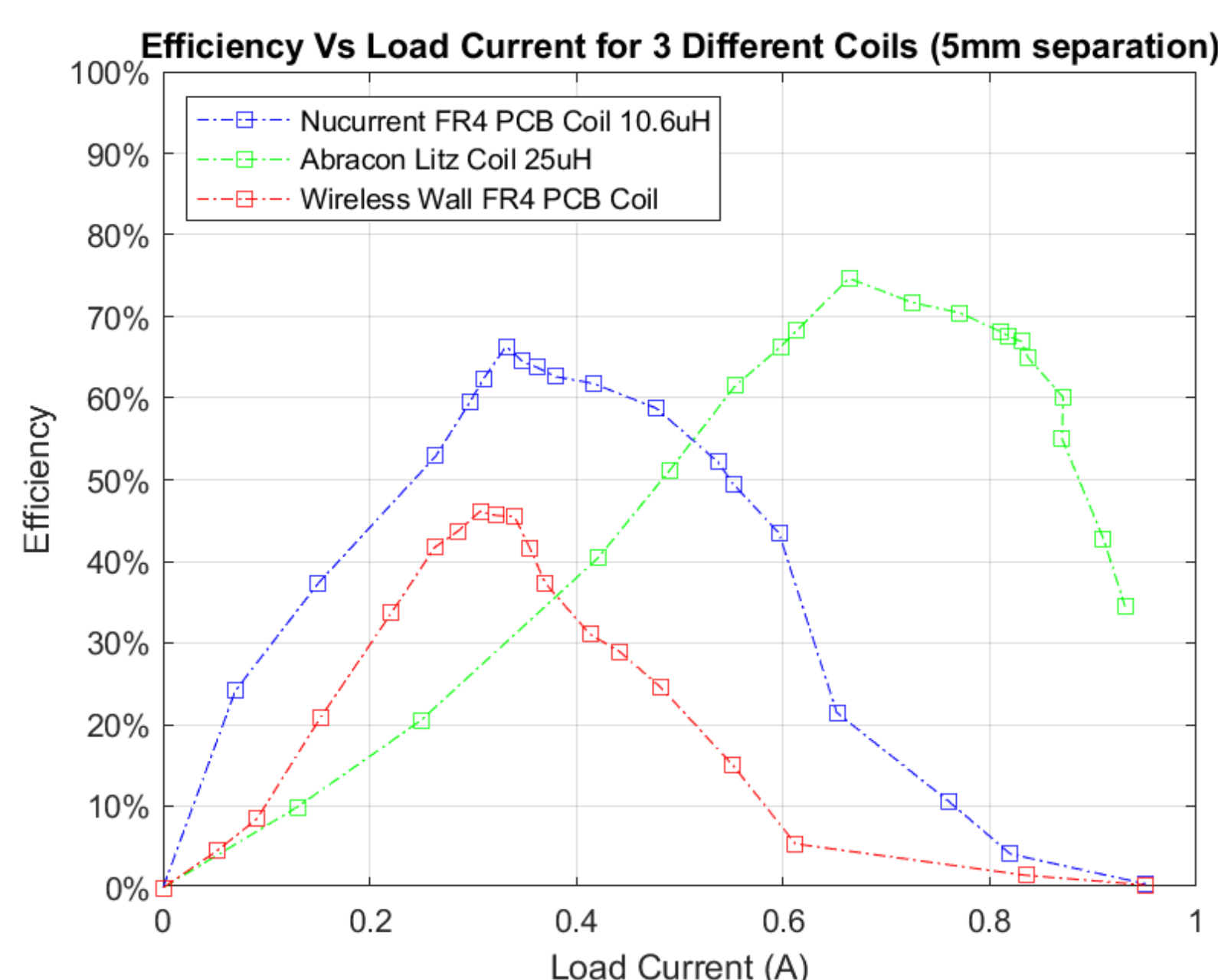
- Coil detection is required to reduce transmitter power drain when there is no receiver coil nearby
- Only the transmitter coil that is in the presence of a receiver coil will engage in power transfer



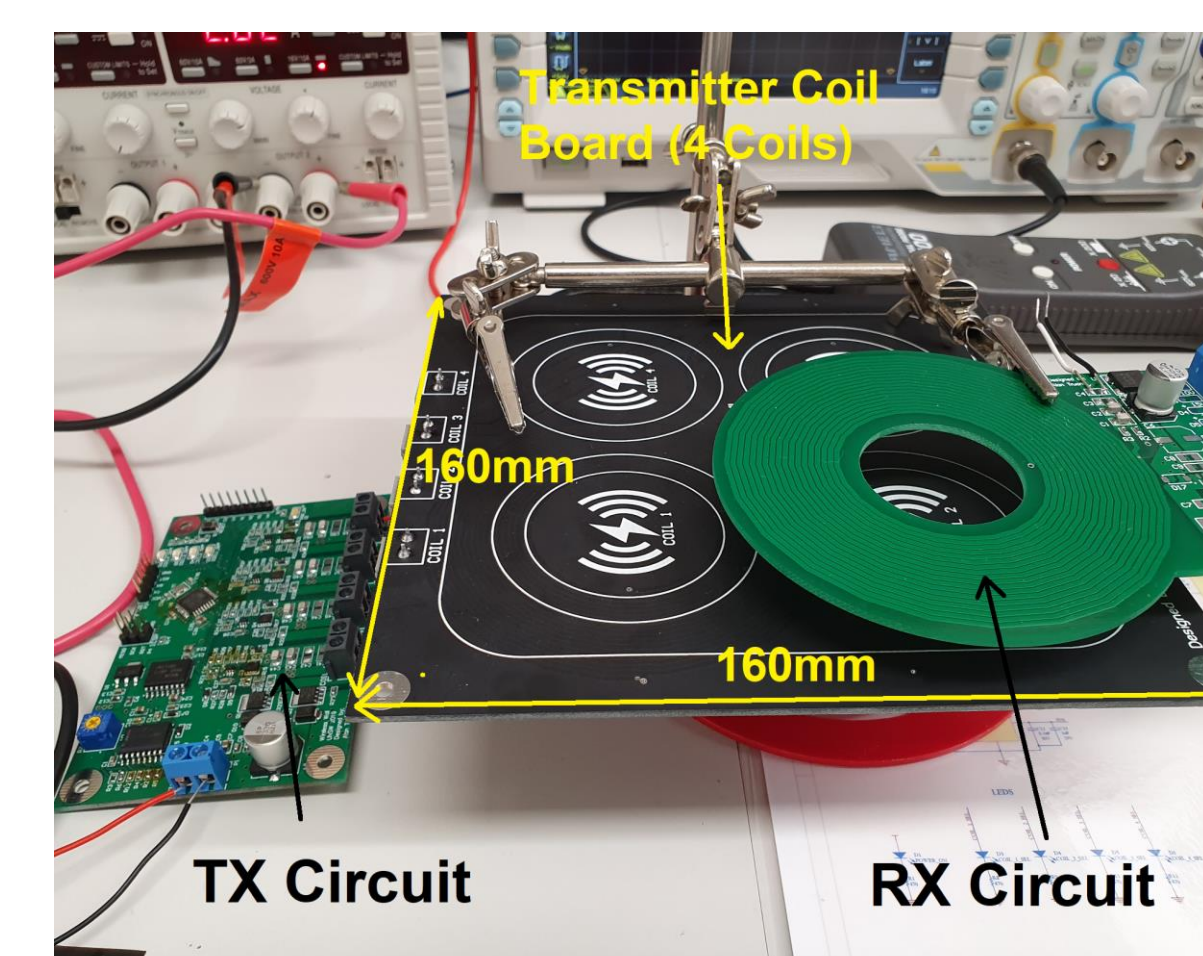
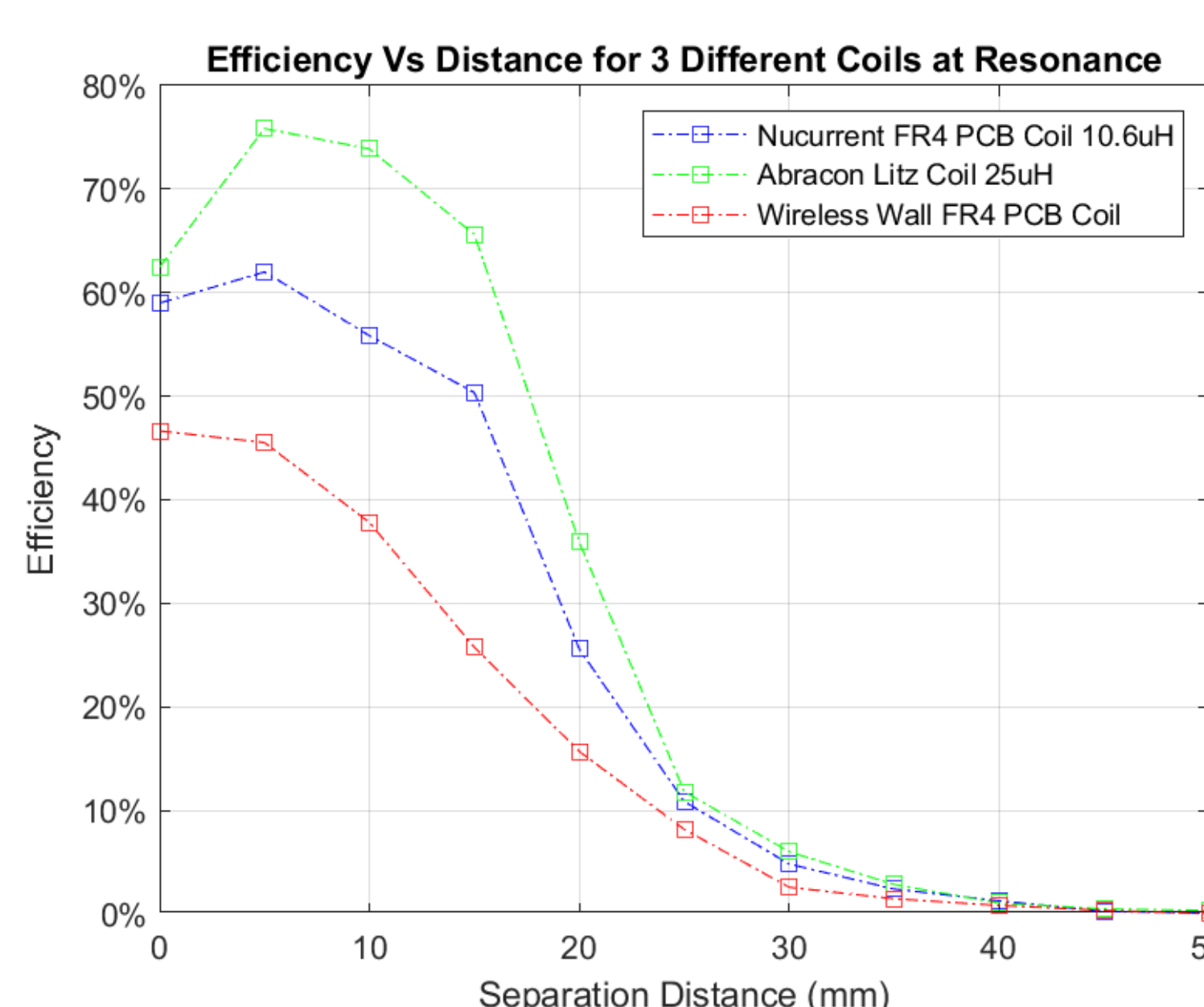
Coil Detection Algorithm Flowchart

Results

- Tests were conducted with 3 coils: Nucurrent PCB coil, Q = 24 @ 100 kHz, Abracon litz coil, Q = 85 @ 100kHz and custom Wireless Wall Coil Q = 8.38 @ 100kHz
- Maximum efficiency achieved with the custom PCB coils was 46% at 0.25A load current
- Litz coil with Q=85 achieved overall wider range and a max of 76% efficiency at 0.65A



- Max efficiency was observed to occur around 5mm within for higher Q coils and at 0mm for lower Q coils.
- Efficiency for all coils dramatically dropped after 20mm



Experimental Setup for Characterisation

Conclusion

- A modular, cost effective and efficient Wireless Powered Wall was designed and built
- Has been demonstrated to successfully wirelessly transfer power to low and medium loads (0-30W)
- Efficiency of 46% but will be improved with more expensive coil design
- Possible applications for this technology include lighting for homes or smart phone charging for hotels

Future Work

- Improving the quality factor of the coil to improve efficiency
- Introduce a control scheme to regulate power flow in transmitter side
- Simultaneous communication and power transfer between RX and TX side
- Enable Qi integration for safe and reliable smart phone charging