Thesis title: Ultra-High Fidelity Spin Qubit Initialisation Using Digital Feedback

Student Name: Mark Anthony Ireland Johnson **Student ID: 3421023**

A. **Problem statement**

The problem this thesis is framed to solve is to incorporate digital feedback with
current spin-qubit devices to alleviate the time cost of gathering and refining data.
This is to be accomplished by minimising the impact of load errors through
electron spin steering. Spin steering is to be performed using a software solution
running in real-time.

B. **Objective**

To improve total experiment fidelity by enhancing the intialisation fidelity. The
ultimate purpose of this is to increase the efficacy of qubit operations which
is required for various quantum computer architectures.

C. **My solution**

Incorporate digital feedback with current spin-qubit devices to minimise the impact
of load errors through electron spin steering. Spin steering is to be performed using a
software solution running in real-time. The solution utilises existing technology and
software which is operated from a MATLAB environment.

D. **Contributions** (at most one per line, most important first)

Applied qubit initialisation with quantum steering via digital feedback
Demonstrated high fidelity quantum operations
Enabled tuning insensitive measurements to be made
High-fidelity Rabi oscillations are easily attainable
Proposed a hardware-based solution, to mitigate software latency issues

E. **Suggestions for future work**

To improve further on initialisation, this software-defined feedback loop should be
shifted into an integrated solution, such as a purpose-built solution
with a microcontroller or FPGA.

While I may have benefited from discussion with other people, I certify that this thesis is entirely my own work, except where appropriately documented acknowledgements are included.

Signature:  Date: 2/6/2016

Thesis Pointers

15	Problem Statement
15	Objective

Theory (up to 5 most relevant ideas)

8	Quantum Information
14	Nuclear and Electron Spin Control
14	Load and Read Errors
15	Quantum Steering of an Electron Spin
16	Electron Spin Initialisation

Method of solution (up to 5 most relevant points)

22	Device Description
24	Gate voltage stimulus
24	NMR control of Rabi Oscillation

Contributions (most important first)

27	Applied qubit initialisation with quantum steering via digital feedback
27-35	Demonstrated high fidelity quantum operations
31	Enabled tuning insensitive measurements to be made
29	High-fidelity Rabi oscillations are easily attainable
36	Proposed a hardware-based solution

My work

16,23	System block diagrams/algorithms/equations solved
27-35	Description of assessment criteria used
24-26	Description of procedure (e.g. for experiments)

Results

27	Succinct presentation of results
27-35	Analysis
27-35	Significance of results

Conclusion

39	Statement of whether the outcomes met the objectives
36-38	Suggestions for future research

Literature: (up to 5 most important references)

A. Morello	Single-shot readout of an electron spin in Si
J. J. Pla	A single-atom electron spin qubit in Si
R. Kalra	The building blocks of a quantum computer...
C. H. Bennett	Quantum information and computation…
C. Bonato	Optimized quantum sensing with a single electron spin using real-time adaptive meas…