

**SCHOOL OF ELECTRICAL, COMPUTER AND TELECOMMUNICATIONS ENGINEERING**

# ECTE451 PROJECT PROPOSAL FORM

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| **1. Candidate Details** | |
| **Name: Kane Stoboi** | **Student No: 3897370** |
| **Supervisor: Zheng Li** | |
| **Title of Project:**  Stepper Motor Feedback Control System | |
| **Brief Overview:**    **Write a paragraph on why this is important. Pretty much re word part a) from the Project description.**  **To solve the issue with current control methods etc…., a** stepper motor control board based around the TMC2100 will be designed to operate a bipolar stepper motor silently and accurately. A feedback system will be used to monitor the incoming step signals from an external controller as well as the actual movement of the stepper motor shaft to ensure no steps are lost during operation. The control board and feedback system will be able to attach easily to the stepper motor requiring little to no modification to a motor.  I’d move these to the Project Plan part a)  Stepper motors are generally controlled using 2-wire or 4-wire control signals; therefore, the control board will require the interpretation of these signals to pass on to the TMC2100 driver.  The system will use an MCU to link the feedback system with the stepper driver circuitry requiring software to be written to interface the two together. | |

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| **2. Project Description:** (Expand to one page maximum) |
| *Describe your project. Questions that you should answer are:*   * 1. *What problem is being addressed?*   2. *Why is this project important?*   3. *What are the objectives and planned outcomes of the project?*   Stepper motors have become a common component used in positioning systems in many applications such as micro-surgical operations in the medical industry [1], the movements of fuel elements in nuclear engineering [2], as well as various other industrial applications. The decision to use stepper motors over traditional DC/AC motors are largely due to their accurate position, speed and motion control [1]. Stepper motors, being brushless motors, require a H-bridge circuit to achieve motion with digital signals controlling the switching of the MOSFETs to energise the stator coils. Although this current chopping is generally the most efficient way of driving stepper motors [3], it induces audio-frequency noise due to the constant energisation and de-energisation of the stator coils. This project will evaluate the options to reduce this audio noise.  Traditional stepper motor controllers use a current controlled chopper design [4] as it produces the maximum velocity, torque and motor resonance dampening while minimising power loss and maintaining high performance for a wide range of velocities [5]. Small variations in coil currents cause eddy currents within the motor stator causing increased power dissipation and high frequency magnetostriction of the stator magnetic material causing audio noise emmitted by most stepper motors [6]. A voltage controlled chopper design significantly reduces the ripple current through the motor windings significantly reducing vibrations and mechanical noise while improving efficiency [6].in addition to reducing the current ripple when driving a stepper motor [4].  Although a voltage controlled chopper design is able to reduce the audio noise emitted from a stepper motor torque applied is reduced, in turn, slip can often occur [4]. Another common cause of slip in stepper motors is the if the excitation frequency of the motor coils is too high [7]. Once the excitation frequency reaches a critical point the motor stalls causing a permanent error in the controller’s positioning [7].  The objective of this project is to design and produce a stepper motor driver board to operate a stepper motor silently while not compromising on the speed or accuracy of positioning and utilise hardware that will remain within the $350 budget.  Objectives in the longer term will be to use a closed loop configuration to maximise the performance of stepper motors by being able to drive them to their maximum torque and speed capacity.  This project will take ECTE451 and ECTE458 to complete, therefore, the planned outcomes for ECTE451 have been developed with the objectives for ECTE458 to be re-visited upon analysis of the preliminary results.  For ECTE451, the initial literature will be analysed, and preliminary simulations/experiments will be run. This will include component research and selection, circuit topology investigations and comparison of results against existing control methods. |

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| **3. Project Plan:** (Two pages maximum) |
| Detail your project plan. This should be a resilient engineering plan accommodating realistic alternatives and contingency measures to meet the objectives and assuming a total duration of two sessions (including ECTE458). Budget constraints should also be considered. Questions that you should answer are:   1. What do you intend doing? Briefly describe the methods that you will use to achieve the objectives stated above as well as the software and/or hardware that will be developed. 2. Why is this strategy being adopted? Indicate with reference to the literature you have read so far. 3. How do you intend to validate your solution/experimental results/simulations/procedures? 4. What is the timeframe for achieving the project objectives? Indicate all milestones and deliverables, clearly showing specific outcomes to be achieved by the end of ECTE451 (no Gantt chart required).   The project will require the design and manufacture of a custom circuit board which will entail the procurement of various electrical components. The stepper motor controller will be based around the principles of a voltage controlled chopper. Additionally, an encoder will be used for the shaft position sensing in order to provide a close loop control system. A stepper motor will be required to mount the controller board to and perform controller testing.  Oo et al show that a set of mathematical equations can be used to describe an open-loop stepper motor and controller [8]. By extending this approach, a closed loop model can be modelled in Simulink to test control algorithms before implementing the design on an MCU.  The MCU software will be written in C++ as it has been used in these references … (…) and will not require additional software resources other than the manufacturers IDE. Open-source software will be used for schematic and PCB layout requiring access to a computer.  Why are you using the TMC2100? Is it popular in research, are there alternatives?  c – The main experiment to be performed is the comparison of the developed control board with an existing controller such as the Pololu A4988.  Data will be collected on the accuracy, speed and audio noise of the motors being driven. The software algorithms will be validated in MATLAB before implementation in C++ e.g. The final hardware will be testing using correct probing techniques with an oscilloscope against competing algorithms.  It’s probably important that you test multiple control algorithms on the same motor to get a fair comparison, and say something about the constants throughout experiments here.  d – Expand this into paragraphs, but that’s pretty much the idea  Tasks   * Complete WHS risk assessment * Meet with workshop staff to discuss project * Component selection (feedback system) * Design of schematic and PCB   + Design of schematic   + Design of PCB including all trace routing and GERBER generation * Order parts * Order PCB * Develop control algorithm that implements feedback into the driver control * Develop MCU Software * Testing of Hardware * Testing of Software * Testing of System |
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| **4. Resources Required:** (Expand to a half a page maximum) |
| This statement should identify any materials (software/hardware) or access to infrastructure required to complete the project.  As the MCU software will be written in C++, it does not require any additional software other than Open-source software will be used for schematic and PCB layout requiring access to a computer. This does not require any purchase of parts  Being a hardware-based project, there will be the purchase of components through the secte store. As the focus of the project is on a low-budget control system, it is envisaged that the budget will remain below $350 as required.  To test the hardware and software control system, access to a laboratory will be required to use equipment such as power supplies, oscilloscope, multimeters and function generators. To ensure that the developed system can be tested against comparable control systems used in research and the real-world, access to a laboratory will be sought out after completing the relevant WHS induction … |

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| **5. Literature Planner:** (Expand to a two page maximum) |
| Attach as an appendix |

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| **6. Mind Map:** (single A4 page) |
| Attach as an appendix |

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| **Student Signature**  ***Declaration by the student: I have understood the feedback provided to me by the supervisor.*** | | |
|  | **Signature** | **Date** |
| **Student Name:** |  |  |

**A marked assessment rubric will be appended once completed**

**References**

[1] M. Raji, A. Shokanbi, and H. Monday, "Design of Ultra-low-end Controllers for Efficient Stepper Motor Control," *MATEC Web Conf.,* vol. 160, p. 02003, 2018.

[2] "Intelligent control system with application in nuclear equipment," ed: IEEE, 2017, p. 353.

[3] M. Dababneh, W. Emar, and I. TTrad, "Chopper Control of a Bipolar Stepper Motor," *International Journal of Engineering,* vol. 7, no. 2, pp. 61-73, 2013.

[4] T. M. Control, "Application Note 21," no. 1.01, 2015.

[5] Trinamic, "Application note: Realizing a low noise PWM chopper " no. 0.1, 2012.

[6] T. M. Control, "Application Note 15," Application Note no. 1.01, 2015.

[7] S. Dorin-Mirel, I. Lita, and M. Oproescu, "Comparative analysis of stepper motors in open loop and closed loop used in nuclear engineering," in *2017 IEEE 23rd International Symposium for Design and Technology in Electronic Packaging (SIITME)*, 2017, pp. 357-360.

[8] H. L. Oo, "Modelling and control of an open-loop stepper motor in Matlab/Simulink," ed: IEEE, 2017, pp. 869-872.