

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

# ECTE498 PROJECT PROPOSAL FORM

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| **1. Candidate Details** | |
| **Name:** Chengxin Huo | **Student No:** 7420262 |
| **Supervisor:** Haiping Du | |
| **Title of Project:**  The cooperative control of a motor and a two-speed magnetorheological fluid dual-clutch transmission of electric vehicles | |
| **Brief Overview:**  Magneto-rheological fluid (MRF) is a typical smart material composed of synthetic hydrocarbon or silicone oil and magnetic particles. The presence of a magnetic field can alter the viscosity of MRF sharply, causing the state of MRF to change from liquid to solid rapidly in milliseconds. The suspended magnetic particles become chain-like structures to resist shear deformation of the MRF flow under the influence of the magnetic field. MRF clutches are usually used as a torque transfer device. Compared to conventional clutches, Magnetorheological fluid clutches (MRFCs) have superior controllability and response, showing significant potential for precise output control of vehicle powertrain systems. This project aims to simultaneously control the states of the motor and magnetorheological fluid to ensure smooth output during vehicle gear shifting. | |

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| **2. Project Description:** (Expand to one page maximum) |
| 1. **What problem is being addressed?**   when traditional clutch shifting, there will be an obvious torque interruption. In this work, we are trying to reduce this phenomenon by controlling the motor speed and MRFC's transmission torque at the same time.   1. **Why is this project important?**   This project can effectively improve the vehicle's dynamic performance and passenger's ride comfort. This helps to design the control method for magneto-rheological fluid to maintain the same output torque at variable speeds.   1. **What are the objectives and planned outcomes of the project?**   This project's aim is to provide a control method to reduce the transmission output speed fluctuation during gear-shifting transients and ultimately publish a related paper. |

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| **3. Project Plan:** (Two pages maximum) |
| 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.**   Firstly, I will construct a simulation system in MATLAB that includes an electric motor, MRFC, output shaft, and brake, and simplify the relationship between input current and output torque in MRFC into a linear relationship. In this simulation system, a corresponding mathematical model will be established to predict the transmission system output speed by synthesising driving motor speed, MRFC input current, output shaft torque, and load torque. After establishing and testing the model in simulation, solve its inverse model to obtain the relationship between motor speed and MRFC input current while keeping the output speed constant. Secondly, the relationship between the input current and the output torque in MRFC is adjusted in the simulation to make the model and inverse model close to the real experimental data. Finally, the obtained inverse model will be applied to physical objects for testing.  Alternative solution:  If the corresponding model cannot be successfully established, a PID controller will be used to regulate the MRFC input current and driving motor speed to reduce the peak and settling time of the output speed control during gear-shifting transients. Finally, apply the PID controller to physical objects.   1. **Why is this strategy being adopted? Indicate with reference to the literature you have read so far.**   The reason for adopting a modelling approach is that it allows for a mathematical description of the system, analysis, and understanding of its characteristics. Only after a clear understanding of the system characteristics can the controller be better designed and its performance analysed. Meanwhile, since the obtained model is purely a mathematical model and there is no direct relationship between model parameters and physical mechanisms, the inverted input and output are still reliable. Therefore, numerical simulation modelling methods are used to obtain the relationship between input speed, output torque, and output speed, which is then reversed and applied to physical objects [1,3].  In this article, researchers use feedforward PID to control the output torque of MFRC. This fact proves that the idea of adjusting the output speed of the clutch transmission device by controlling the output torque of MFRC and the motor speed through PID controller proposed in the alternative solution is feasible[2].  [1] J. Zhao *et al*., "Modeling and Torque Control Against Rate-Dependent Hysteresis of a Magnetorheological Fluid Dual Clutch in an Electric Vehicle Transmission System," in *IEEE/ASME Transactions on Mechatronics*, doi: 10.1109/TMECH.2024.3392554.  [2] [Y. Liang](https://digital-library.theiet.org/search?value1=&option1=all&value2=Y.+Liang&option2=author)  *et al*, “Investigation of data-driven modelling and feedforward control for a two speed magnetorheological fluid dual clutch transmission of electric vehicles,” in: CEVVE, 2023, pp. 66 – 72.  [3] Joshua L. Proctor *et al.*, “Dynamic Mode Decomposition with Control,” in: SIAM Journal on Applied Dynamical Systems, 2016, pp. 142-161.   1. **How do you intend to validate your solution/experimental results/simulations/procedures?**   After obtaining the model, simulation experiments and physical experiments can be designed to compare the difference between predicted speed and simulated speed to determine the accuracy of the model. When evaluating the effectiveness of the inverse model and PID controller, the rate of change of the grating sensor on the output axis is used to determine the superiority or inferiority of the control method   1. **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 ECTE498 session 1 (no Gantt chart required).**   Week4-6:  Familiar with MATLAB simulation environment, build simulation system including motor, MRFC, output shaft and brake  Week7-8  Conduct physical experiments to obtain data on motor speed, MRFC input current, output shaft torque, and speed, and establish a preliminary data model.  Week9-  Improve mathematical models and establish a realistic relationship between MRFC input current and output torque  Week10-11  Solve the inverse model.  Week11-13  Before the end of ECTE498, complete all simulation content, learn LabView usage, and prepare to input algorithms into physical objects.  Second semester  Deploy the algorithm on a physical platform, evaluate its response speed and accuracy, and continue to adjust the control method |

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| **4. Resources Required:** (Expand to a half a page maximum) |
| access to Lab 6-225,  NI myRIO-1990  Permanent magnet synchronous motor  The torque sensor  Speed sensor  current sensor  Power Supply  Magneto-Rheological Fluid  motor controller (Roboteq MBL-1660) |

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| **5. Literature Planner:** (Expand to as required) |
| 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:**  **Chegnxin HUo** |  | **11/08/2024** |

***Note: the typical over all page count should not exceed 15 pages***

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