



Laidlaw Undergraduate Leadership and Research Programme  
Application – 2022 Cohort

Name	<i>Mihai Mesteru</i>
Programme	<i>Electronic Engineering</i>
Year of Study	<i>3<sup>rd</sup> Year</i>
Research Project Title	<i>Revisiting the Rectifier: A More Efficient Approach to Modern Electricity Supply</i>
Proposed Supervisor(s)	<i>Professor Declan O’Loughlin – Electronic Engineering</i>

Before completing this submission, you should review the [Laidlaw Programme Application Guide](#) and ensure you have included every component requested

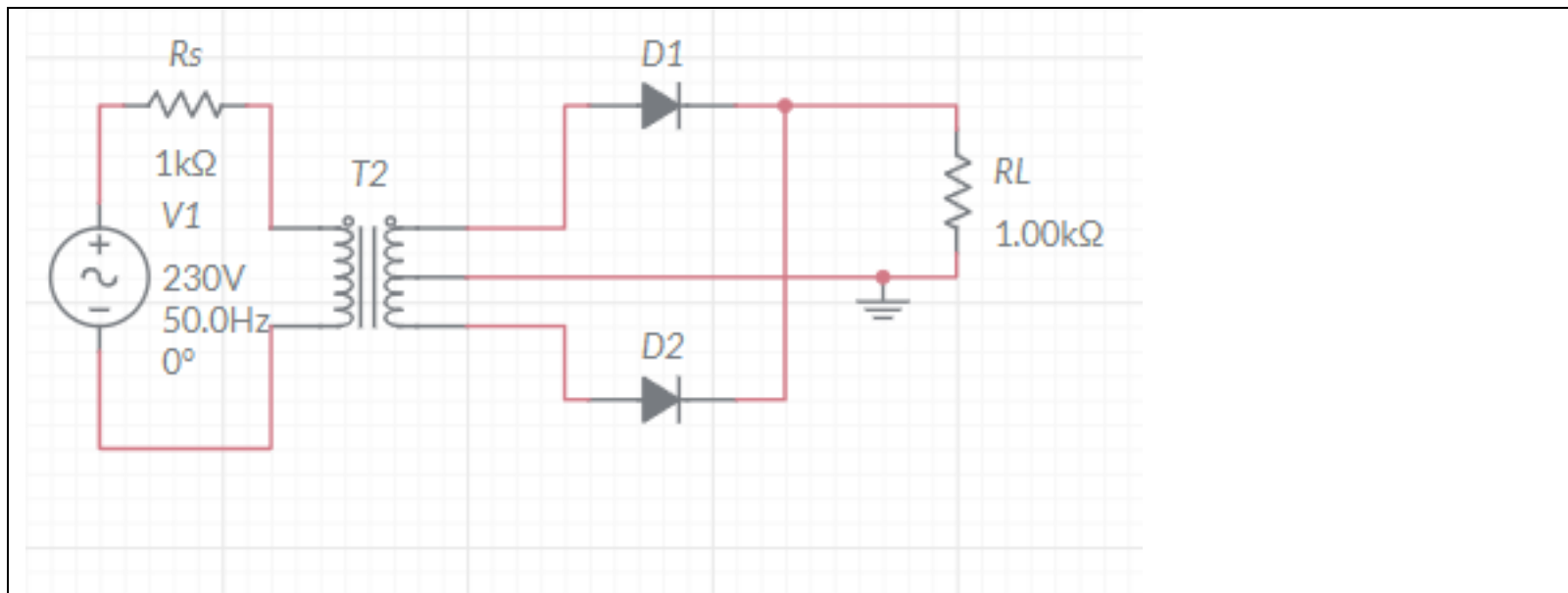
Research Project Proposal (1000 words max.)

**Introduction**

In today’s society, most people rely on handheld devices which are battery powered and thus need a direct current with low voltage. However, appliances in use every day are powered by an alternating current with a high voltage via a socket. Alternating current proves to be the most efficient way to transport electrical power over long distances and leads to the least amount of wasted power. Albeit efficient, this alternating current must be converted into a direct current to ensure a uniform supply of electricity without any interruptions – which is achieved via a rectifier. However, in these conversions, a certain amount of the input is lost in the process, mainly due to the diode threshold voltage as well as through losses associated with harmonic distortion. Thus, due to these losses, the most efficient a rectifier can be (without modifying the input voltage) is approximately 81%; meaning only 81% of the input alternating current’s power is output as a direct current.

**Outcome**

The outcome of this research project is to increase the output efficiency of the most efficient rectifier in use today. The research project will be focused on how the input losses can be kept to a minimum to ensure that the output is maximised, thus increasing the efficiency of the rectifier already in use today, which can be seen below:



This research project will aim to introduce passive circuit elements to effectively “engineer” a more efficient waveform that will incur less losses.

### Motivation

I’ve chosen to investigate this issue thoroughly as, if successful, could lead to a less significant loss of power. A much more efficient rectifier is important in facilitating a more sustainable world - which is increasingly important as society progresses and our reliance on electrically powered devices in day-to-day life grows. An increase in the demand for electricity is to be expected - yet we cannot continue to waste power in the process of powering devices.

### Applications of the Outcome

A more efficient rectifier ultimately leads to less wasted electricity and power, which is lost in the conversion process from alternating current to direct current. Increasing the rectifier by just 1% can lead to a **€12.74 - 19.87** (based on a monthly cost of the cheapest and most expensive provider) reduction in household power costs due to less wasted electricity per year. Translated to the region of North Dublin, this leads to a saving of **€998,701 - 1,557,629** per year. This is paramount, especially with the ever-increasing costs of electricity, with electricity costs increasing by 9.3% YoY (ESB, 2021).

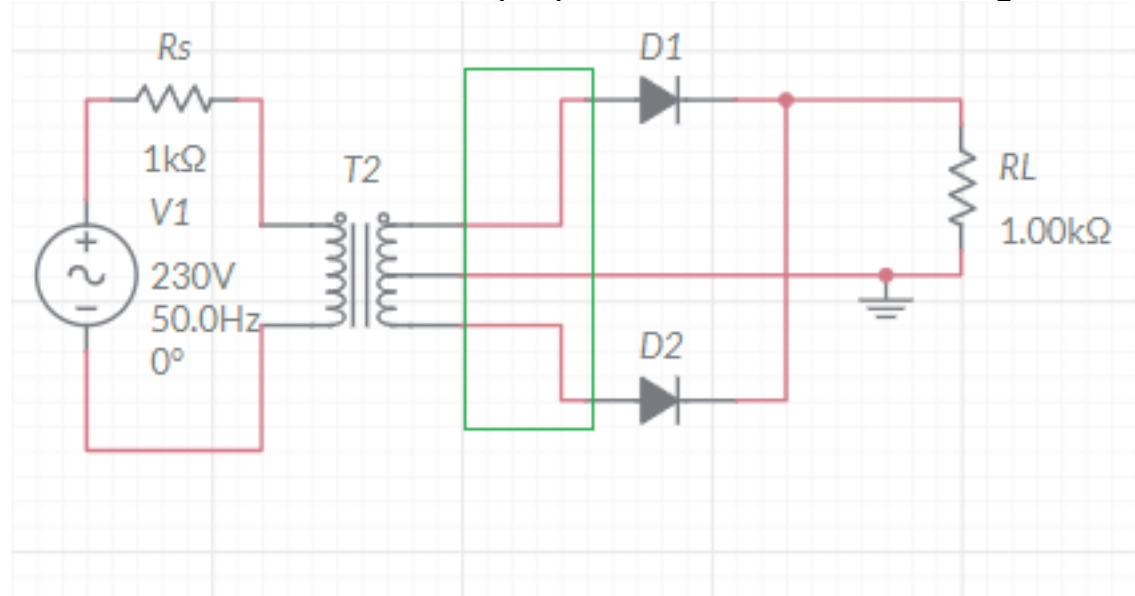
A more efficient rectifier has use in data centres - an area where electricity is consistently putting stress on the electricity supply, and where these could use **up to 70% of Ireland’s electricity by 2030** (Bresnihan, 2021). Most data centres have a fuel to server efficiency of around 17.5% (Zhao et al., 2014). Hence, increasing the rectification efficiency by just 1% can save \$250 per server rack, and with over 15,000 server racks at full capacity, this can amount to a total saving of **€3.75 million**. Furthermore, a typical server rack requires about 7kW of energy, and with a 1% rectification efficiency increase, 70 watts of energy can be saved - and scaling this to over 15,000 racks, 1.05MW can be saved. This energy can be used to curve the demand, and thus reduce the cost of electricity in Ireland.

More generally, according to the EIA, 34% of all electrical energy is wasted globally on average, with 39.4% electricity wasted due to transformation losses (SEAI, 2018) in **Ireland**. Increasing the rectification efficiency by just 1% can lead to an additional **233.98-terawatt hours** globally. This is enough to run the entire country for almost **9 years** as Ireland’s energy cost is circa 26 terawatt hours (SEAI, 2018).

## Methodology

The overall aim of the proposed project is to improve the efficiency of consumer rectifiers. Specifically, common and cheap electronic components will be used to alter the input AC current to minimise the overlap between the voltage and current components. These changes help address fundamental limitations of the other rectifier components and help improve the overall efficiency.

In short, I aim to use a combination of capacitors, resistors and inductors to try and minimise the overlap between the voltage across and the current through the diode. Most of the losses are concerned with the voltage it requires to make use of the diode (termed “threshold voltage”). Being able to manipulate these waveforms will incur in less power wasted in using the diodes in the original design. The highlighted area in green in the schematic below shows the proposed area I will be aiming to modify to achieve this:



### Proposed Timeline

As the project is vigorous, I will be keeping to a strict timeline to ensure that the project can be completed in the provided time frame.

The **first week and a half** will be spent ideating how different design iterations can impact the voltage signal. My time will be spent thinking about different ways I can enhance the technology in use today or how I can incorporate different elements of these into my project. My designs will firstly be sketched and checked with my supervisor, and then translating these conceptual designs onto industry standard CAD software. This initial stage of my project will require the use of my knowledge of capacitors, inductors and in turn filters - and how I can use these components to influence the incoming voltage signal. Furthermore, I will also simulate these designs on the CAD software where I will determine the appropriate component values and my experimental design.

The **next 3.5 weeks** will be spent building and analysing these different circuits. Throughout this period, I will dedicate a large portion of my time to data acquisition. I will be translating my conceptions into physical analogue circuits, and will be testing my designs extensively, with help from my supervisor.

The **last week** will be spent on using the acquired data to produce a coherent report with my findings. This report will include a final design that will either build on technology already available, or introduce a brand new design.

This research project is prone to uncertainty. In the event that I am unable to find how a design improves efficiency, I will spend an additional 4 days simulating and debugging



more ideas or any rough ideas I have formed up until that point. Moreover, I will allow myself an additional one or two days (as needed) to finalise a conceptual design.

In theory, I do not expect that the building of these designs will require a duration of 3.5 weeks - however I am permitting myself an extended amount of time to ensure that I will have the best chance in succeeding in this project.

**Leadership-in-Action experience proposal (500 words max.)**

**LiA Category**

Category B: Leadership Placement

I want to learn how to become a motivator, mentor, and competent leader ready to make a change. I strongly believe that the Leadership Placement would personally benefit me the most as I would directly be able to apply skills that I would have learned through the programme and further advance them in the context of coming up with a solution to a problem in a disadvantaged community. Furthermore, I feel that I would become more culturally sensitive and intelligent as the Leadership Placement would allow me to appreciate the different traditions, customs, and lifestyles different people around the world follow. Being able to apply the leadership skills learned throughout the programme to participate in a project that creates a positive impact in a disadvantaged community is paramount to the development of my leadership skills. I strongly believe, and hope in the future, to create inventions that impact people in some sort of a positive way – however minuscule. This is a personal passion of mine, and I feel that being able to live that partaking in the Leadership Placement will fuel my desire to learn how to lead and to take my leadership skills to the next level.

Throughout my studies in Engineering, I have worked on a project which tackles the lack of electricity in a Zimbabwean school. Thus, throughout the Leadership Placement, I would take a leadership role that is involved with the planning, organising, and making of a specific solution that tackles a problem in a disadvantaged community. I would like to be involved in all of the stages – from the ideation phase all the way to testing the final solution. The Leadership Expedition would allow me to develop my ability to lead without authority and also my cultural intelligence and capacity for empathy due to the nature of the expedition. In addition, I will be able to hone my collaboration skills – and also learn how to empower the team as they work. Communication is a preeminent skill that would be impacted majorly as I envisage myself



delegating tasks to different people and conversing with them regularly to ensure that the work is completed to a high standard and to deal with any issues they might have. Moreover, I will ensure that morale within the team is kept to a very high level. The Leadership Placement will allow me to become more empathetic due to having to interact with the team on a personal level, as well as the community.