VR/AR for Electrical Machines: An Interactive Virtual Reality Module for Alternator Load Testing

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How to Cite this Article:
T, S. K., M, J., P, G. & M, S. K. (2026). VR/AR for Electrical Machines: An Interactive Virtual Reality Module for Alternator Load Testing. International Journal of Creative and Open Research in Engineering and Management, 02(04). https://doi.org/10.55041/ijcope.v2i4.965

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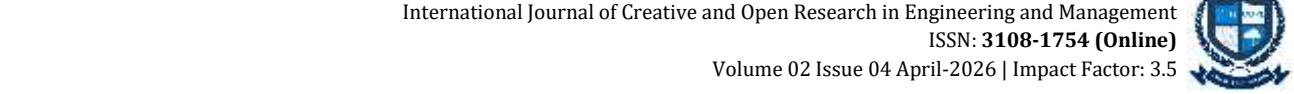
Abstract:

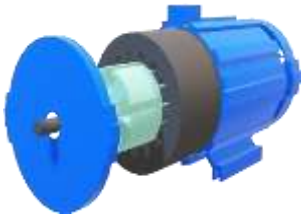
An interactive Virtual Reality (VR) module for performing load tests on alternators using the Meta Quest 2 headset is presented in this paper. The system enables students to perform a complete alternator load test procedure within a virtual environment, allowing them to observe the actual movement of motors. They can interact with models using controllers, and this VR module is designed to be interactive for the user. 3D models that are Alternator, DC Motor, and Rheostat were designed in Blender and SolidWorks and exported to Unity as an FBX file format. Unity 2022.3 LTS using the XR Interaction Toolkit with OpenXR. Users interact via a poke-style controller to switch between AC/DC supplies, start the motor, apply load steps, fetch instrument readings into a results panel, and explore the internal motor construction. The module is designed as a pre-laboratory training tool to improve conceptual clarity and reduce the risk of accidents in physical labs. The long-term vision is to contribute to XR as a Service (XRaaS), providing scalable simulation-based training across the electrical engineering curriculum.

Keywords: Virtual Reality ; 3D modelling; Unity game engine; Blender; Electrical Machines; Alternator load test ; Engineering Education; Meta Quest 2.



I. INTRODUCTION

Students and trainers in electrical engineering laboratories frequently encounter difficulties when working with high-voltage rotating machines. Manual training exposes users to risks, including electric shock, mechanical injury, and equipment damage, while also requiring repeated capital investment in physical equipment maintenance. Industries similarly spend considerable resources training employees on electrical machine operation before those employees interact with real plant equipment.This paper presents a VR-based training module that addresses these challenges by simulating the



complete alternator load test experiment on the Meta Quest 2. Users are allowed to perform every step of the procedure without access to physical equipment. Users perform the procedural familiarity and conceptual understanding in advance of real laboratory sessions; therefore, this VR training can reduce accidents and confusion with procedure and improve the learning experience.

II. LITERATURE REVIEW

There is a Ukraine based company that is digital engineering magic people were developing these VR training modules for many experiments like mustimeter and transformer oil test etc, we are interested to develop a VR model as we desired so we start working on unity and blender and in this process the work done by my professors i.e. VR for home automation is helped to us, and a VR based digital twins and VR trainings for soldiers developed by XR monk people like all these previous projects have been are very helpful, so then we started worked out VR model, this is mainly to students, those who are faced difficulty while connections and procedure, they can use our VR module for many times, user can understand the procedure while performing experiment virtually. which makes it easier to perform in real experiments.

III. METHODOLOGY

3D Modeling : All primary machine models, the alternator, induction motor, and DC motor, were designed in Blender with correct textures and optimised polygon counts. The rheostat was designed in SolidWorks and exported in GLB format; since Unity accepts only FBX, Blender was used for format conversion. Maintaining fewer polygons of a 3D model is difficult because the more detailed 3d model requires more polygons, excess faces increase rendering time and processor load, which can cause application crashes on standalone VR hardware. In Blender edit mode, Extrude, Bevel, Loop Cut, and modifiers, including Array, Boolean, and Curve, were used to construct machine geometries. Supplementary objects (buttons, table, warehouse environment) were imported from an open-access web, i.e., Sketchfab.

Fig 1: Alternator (Blender) Fig 2:Rheostat(SolidWorks)

VR Development: The project is developed in Unity 2022.3 LTS version with OpenXR is the XR runtime and an Android build target for Meta Quest 2 because the Quest 2 uses the Android operating system. We chose OpenXR for its runtime standard and imported the Meta XR All- in-One SDK[7] to enable direct headset deployment, controller input, and hand-tracking. The XR Interaction Toolkit was installed via Package Manager to provide prefabs for teleportation, poke interaction, and grabbing and many more. An XR Origin prefab was added to the scene with Teleportation Area and Teleportation Anchor scripts configured to activate from the thumbstick.Blender models were exported as FBX and imported into Unity with correct scale, colliders, and Poke Interactable components on button objects. The controller ray served as the far-field interactor, and the controller head-tip as the near-field (poke) interactor. C# scripts were written so that poking a labelled button surfaces the corresponding UI panel above the table, while other buttons control AC supply, DC supply, motor start, load level, and internal construction view.The user begins by observing the complete experimental setup. On-

table buttons display the circuit diagram, procedure steps, and expected result graphs as floating UI panels. The user then switches on the AC and DC supply and starts the motor, which reaches its rated speed of 1500 rpm. At any point, the internal construction button may be pressed to explore the motor in a cut-away view.With the motor at steady state, the load test begins with stepwise load application (1 A, 2 A, etc.). With each increment, a gradual drop in terminal voltage and rotor speed is observed, replicating real alternator behaviour under load. The Fetch button records the corresponding voltage, current, and speed readings into a results panel. After all load steps, the user reviews the data table and compares it with reference graphs displayed in the environment.

IV. RESULTS AND DISCUSSION

The following figures show representative frames from the deployed application, demonstrating the experiment setup, interactive UI panels, push- button and lever controls, load switching, poke interaction, and the results panel. All interactions functioned correctly on the Meta Quest 2 in both controller and hand-tracking modes.

Fig 3: Experiment setup

Figure 4: Panel terminals

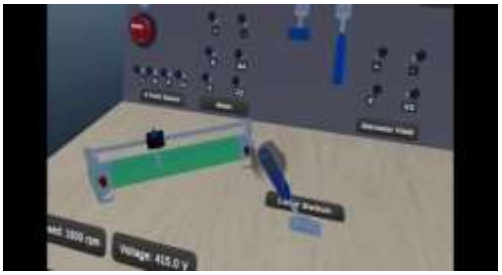


Figure 5: Load switch (lever)

Figure 6: Load buttons

V. CONCLUSION

This paper has presented a fully functional VR alternator load-test module deployed on the Meta Quest 2, developed in Unity 2022.3 LTS using Blender and SolidWorks machine models. The module allows students to perform every step of the alternator load-test experiment in a safe, immersive environment. The key novelty over prior work is the simulation of a dynamic performance test with the incremental load application, real-time observation of voltage and speed drop, and an instrument data-fetch mechanism.

VI. FUTURE SCOPE

By the end of 2030 we are planning to expand more training modules like this and digital twins, the main theme of our work is XRaaS i.e XR as a service, in previous past 30-40 years SaaS(Software as a service) is most dominant stream same as this XRaaS is going to next big thing in next 30 years, So we are trying to contribute in this journey.

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