Hybrid Electric Vehicle Simulation Operation Across Distributed Laboratories using Hardware Integrated Virtual Environment Concept

Laxman Timilsina[1*], Elutunji Buraimoh[1], Ali Moghassemi[1], SM Imrat Rahman[1], Ali Arsalani[1],
Grace Muruthii[2], Okan Ciftci [1], Gokhan Ozkan[1,3], Behnaz Papari[1,2], Christopher S. Edrington[1], Akram Papari [4]
E-mails: {ltimils*, eburaim, amoghas, smimrar, aarsala, gmuriit, ociftci, gokhano, bpapari, cedring}@clemson.edu,
apapari1973@gmail.com
[1]*Holcombe Department of Electrical and Computer Engineering, Clemson University, Clemson 29634, SC, USA*
[2]*Department of Automotive Engineering, Clemson University, Greenville 29607, SC, USA*
[3]*Dominion Energy Innovation Center, Clemson University, North Charleston 29405, SC, USA*
[4]*University of Tehran, Tehran, Iran*

2024 IEEE 9th Southern Power Electronics Conference (SPEC) | 979-8-3503-5115-6/24/$31.00 ©2024 IEEE | DOI: 10.1109/SPEC62217.2024.10892989

***Abstract*—The research on hybrid electric vehicles (HEVs) poses significant cost challenges due to the necessity of assembling various components and ensuring the fidelity of the entire system, especially when testing new algorithms or integrating additional devices. In research institutes, different laboratories may specialize in hardware or control aspects of HEVs, with some possessing most components while others lack certain elements. This fragmented distribution often necessitates purchasing all components, increasing research expenses substantially. To address this issue, this paper presents a framework introducing the concept of a hardware-integrated virtual environment (HIVE) that facilitates the virtual connection of components dispersed across multiple locations, enabling comprehensive research on the entire vehicle system without physical integration. To test this framework, this study utilizes a series HEV model developed in MATLAB, which is operated in real-time using Speedgoat, a digital real-time simulator. One laboratory possesses all the vehicle components except for the battery, while another laboratory houses the missing battery component, also developed in MATLAB and operated in real-time using Speedgoat. This study successfully establishes connectivity between the two laboratories, enabling the seamless operation of the entire HEV model across distributed locations.**

***Index Terms*—microgrid, lithium-ion battery, degradation, forecasting**

I. Introduction

In recent years, there has been significant interest in developing systems that enable access to remote laboratories via networking infrastructure, with numerous software platforms emerging to manage instrumentation. Few research have been proposed to connect multiple laboratory components in these settings and there is still a lack of thorough investigation into the challenges of connecting remote devices of a system and running the whole system successfully. This advanced concept of connecting distributed laboratories amplifies testing capabilities by interconnecting real-time simulators, Power Hardware in Loop (PHIL) testbench, and co-simulation frameworks [1]. Through this interconnected network, a comprehensive research infrastructure can be formed, enabling the sharing of resources and integration of facilities across distant locations with varying hardware setups. Consequently, the virtual linking of laboratories facilitates the expansion of individual laboratory capabilities, facilitating studies encompassing large-scale, system-level, and interdisciplinary scenarios [2].

This paper provides an overview of the architecture devised within Clemson University's geographically dispersed laboratories. The objective is to coordinate and connect various components of a system situated at distinct locations, ensuring the seamless operation of the system with heightened reliability and resilience. Through this study, key questions regarding this interconnection approach like: How could this particular laboratory interconnection be implemented, in which cases would interconnection be beneficial, and for whom, to which laboratories and facilities could this interconnection be applied to, and what the delay is between information sent and received in such a setup, will be addressed [3].

The rationale behind this investigation lies in the costliness of HEV components, making it impractical to assemble all necessary parts within a single laboratory for research purposes. Hence, Clemson University has undertaken this research endeavor to establish connectivity between a crucial, expensive component—the battery of a Military HEV situated at the SEAL laboratory in CUICAR, Greenville, SC, US—and the RT-COOL laboratory located at the Main Campus in Clemson, SC, US, a distance of 31 miles (49.6 km).

A. Concept of Real-Time Co-Simulation

Real-time co-simulation is an essential approach in modern power system research and development, enabling the integration of different simulation domains into a cohesive framework. In power or energy systems, real-time co-simulation allows for the coupling of various simulators and hardware setups to perform comprehensive and synchronized simulations. This method is particularly valuable for studying the interactions between physical power hardware, such as generators, transformers, and inverters, and their digital twins or control algorithms simulated in real-time [4], [5].

One of the primary advantages of real-time co-simulation is its ability to provide accurate and timely feedback between the simulated and real-world components, ensuring that the system's dynamic behavior is faithfully represented. This is crucial for testing scenarios like fault conditions, stability analysis, and control strategy validation, where timing and response accuracy are paramount. By employing real-time co-simulation, researchers can test the performance and resilience of power systems under various conditions without the need for costly and potentially risky physical experiments [6].

The integration of co-simulation frameworks, such as the VILLASframework used in this study, facilitates data exchange and synchronization between geographically distributed laboratories. This framework supports real-time data handling, allowing for seamless communication and interaction between different simulation environments [2]. For example, in the context of Clemson University's research, the VILLASnode gateway manages simulation data flow, ensuring that components like the Military HEV battery at one location can interact with the rest of the HEV system components at another location in real-time.

Through the adoption of real-time co-simulation, the research infrastructure at Clemson University is poised to achieve a higher level of flexibility and capability, enabling detailed studies on system-level interactions, distributed energy resources, and advanced control strategies. This approach not only enhances the research potential but also promotes the development of innovative solutions for the challenges faced by modern power systems.

B. Statement of Contribution

This paper introduces a real-time framework designed to connect geographically distributed laboratories, creating a hardware-integrated virtual environment (HIVE) concept. HIVE enables the seamless integration of components located at different sites into a unified system, allowing for simulations as if they were running at a single location. The VILLASframework, a toolset for local and geographically distributed real-time co-simulation, is employed to facilitate data exchange between these laboratories. Within this framework, the VILLASnode gateway handles simulation data, providing interfaces to various simulation equipment, databases, and web services, thus enabling data transfer. The laboratories are connected via the internet, utilizing the Internet-2 network at Clemson University for communication through VILLASnode, which is deployed at each laboratory using Raspberry Pis.

The paper demonstrates the HIVE concept with a series HEV system, where the vehicle's battery operates in one laboratory while the rest of the system runs in another. This setup allows for comprehensive vehicle simulation and testing by connecting geographically separated components. An energy management (EM) system controls the vehicle, with one power-generating source (the battery) at one location and another source (the internal combustion engine) at a different location, integrated with the rest of the vehicle system.

The remaining paper is segmented as follows: Section II explains the series HEV system considered in this study. Section III explains in detail the communication technique used for this HIVE concept. The simulation and results of this SHEV with HIVE concept are explained in detail in Section IV. Finally, Section V provides the paper's conclusion and suggests future research directions.

II. HYBRID ELECTRIC VEHICLE SYSTEM

This paper focuses on the operation of hybrid electric vehicle (HEV) systems distributed across multiple laboratories. The vehicle model under study employs a series powertrain topology, as illustrated in Fig. 1. The powertrain configuration includes an internal combustion engine (ICE) that drives a generator. This generator is linked to a common DC link maintained at 600 V through an AC/DC converter. Additionally, a battery serves as another power-generating source connected to the DC-link via a bidirectional DC-DC converter. The nominal terminal voltage of the battery is 400V, while the DC-link side of the converter is controlled to maintain a voltage of 600V through dedicated voltage and current control blocks.

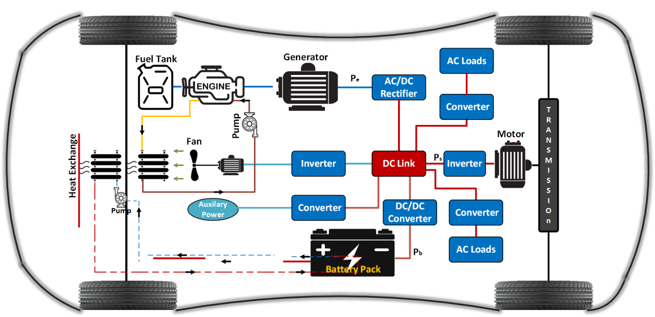

Fig. 1: HEV architecture considered in this study.

The motor, which drives the vehicle body, is connected to the DC link through a DC/AC converter. The vehicle body encompasses various components, including the body masses, transmission, suspension system, tires, and aerodynamic elements. Central to the system is the supervisory controller, known as the energy management (EM) system, which determines the power distribution between the power-generating sources. This controller also responds to commands from a driver model, facilitating adherence to speed demands specified by various drive cycles. This distributed laboratory setup allows for the comprehensive testing and simulation of HEV systems, integrating geographically separated components into a cohesive operational framework. Some of the key vehicle body parameter used in this study is provided in Table I.

A Simscape-based diesel engine model, characterized by a maximum power output of 60 kW, is employed in this study.

TABLE I: Key vehicle parameters.

Parameter	
Air density	1.18 kg/m^3
Frontal area	3 m ^{2}
Air drag coefficient	0.4
Vehicle total mass	1200 kg
Coefficient of rolling resistance	0.001
Gravitational force	9.81 m/s^2
Efficiency of gear system	0.95
Regenerative coefficient	0.5
Gear ratio	13
Radius of the Tire	0.3 m

The engine operates with a maximum speed of 7000 rpm and a stall speed of 500 rpm. It is defined by an inertia of 0.2 kg/m^2 and a time constant of 0.2 seconds. This model receives either a throttle or torque command as input. The throttle input signal ranges from zero to one, representing the fraction of the maximum possible torque demanded by the engine. Additionally, the torque command input signal can vary from zero up to the maximum torque value.

Similarly, another power-generating source in this study is a 12 kWhr (30 Ahr) Lithium-ion battery pack with a nominal voltage of 400V. A Li-ion battery pack block available in Simscape, characterized by an internal resistance of 0.1 ohms, is utilized. This battery is directly connected to a DC-DC bi-directional converter, which maintains 600V at the other end, referred to as the DC-link voltage. The converter processes power from the battery pack, regulates the output voltage, and controls the currents through the battery pack to supply the optimal energy required by the vehicle. The input to the DC-DC bi-directional converter is the battery pack, while the output is connected to the motor drive and generator drive. The bi-directional DC-DC power electronic converter is modeled using a Simscape block, with a MOSFET serving as the switching device. The MOSFET has a drain-source on resistance of 0.001 ohms, an off-state conduction of 1×10^{-5} per ohm, and a threshold voltage of 0.5V. Several advanced machine learning models have been developed to maintain the DC-link voltage [7]. Here in this study, a closed-loop control system utilizing a PI controller is employed to maintain the DC-link voltage at 600V. For current control, P and I values of 0.02 and 2 are selected, while for voltage control, P and I values of -10 each are used.

Since this is an HEV, the presence of multiple power-generating sources within the vehicle necessitates the need for an EM system. EM systems are commonly utilized in HEVs due to their fuel-saving capabilities [12], [13]. Several algorithms have been developed till now for the HEVs [9]. In this study, a constrained optimization function for the reduction of fuel consumption is employed and deployed in a controller, i.e., Raspberry Pi. The objective of the EM used in this study is to optimize fuel consumption and can be generally formulated as follows:

$$\min \sum_{s\in\mathcal{S}} f_s(P_s(t_k)) \tag{1a}$$

$$P_s(t_k) \in \mathcal{P} \tag{1b}$$

where, t_k is the time instant in the discrete domain, $\mathcal{S}$ is the set of indices of energy sources, and $P_s(t_k)$ is power generated by source s at t_k, and $\mathcal{P}$ is correspondingly the constraints set of $P_s(t_k)$. This EM is used from the previous study [12] and is explained in detail in this study.

III. COMMUNICATION FOR GEOGRAPHICALLY SEPARATED LABORATORIES

Two geographically separated laboratories are considered: RT-COOL at the Main Campus located in Clemson and SEAL at the CUICAR Campus in Greenville. RT (real-time)-devices from each laboratory are used to implement the proposed framework. To connect these two laboratories and facilitate data exchange, a framework is developed using the VILLASframework. VILLASframework framework is a toolset for local and geographically distributed real-time co-simulation. Within the VILLASframework, there is a modular gateway called VILLASnode, specifically designed for handling simulation data. This component provides interfaces to various simulation equipment, databases, and web services. Consequently, VILLASnode is utilized to facilitate the transfer of data between these two laboratories. To achieve this, both laboratories need to be connected to the same internet, where Clemson University's internet-2 network is employed for communication through VILLASnode in this task. To implement VILLASnode for data exchange, it has to be deployed at each laboratory, which is done using Raspberry Pi. As depicted in Fig. 2, a Raspberry Pi is utilized in each laboratory to run VILLASnode and facilitate the exchange of data.

For the implementation of the HIVE framework, the HEV is segmented and deployed on Speedgoats, RT simulators, located in the RT-COOL and SEAL laboratories. Fig. 2 shows the segmentation of a single HEV system where the battery of the model is separated from the rest of the vehicle system. The battery is run in the SEAL laboratory (CUICAR campus) and the rest of the system is in the RT-COOL laboratory (Main campus). As illustrated in the framework shown in Fig. 3, Raspberry Pi-1 is used to deploy VILLASnode on the Main Campus and is responsible for transmitting data from Speedgoat-1 to another Raspberry Pi-2 located at the CUICAR Campus. Similarly, Raspberry Pi-2 receives this data and forwards it to another Speedgoat, which runs a portion of the SHEV model. Once the model is operational in the SEAL lab, it sends the data back to Raspberry Pi-2 using UDP communication, which in turn transmits it to Raspberry Pi-1 in the RT-COOL laboratory via VILLASnode. Since these two laboratories are geographically separated, there will be some latency in the communication [8]. For this, an SEL-9524 GNSS Antenna and SEL-2488 satellite-synchronized network clock are employed to obtain satellite time at both locations to calculate the delays at each laboratory.

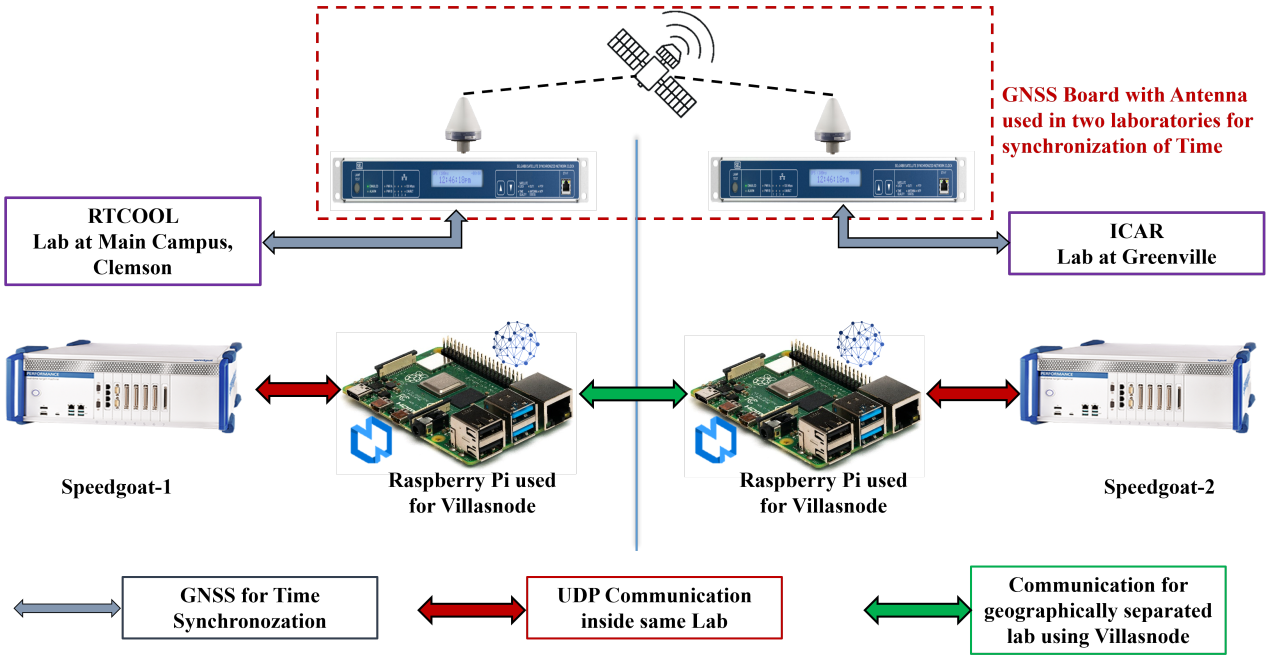

Fig. 2: Interconnection framework of two laboratories.

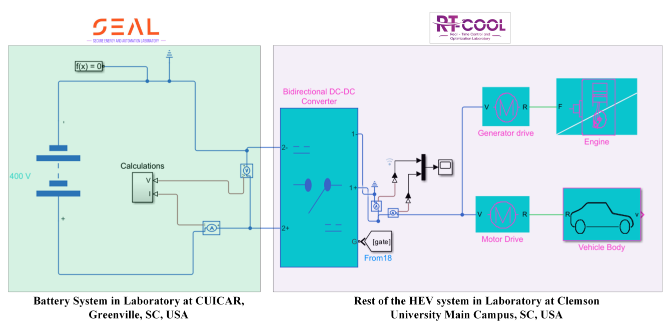

Fig. 3: Hybrid Electric Vehicle System components segmented between two laboratories.

As previously discussed, the simulation is developed in MATLAB/Simulink and deployed on Speedgoat, a real-time simulator. Additionally, the Energy Management (EM) system is implemented on a Raspberry Pi, which serves as the controller for this study. Communication between the Speedgoat and the Raspberry Pi is facilitated via UDP, with a data exchange sampling rate of 0.5 seconds. Two simulation files, each operated in separate laboratories, are provided in Appendices 1 and 2 for reference.

A. Ideal Transformer Model

The lithium-ion battery is deployed in a real-time simulator at the SEAL lab. Due to its remote location and lack of physical connection to the rest of the vehicle system, an ideal transformer model (ITM) is utilized. The ITM, a common co-simulation interface algorithm, connects different subsystems in a co-simulation environment by using controlled voltage and current sources to replicate the remote subsystem's behavior locally [14]. However, the ITM's stability and accuracy can be affected by the presence of delay, which is also calculated and will be explained in detail in the following section.

To address the challenge of delay and ensure the stability and accuracy of the ITM, we employ a model-free delay prediction approach based on sliding mode control (SMC) principles. The key idea is to predict the delay-induced error in the coupling signals (voltage and current) and compensate for it in real-time as shown in the subsequent subsections.

B. Sliding Mode Control for Error System

In this context, the error system represents the difference between the undelayed remote signals (voltage and current) sent from the SEAL laboratory and RTCOOL laboratory and the predicted signals at the local simulator. The aim is to ensure that this error remains zero despite the presence of communication delays.

Let $V_r(t)$ and $I_r(t)$ represent the remote voltage and current signals, respectively, and $\hat{V}(t)$ and $\hat{I}(t)$ represent the predicted local voltage and current signals. The error signals $e_v(t)$ and $e_i(t)$ can be defined as:

$$e_v(t) = V_r(t) - \hat{V}(t)$$

$$e_i(t) = I_r(t) - \hat{I}(t)$$

The objective is to drive $e_v(t)$ and $e_i(t)$ to zero. Using sliding mode control, we can define a sliding surface $s(t)$ for the error system. For simplicity, consider the voltage error system:

$$s_v(t) = \frac{d}{dt}e_v(t) + \lambda e_v(t)$$

where λ is a positive constant that determines the convergence rate of the error.

To apply sliding mode control, we need to design a control law that forces the system to reach and stay on the sliding surface. A commonly used control law in SMC is:

$$\dot{s}_v(t) = -K\text{sign}(s_v(t))$$

where K is a positive gain and $\text{sign}(s_v(t))$ is the sign function.

The control input $u(t)$ is designed to counteract the effect of the delay and ensure that $s_v(t)$ remains zero. For the voltage error system, the control law can be expressed as:

$$u_v(t) = -\lambda e_v(t) - K\text{sign}(s_v(t))$$

Similarly, for the current error system, we define:

$$s_i(t) = \frac{d}{dt}e_i(t) + \lambda e_i(t)$$

$$\dot{s}_i(t) = -K\text{sign}(s_i(t))$$

$$u_i(t) = -\lambda e_i(t) - K\text{sign}(s_i(t))$$

The control inputs $u_v(t)$ and $u_i(t)$ are applied to the local simulator to adjust the predicted voltage and current signals, thereby compensating for the delay.

C. Delay Prediction and Compensation

To implement this in a real-time co-simulation environment, we first estimate the communication delay τ between the remote and local laboratories. This delay can be measured and monitored continuously.

Given the delay τ, we predict the future values of the remote signals $V_r(t+\tau)$ and $I_r(t+\tau)$. Using the sliding mode control law, we adjust the local signals to match these predicted values.

The predicted voltage and current at the local simulator can be updated as:

$$\hat{V}(t+\tau) = V_r(t) + u_v(t)$$

$$\hat{I}(t+\tau) = I_r(t) + u_i(t)$$

By continuously updating $\hat{V}(t)$ and $\hat{I}(t)$ using the control laws $u_v(t)$ and $u_i(t)$, we ensure that the error signals $e_v(t)$ and $e_i(t)$ remain zero, thereby achieving accurate and stable co-simulation despite the presence of communication delays.

s

IV. Simulation and Results

This section presents the result of the simulation of HEV across geographically distributed laboratories utilizing the HIVE concept. An FTP75 drive cycle, which runs for 4200 seconds and represents a standardized urban driving condition, is employed to drive the HEV in this simulation. The HEV model was developed within the MATLAB/Simulink environment and executed in real-time using a Speedgoat, a digital real-time simulator. To facilitate distributed simulation, the HEV components were partitioned across two laboratories: one housing all components except the battery, and the other dedicated to the battery model, also implemented in MATLAB/Simulink and executed in real-time. Data exchange between the two laboratories is facilitated using VILLASnode through a Raspberry Pi, as discussed earlier.

The HEV is driven using the FTP75 drive cycle, and the total power demanded by the vehicle is illustrated in Fig. 4 (a). The EM system effectively distributes power between the internal combustion engine (ICE) and the battery. The power allocated to ICE is as shown in Figures 4(b), and it serves as a control metric for distributing power between the ICE and the battery.

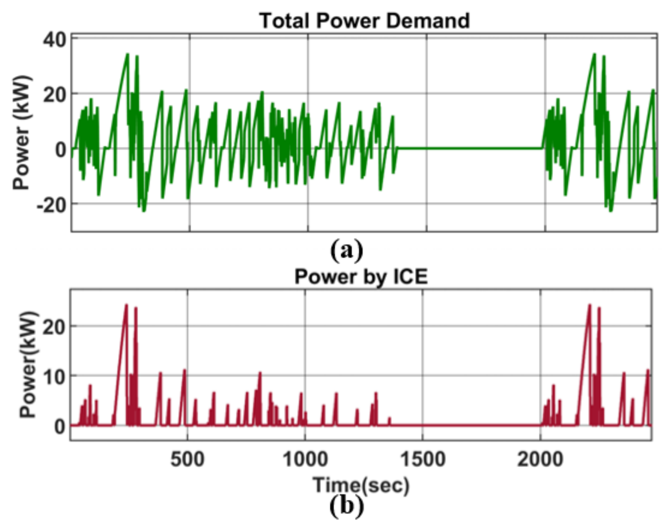

Fig. 4: Results from the EM: (a) Total power demanded by HEV (b) Power allocated to the ICE by the EM.

Fig. 5 illustrates the comparison between the power allocated by the EM to the ICE and the actual power delivered by the ICE during the HIVE-based simulation. The graph demonstrates that the ICE closely follows the power commands provided by the EM, indicating the effectiveness of the EM in controlling the operation of HEV.

To maintain stable system operation, a DC bus voltage regulation scheme is implemented. As depicted in Figure 6, the DC bus voltage exhibits minor fluctuations around the nominal value of 600V, as further emphasized in the magnified inset. Despite these oscillations, the actual DC link voltage remains confined within a 5% tolerance band, effectively attenuating

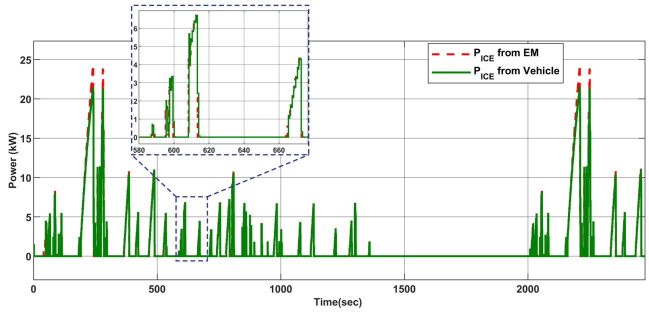

Fig. 5: Comparison of power supplied by the ICE during vehicle operation with power allocated by the EM.

potential system instabilities and keeping the integrity of powertrain components safe.

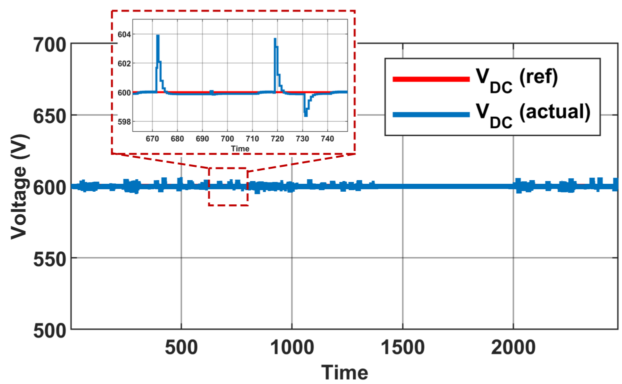

Fig. 6: Comparison of actual DC link voltage with the reference voltage

The current demanded by the vehicle system from the battery at the RT-COOL laboratory is shown in Fig. 7(a). This current is fed as an input to the controlled current source connected across the battery in the SEAL lab, and the actual current out from the battery is shown in 7(b), which is exactly the same as the current demanded by the vehicle in RT-COOL.

Similarly, the terminal voltage of the battery during the simulation at SEAL laboratory is shown in Fig. 8(a). This voltage is sent to RT-COOL laboratory through VILLASnode and is connected as an input to the controlled voltage source. The voltage measured in RT-COOL is shown in Fig. 8(b), which replicates the previous waveform. Hence, with this it can be further verified that even though the battery is operating a different location it can be connected using ITM as if the battery is operating at the same location.

The above explanation and results demonstrate that the HEV operates effectively using the HIVE concept across distributed laboratories. The vehicle was driven using a predefined FTP75 drive cycle. To further validate the robustness of the framework, the vehicle's actual speed is compared to the reference speed defined by the drive cycle. In Fig. 9 , the vehicle's speed tracking is shown alongside the reference speed command.

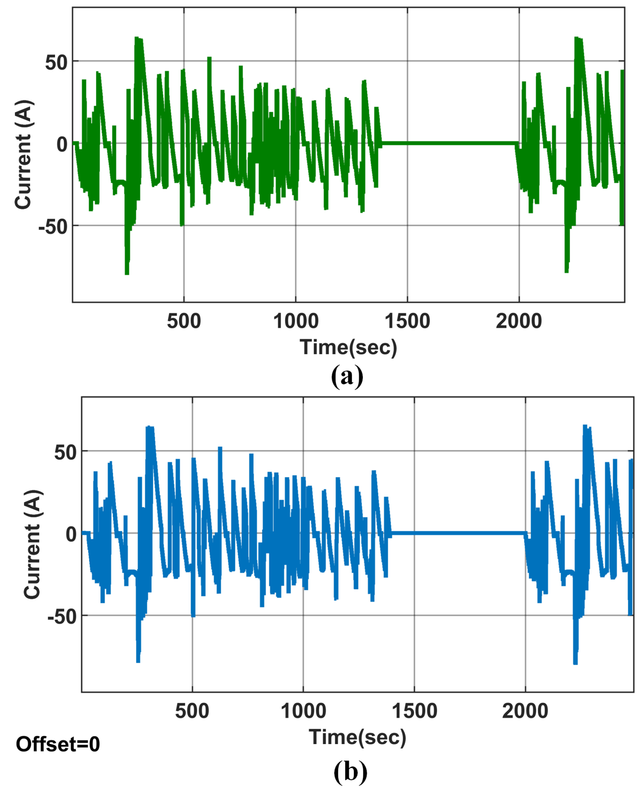

Fig. 7: (a) Current demanded by the vehicle from battery at Main campus, Clemson (b) Current supplied by the battery at ICAR Campus, Greenville

This comparison indicates that the framework is functioning flawlessly.

The data is being transferred from one laboratory to another laboratory continuously, which is already shown by the results above. Now, since these laboratories are geographically separated so, there will be some latency. To measure this delay SEL-9524 GNSS Antenna and SEL-2488 satellite synchronizing network clock are used to get the satellite time. This time is sent from one location to another and vice-versa in order to calculate the associated delay. Fig. 10 (a) and (b) represent the delay observed in RT-COOL and SEAL laboratories, respectively. From these two plots, it can be seen that the delay fluctuates and varies between 0.002 to 0.03 seconds.

V. Conclusion and Future Works

This study establishes a framework for linking geographically seperated components of a system, enabling them to function cohesively as a unified entity. Through simulations involving the interconnection of two laboratories located in Clemson, SC, and Greenville, SC, respectively, for an HEV system, this paper demonstrated the HIVE framework's viability and effectiveness in managing HEV operations across these locations.

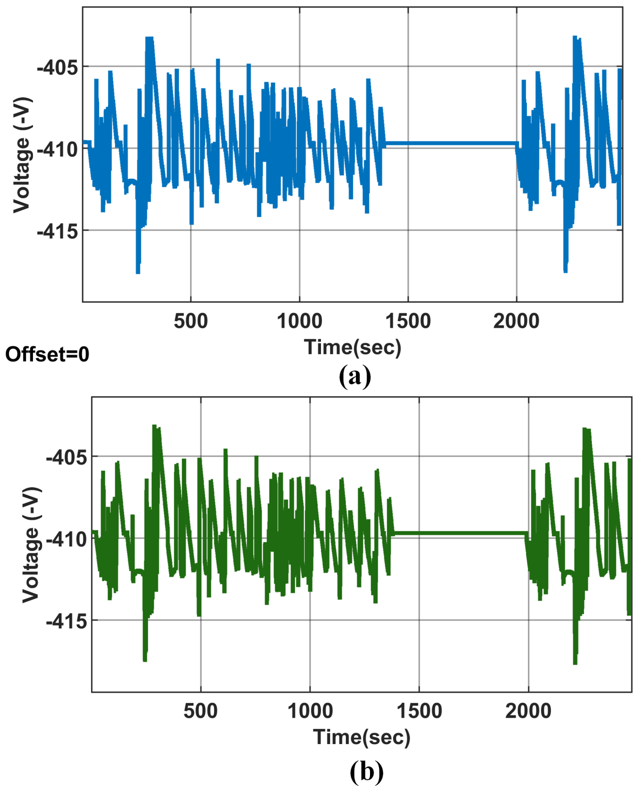

Fig. 8: Voltage of battery (a) received at Main Campus, Clemson (b) measured at ICAR Campus, Greenville

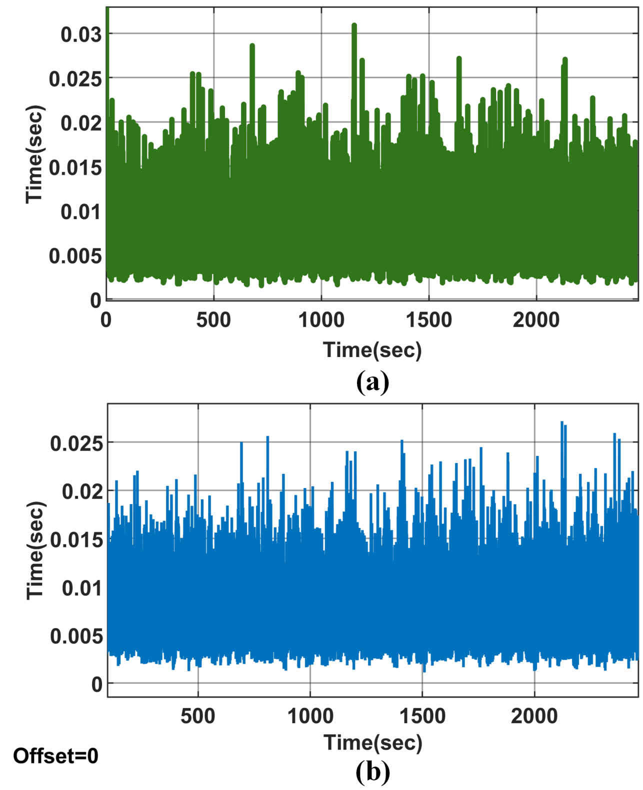

Fig. 10: Delay observed during communication in (a) Main campus, Clemson (b) ICAR Campus, Greenville

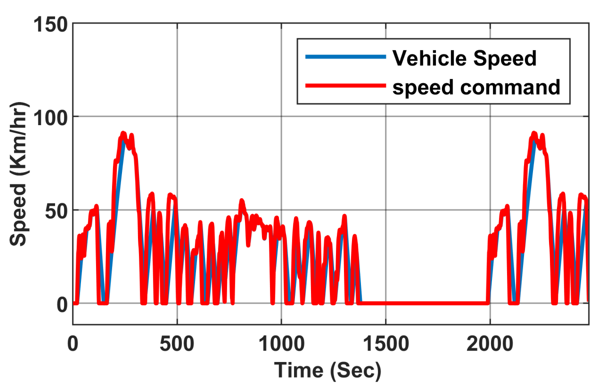

Fig. 9: Comparison of vehicle speed and reference drive cycle speed.

Additionally, the study involved calculating the data transmission delay between the laboratories using the SEL-9524 GNSS Antenna and the SEL-2488 satellite synchronization network clock. These tools provided precise satellite time data necessary for calculating the delay. Moving forward, the next phase of this research will focus on integrating the delay compensation techniques to minimize the impact of the delay on the system and maintain stability.

ACKNOWLEDGMENT

The authors would like to acknowledge the Warren H. Owen Distinguished Professorship Endowment for its support of the research effort.

This work was supported by Clemson University's Virtual Prototyping of Autonomy Enabled Ground Systems (VIPR-GS) under Cooperative Agreement W56HZV-21-2-0001 with the US Army DEVCOM Ground Vehicle Systems Center (GVSC).

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited. OPSEC8999.

REFERENCES

[1] S. Vogel et al., "Improvements to the Co-simulation Interface for Geographically Distributed Real-time Simulation," IECON 2019 - 45th Annual Conference of the IEEE Industrial Electronics Society, Lisbon, Portugal, 2019, pp. 6655-6662

[2] S. K. Srivastava, R. Cox, E. Shoubaki, G. Ozkan and B. Chowdhury, "Geographically Distributed Real Time Co-Simulation Testbed For Community Microgrids," *8th IEEE Workshop on the Electronic Grid (eGRID)*, Karlsruhe, Germany, 2023, pp. 1-6, doi: 10.1109/eGrid58358.2023.10380843.

[3] R. Valova and B. Gwen "Distributed energy resource interconnection: An overview of challenges and opportunities in the United States." *Solar Compass 2*, 2022, 100021.

[4] I. K. Park, Y. Zhang, and J. Sim, "Co-simulation of OpenDSS and RTDS to realise real-time simulation of large distribution networks", *The 26th International Conference and Exhibition on Electricity Distribution*, 2021, pp. 2524 – 2528.

[5] M. Stevic, A. Estebsari, S. Vogel, E. Pons, E. Bompard, M. Masera, and A. Monti, ”Multi-site European framework for real-time co-simulation of power systems,” *IET Generation, Transmission & Distribution*, 11(17), 2017, pp. 4126-4135.

[6] E. Buraimoh, G. Ozkan, L. Timilsina, P. K. Chamarthi, B. Papari and C. S. Edrington, ”Overview of Interface Algorithms, Interface Signals, Communication and Delay in Real-Time Co-Simulation of Distributed Power Systems,” *IEEE Access*, vol. 11, pp. 103925-103955, 2023, doi: 10.1109/ACCESS.2023.3317250.

[7] T. Mohamed, M. Kezunovic, Y. Paudel, V. Vittal, A. Pal, D. Joshi, Menuka KC, M. V. Venkatasubramanian and G. Torresan, ”Automated Detection and Classification of Critical Power System Events using ML on PMU Data,” *2024 International Conference on Smart Grid Synchronized Measurements and Analytics (SGSMA)*, May 2024.

[8] S. Ghimire, D. Joshi, V. M. Venkatasubramanian, G. Torresan, P. Chabas, and S. Hivart, ”Wide-area measurement based online oscillation alarming system at RTE,” *IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids*, 2024.

[9] D. Joshi, S. Ghimire, S. S. Shiuab, and V. M. Venkatasubramanian, ”Computational analysis of online oscillation monitoring algorithms,” *IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids*, 2024.

[10] A. Arsalan, J. Ahmad, M. Tahir and S. K. Mazumder, ”Distributed Control and Power Management of Islanded DC Nanogrids with Applications to Rural Electrification,” 2020 IEEE Energy Conversion Congress and Exposition (ECCE), Detroit, MI, USA, 2020, pp. 4662-4667, doi: 10.1109/ECCE44975.2020.9236352.

[11] L. Timilsina, P.R. Badr, P. H. Hoang, G. Ozkan, B. Papari, and C. S. Edrington, “Battery degradation in electric and hybrid electric vehicles: A survey study,” *IEEE Access*, vol. 11, pp. 42431-42462, 2023.

[12] L. Timilsina, P. H. Hoang, A. Moghassemmi, P.K. Chamarthi, G. Ozkan, B. Papari, and C. S. Edrington, ”A Real-Time Prognostic Based Control Framework for Hybrid Electric Vehicles,” *IEEE Access*, vol. 11, pp. 127589 - 127607, 2023.

[13] L. Timilsina, P. H. Hoang, A. Arsalan, G. Ozkan, B. Papari, and C. S. Edrington, “Degradation Abatement In Hybrid Electric Vehicles Using Data-driven Technique,” *Transportation Research Procedia*, vol. 70, pp. 52-60, 2023.

[14] E. Buraimoh et al., “Model Free Time Delay Compensation for Damped Impedance Method Interfaced Power System Co-Simulation Testing,” SAE Technical Paper; 2023.