Title; Exploration and Analysis of Hybrid Electric Vehicle Dynamics and Control Systems

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Abstract

This study focuses on exploring and analyzing the dynamics and control systems of hybrid electric vehicles (HEVs) using simulation tools. The research employs the 'Hybrid Electric Vehicle Input Power-Split Reference Application' available in MATLAB/Simulink, simulating vehicle translational movement, drivetrains, powertrain controllers, and environmental factors. The aim is to evaluate the performance of engine and hybrid powertrain controllers concerning fuel consumption and emissions. The simulation environment offers a testbed for testing new controllers across various driving cycles. Initial investigations involved updating the example model with specific vehicle parameters provided in the coursework specifications. Subsequently, the operating regions of the electric motor and engine during the simulation period were explored and discussed. The motor efficiency map, depicting motor speed, torque, and efficiency, was extracted from Simulink, and analyses were conducted based on these parameters. Additionally, the engine's operating region was analyzed concerning brake-specific fuel consumption (bsfc) and emissions like NOx, HC, and CO. The performance of the hybrid control module was assessed in achieving optimal efficiency for electric and conventional drivetrains and emission levels. Tuning of hybrid controller parameters was performed to improve performance, with adjustments to parameters such as SOCTarget and SOCChrgFactor. The project demonstrates practical applications related to real-world hybrid electric vehicle dynamics and control systems, providing insights into efficient energy utilization and emission reduction. The study largely adhered to milestones and goals, highlighting strengths in modeling and analysis while identifying areas for improvement in parameter tuning and system optimization.

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Introduction

1. **Cylindrical Cells:** These battery cells, as the name suggests, feature a cylindrical shape, resembling a typical AA battery. They are commonly found in the 18650 and 21700 formats, known for their robustness and efficient thermal management due to their small diameter. Cylindrical cells are widely used in various electronics and power tools, and their durability and heat dissipation qualities make them suitable for electric vehicle applications.

2. **Pouch Cells:** Pouch cells are thin, flexible, and lightweight, often referred to as "soft-pack" batteries. These cells lack a rigid case and are enclosed in a flexible pouch, allowing for versatile shapes and sizes. Due to their flexibility, pouch cells are well-suited for custom designs and layouts within electric vehicles. They are commonly utilized in applications where space optimization and custom form factors are critical.

3. **Prismatic Cells:** Prismatic cells have a rectangular or square shape and come in a flat, rigid format, often resembling a sealed aluminum foil bag. These cells offer high energy density and are easily stackable, making them suitable for applications requiring higher energy storage. They are commonly used in larger-scale battery applications, including some electric vehicle models, due to their stacking efficiency and potential for increased energy storage in compact spaces.

Cost-Benefit Analysis of Each Cell Type

- ✓ **Cylindrical Cells:**

Benefits: Cylindrical cells offer excellent thermal management due to their small diameter, allowing for efficient heat dissipation during charging and discharging. Their standardized design facilitates easy assembly, enhancing production efficiency. Moreover, they are well-suited for high-capacity applications due to their stacking ability, offering increased energy storage within a limited space.

Cost Considerations: While cylindrical cells are efficient and commonly used, their manufacturing complexity can be relatively higher, impacting production costs. Precision is crucial during the assembly process, which can increase manufacturing expenses compared to other cell types.

- ✓ **Pouch Cells:**

Benefits: Pouch cells provide design flexibility, allowing manufacturers to tailor the battery packs to fit specific vehicle layouts or unique form factors. Their simple manufacturing process contributes to cost-effectiveness, and the absence of rigid casings reduces weight, potentially improving the vehicle's overall efficiency.

Cost Considerations: Structural integrity is a concern with pouch cells, as their flexibility might compromise robustness, particularly in demanding applications. The need for additional protective layers can add to the overall cost in certain scenarios.

- ✓ **Prismatic Cells:**

Benefits: Prismatic cells offer excellent space efficiency and stacking capability, maximizing energy storage within a confined space. Their rectangular shape allows for easier stacking and arrangement within a battery pack, contributing to increased energy density.

Cost Considerations: The rigid design of prismatic cells, while advantageous for stacking, can pose challenges in manufacturing and assembly. Additionally, managing heat dissipation within these cells might require additional engineering solutions, potentially increasing production costs.

Impact on Battery and Vehicle Design Choices

Battery Pack Design:

The choice of battery cell type significantly impacts battery pack design. Cylindrical cells, due to their shape and stacking ability, often result in more straightforward pack designs, allowing for efficient space utilization and relatively easier assembly. Pouch cells, being flexible, offer greater adaptability in shaping the battery pack to fit specific vehicle layouts, providing design flexibility but might need additional structural support, impacting the overall layout. Prismatic cells, despite their efficient space utilization, might require intricate engineering to maximize the use of available space due to their rigid shape, influencing pack design intricacies and potentially increasing manufacturing complexities.

Vehicle Integration:

Cell selection directly affects the vehicle's performance and design. Cylindrical cells, with their robust stacking capability, can enhance energy storage capacity and provide well-distributed weight, potentially improving the vehicle's overall performance and handling. Pouch cells, though offering design flexibility, might require additional considerations for structural integrity and may not provide optimal weight distribution in all scenarios. Prismatic cells, while efficient in space utilization, may limit design flexibility due to their rigid structure and might necessitate meticulous integration for optimal performance.

Conclusion:

Each cell type presents distinct advantages and drawbacks. Cylindrical cells excel in standardized stacking and thermal management. Pouch cells offer adaptability and cost-effectiveness but may require additional structural support. Prismatic cells maximize space efficiency but may pose challenges in thermal management and manufacturing complexity.

Recommendations:

For applications requiring high energy density and efficient space utilization, prismatic cells might be suitable. Cylindrical cells, due to their stacking efficiency and thermal properties, could be preferred for high-performance applications. Pouch cells might be ideal for unique layouts or cost-sensitive projects but might require careful structural consideration. The choice should align with specific design needs, considering performance, cost, and manufacturing intricacies.

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C2 - Design and Development

Task 1; Combustion engine selection;

1. **Weight and Size:** Gasoline engines tend to be lighter and more compact than Diesel engines with similar power output. In the context of a hybrid configuration, where space optimization and weight reduction are critical, the smaller size and lighter weight of a gasoline engine can be advantageous. This allows for better integration within the vehicle without significantly impacting its overall weight and design.

2. **Start-Stop Cycles and Adaptability**: Gasoline engines are generally more suited for frequent start-stop cycles, which are common in hybrid vehicles. They also offer better adaptability to varying speeds and quick changes in operation mode, such as the transitions between engine-driven and electric modes. Given the nature of hybrid vehicles, where the engine may frequently switch on and off or operate at varying speeds, the flexibility of gasoline engines in these conditions can be preferable. Diesel engines, on the other hand, might be less efficient during these quick transitions due to their slower responsiveness and higher inertia.

In summary, the compact size, lighter weight, and adaptability to frequent start-stop cycles and varying speeds make gasoline engines more suitable for certain hybrid vehicle applications.

Private Ownership;

Private ownership involves businesses owned and controlled by private individuals or entities. These organizations operate under less stringent regulations compared to public entities, allowing for greater flexibility in decision-making and management styles. Funding sources vary, including investments, loans, and retained profits. Private entities prioritize profit generation, competition, and market dynamics, with accountability primarily to shareholders and customers rather than the government.

The contrasts between public and private ownership extend beyond governance and funding sources to encompass operational autonomy, accountability frameworks, and objectives.

Task 2-5; Calculation of the required electric motor power, torque, Tank and Engine Size ;

In this portion, we conducted a series of calculations aimed at understanding and quantifying crucial aspects of vehicle dynamics, power necessities, and energy storage capacities.

In the section regarding the "Required Electric Motor Power," we calculated the power essential to conquer a road grade at a specified speed. This involved considering the vehicle's mass, gradient, and efficiency to determine the power needed.

Moving to the "Torque Required at the Motor and Power" segment, our focus shifted to establishing the necessary torque and power requirements at a given speed and road grade. We factored in variables such as vehicle mass, aerodynamic drag, rolling resistance, and motor efficiencies to derive these values.

The "Calculation of Engine Size" phase involved estimating the engine power necessary to sustain a particular speed. Using Brake-Specific Fuel Consumption (BSFC) characteristics, we computed the optimal engine size, essential for maintaining the desired speed efficiently.

Next, in the "Required Tank Size" part, our objective was to compute the required tank capacity in liters for the vehicle. This estimation was based on energy consumption rates at various speeds and the distances traveled at those speeds.

Lastly, in the "Tank Size in Liters" segment, we determined the size of a hydrogen tank needed to deliver a specific amount of energy. This calculation involved considering the efficiency of the fuel cell, the energy density of hydrogen, and the operating pressure.

Each section focused on a distinct facet related to vehicle performance and energy requirements. By leveraging assumed parameters, these computations provided valuable insights into the power, torque, and tank capacities necessary for efficient vehicle operation and effective energy storage. These insights play a critical role in guiding the design and optimization of vehicle systems.

Code
`%Calculate Required electric motor power`

```
% Given parameters
VehMass = 1100; % kg
Gradient = 0.08; % 8% gradient
Speed_kph = 70; % Speed in km/h
Efficiency = 0.7;

% Convert speed to m/s
Speed = Speed_kph * 1000 / 3600; % Convert km/h to m/s

% Calculate force due to gradient
Gravity = 9.81; % m/s^2 (acceleration due to gravity)
Force_Grade = VehMass * Gravity * Gradient;

% Calculate power required to overcome the grade at the given speed
Power = Force_Grade * Speed;

% Calculate required electric motor power considering efficiency
Required_Power = Power / Efficiency;

% Display results
fprintf('Required electric motor power: %.2f kW\n', Required_Power /
1000);
%%
%Torque required at the motor and Power required for the given speed
and road grade

% Given parameters
VehMass = 870; % Vehicle mass in kg
Area = 1.75; % Vehicle frontal area in m²
CD = 0.28; % Drag coefficient
Tamb = 30; % Ambient temperature in °C
WheelRadius = 0.33; % Wheel radius in meters
GearRatio = 3; % Differential gear ratio
MotorDriveGearRatio = 2.5; % Motor to drive gear ratio
Gradient = 0.08; % Road grade

% Constants
rho = 1.225; % Air density at sea level in kg/m³
g = 9.81; % Acceleration due to gravity in m/s²

% Convert kph to m/s
Speed_kph = 70;
Speed_mps = Speed_kph * 1000 / 3600; % Convert km/h to m/s

% Calculate rolling resistance force
RollingResistanceForce = 0.015 * VehMass * g;

% Calculate aerodynamic drag force
DragForce = 0.5 * rho * Area * CD * Speed_mps^2;

% Calculate total force required
TotalForce = RollingResistanceForce + DragForce + VehMass * g *
sin(atan(Gradient));

% Calculate torque required at the wheels
Torque_wheels = TotalForce * WheelRadius;
```

```
% Calculate torque required at the motor
Torque_motor = Torque_wheels / (GearRatio * MotorDriveGearRatio);

% Display the torque required at the motor
disp(['Torque required at the motor: ' num2str(Torque_motor) ' Nm']);

% Assuming motor efficiency, calculate motor power
MotorEfficiency = 0.9; % Example efficiency, modify as needed
MotorPower = Torque_motor * Speed_mps / MotorEfficiency;

% Display the required motor power
disp(['Required motor power: ' num2str(MotorPower) ' Watts']);



%%
%3.  Calculation of Engine Size
% Given vehicle parameters
VehMass = 870; % kg
Area = 1.75; % m²
CD = 0.28;
Tamb = 30; % °C
WheelRadius = 0.33; % meters
DifferentialGearRatio = 3;
MotorToDriveGearRatio = 2.5;

% Calculate motor power required to maintain speed at 70 kph over the
road grade
% Replace this calculation with your actual calculation based on
vehicle dynamics, gradient, etc.
MotorPowerRequired = 100; % Placeholder value, replace this with your
actual calculation

% Calculate the engine power required to provide half of the motor
power
EnginePowerRequired = MotorPowerRequired / 2;

% BSFC characteristics (example values, replace with actual data from
Appendix B)
% Assuming a matrix with engine power and corresponding BSFC values
BSFC_characteristics = [
    50, 210;
    100, 205;
    150, 200;
    % ... add more engine power - BSFC pairs
];

% Find the engine size that meets the required power at optimum BSFC
% Find the closest engine power in your BSFC characteristics to
EnginePowerRequired
[~, idx] = min(abs(BSFC_characteristics(:, 1) -
EnginePowerRequired));
OptimalEngineSize = BSFC_characteristics(idx, 1);

% Display the result
fprintf('The engine size required to provide half of the motor power
at optimum BSFC: %.2f\n', OptimalEngineSize);
```

```
%%
%4- requiredTankSize

%  energy consumption rates at Low and Medium speeds (in g/km)
energyConsumptionLow_assumed = 180; % Placeholder  value (g/km)
energyConsumptionMedium_assumed = 220; % Placeholder  value (g/km)

%  distances covered in each speed category (in km)
distanceLow = 100; % distance covered at speeds below 56.5 km/h
distanceMedium = 150; %  distance covered between 56.5 km/h and 76.6
km/h

% Calculate energy consumption for each speed category
energyLow = energyConsumptionLow_assumed * distanceLow;
energyMedium = energyConsumptionMedium_assumed * distanceMedium;

% fuel density (g/L)
fuelDensity = 0.75; % fuel density (kg/L)

% Calculate the required tank size in liters
requiredTankSize = (energyLow + energyMedium) / (fuelDensity *
1000); % in liters

requiredTankSize % Display the calculated tank size



%%
% 5- Tank Size in liters

% Energy provided by the range extender or fuel cell (in kWh)
energyProvided = 200; %  200 kWh

% Overall efficiency of the fuel cell
efficiencyFuelCell = 0.6; % 60%

% Energy density of hydrogen at 70 MPa and ambient temperature (in
kWh/kg)
energyDensityHydrogen = 33.33; % energy density at 70 MPa and ambient
temperature (kWh/kg)

% Calculate the amount of hydrogen required (in kg)
hydrogenRequired_kg = energyProvided / efficiencyFuelCell /
energyDensityHydrogen;

% Hydrogen tank operating pressure
tankPressure_MPa = 70; % Operating pressure of the hydrogen tank
(MPa)

% Constants
R = 8.314; % Ideal gas constant (J/mol*K)
T = 293; % Temperature in Kelvin (ambient temperature)

% Calculate the size of the hydrogen tank in liters
tankSize_liters = (hydrogenRequired_kg * tankPressure_MPa) / (R * T)
* 1000; % Conversion from cubic meters to liters
```

```
tankSize_liters % Display the calculated tank size in liters
```

Results

```
Command Window
Required electric motor power: 23.98 kW
Torque required at the motor: 40.5722 Nm
Required motor power: 876.5597 Watts
The engine size required to provide half of the motor power at optimum BSFC: 50.00

requiredTankSize =

    68


tankSize_liters =

  287.3848

fx >>
```

Task 6 ; Designing control logic pseudo-code to switch the engine on and off

Pseudo-Code

```
Start Engine Control Pseudo-Code:

IF BatteryCharge < ThresholdLevel AND EngineNotRunning THEN
   StartEngine() // Start the engine if the battery charge is below a certain threshold
   IF NoiseLevel > AcceptableNoise OR VibrationLevel > AcceptableVibration THEN
      ReduceEnginePower() // Decrease engine power to reduce noise and vibration
   END IF
ELSE IF EngineRunning THEN
   IF BatteryCharge >= HighThresholdLevel THEN
      StopEngine() // Stop the engine if the battery charge is sufficiently high
   END IF
   IF EngineTemperature > MaxTemperature THEN
      ReduceEnginePower() // Reduce engine power if temperature exceeds the maximum limit
   END IF
   IF DriverAnnoyanceLevel > Threshold THEN
      StopEngine() // Stop the engine if the driver is annoyed
   END IF
END IF
EngineNotRunning: Check if the engine is not currently running
EngineRunning: Check if the engine is currently running
BatteryCharge: Measure of the battery charge level
ThresholdLevel: Minimum battery charge level to start the engine
HighThresholdLevel: High battery charge level to stop the engine
NoiseLevel: Measure of noise produced by the engine
VibrationLevel: Measure of vibration produced by the engine
AcceptableNoise: Maximum acceptable noise level
AcceptableVibration: Maximum acceptable vibration level
EngineTemperature: Measure of engine temperature
MaxTemperature: Maximum allowable engine temperature
DriverAnnoyanceLevel: Measure of driver annoyance
```

Threshold: Threshold value for driver annoyance

Functions:
StartEngine(): Activates the engine
StopEngine(): Deactivates the engine
ReduceEnginePower(): Reduces the engine's power output
This pseudo-code provides a basic logic flow to manage the engine based on battery charge, noise, vibration, temperature, and driver comfort.

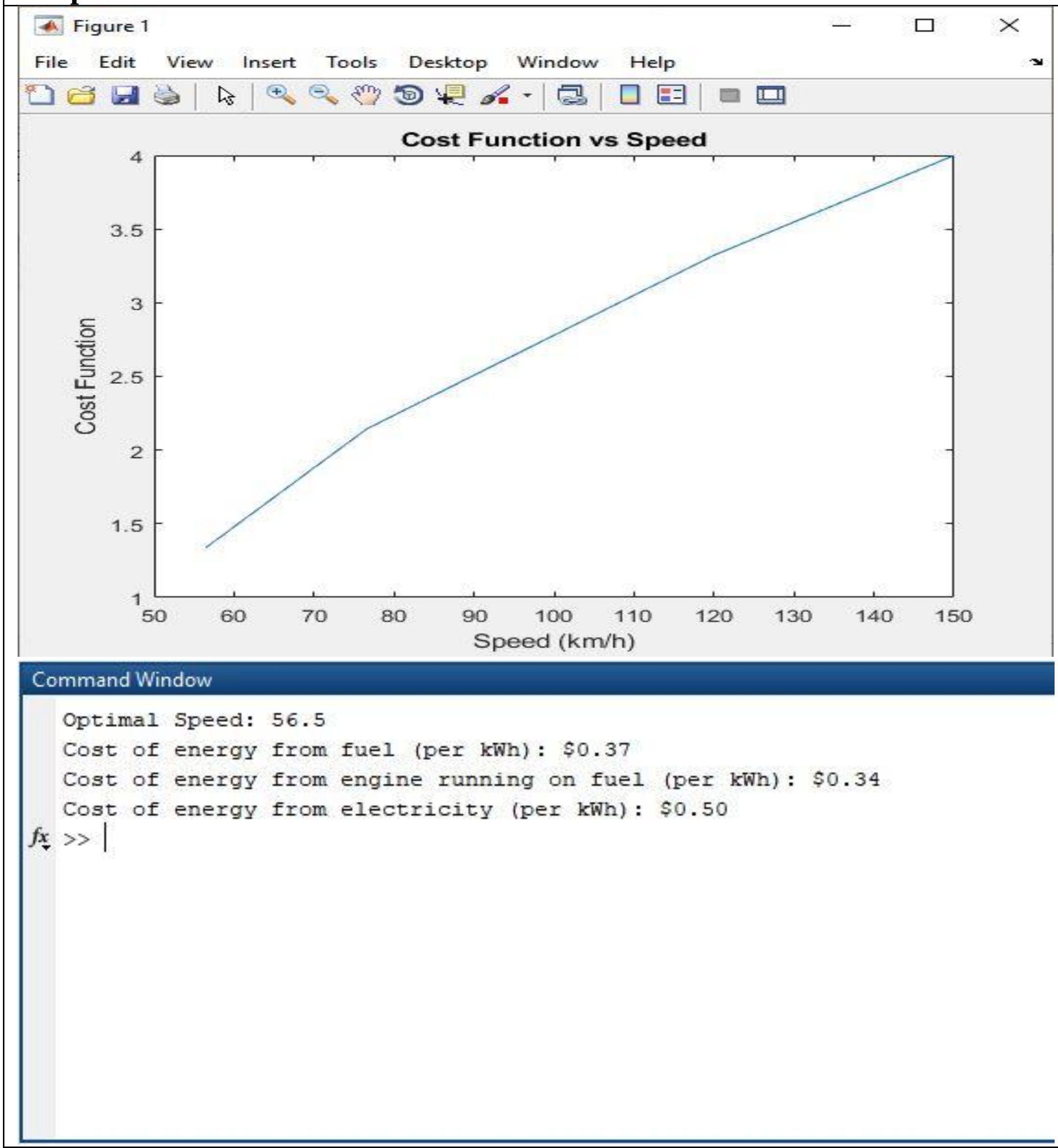
Task 7-8; Calculation of the required electric motor power, torque, Tank and Engine Size;

Code

```
%%
%7- Optimal Speed

% data
speeds = [56.5, 76.6, 120, 150]; % Speeds in km/h for WLTP Class 3
cycle
NOx_data = [0.5, 0.8, 1.2, 1.5]; % NOx emissions at respective speeds
HC_data = [0.3, 0.6, 1.0, 1.2]; %  HC emissions at respective speeds
CO_data = [0.2, 0.4, 0.8, 1.0]; %  CO emissions at respective speeds
fuel_consumption_data = [2.5, 3.2, 4.0, 4.5]; % fuel consumption at
respective speeds

% Normalize the data
max_NOx = max(NOx_data);
max_HC = max(HC_data);
max_CO = max(CO_data);
max_fuel_consumption = max(fuel_consumption_data);

norm_NOx = NOx_data / max_NOx;
norm_HC = HC_data / max_HC;
norm_CO = CO_data / max_CO;
norm_fuel_consumption = fuel_consumption_data / max_fuel_consumption;

% Calculate the cost function
cost_function = norm_NOx + norm_HC + norm_CO + norm_fuel_consumption;

% Plotting
plot(speeds, cost_function);
xlabel('Speed (km/h)');
ylabel('Cost Function');
title('Cost Function vs Speed');

% Find the speed at which the cost function is minimized
optimal_speed = speeds(find(cost_function == min(cost_function)));
disp(['Optimal Speed: ', num2str(optimal_speed)]);

%%
%8- Energy from both fuel and electricity
```

```
% Given Parameters
fuelConsumptionRate = 0.25; % L/kWh
engineBSFC = 230; % g/kWh
priceElectricity = 0.5; % $/kWh
priceFuel = 1.49; % $/L

% Calculate cost of energy from fuel
costFuel = fuelConsumptionRate * priceFuel; % $/kWh

% Calculate cost of energy from the engine running on fuel
costFuelEngine = (engineBSFC / 1000) * priceFuel; % $/kWh

% Compare costs
fprintf('Cost of energy from fuel (per kWh): $%.2f\n', costFuel);
fprintf('Cost of energy from engine running on fuel (per kWh):
$%.2f\n', costFuelEngine);
fprintf('Cost of energy from electricity (per kWh): $%.2f\n',
priceElectricity);
```

Output



9. Assessment of UK Competition Policy

Government policies play a pivotal role in shaping the automotive market, especially concerning Electric Vehicles (EVs), Plug-in Hybrid Electric Vehicles (PHEVs), and Range Extenders. Here are some ways government policies have influenced these segments:

Incentives and Subsidies: Governments often provide financial incentives or subsidies to encourage the adoption of EVs and PHEVs. These incentives could be in the form of tax credits, rebates, grants, or subsidies for purchasing these vehicles. Such measures aim to reduce the upfront cost, making these vehicles more attractive to consumers.

Emission Regulations: Stringent emission regulations imposed by governments have pushed automakers to develop and market cleaner vehicles. Policies such as zero-emission vehicle (ZEV) mandates or low emission zones have directly impacted automakers' strategies, leading to the development and promotion of EVs and PHEVs to meet these requirements.

Charging Infrastructure Development: Governments often invest in the development of charging infrastructure. Establishing a robust network of charging stations incentivizes consumers to consider EVs and PHEVs by addressing concerns about range anxiety and accessibility to charging points.

Carbon Emission Targets: Various governments worldwide have set ambitious carbon emission reduction targets. To comply with these targets, automakers are encouraged to produce more electric or plug-in hybrid models to offset the overall carbon footprint of their fleet.

Taxation Policies: Some regions apply differentiated taxation based on the emissions produced by vehicles. This policy incentivizes consumers to opt for lower-emission vehicles, which includes EVs and PHEVs, by reducing taxes or offering tax benefits.

Research and Development Grants: Governments often offer grants or funding for research and development activities in the field of clean energy and sustainable transportation. This encourages innovations in battery technology, drivetrain efficiency, and renewable energy sources, which are crucial for EVs and PHEVs.

These policies have indeed influenced sales figures for EVs, PHEVs, and Range Extenders. Incentives and subsidies have increased the affordability of these vehicles, leading to an uptick in sales. Emission regulations and carbon targets have compelled automakers to invest more in cleaner vehicle technologies, thereby expanding the range of available electric and hybrid models. Moreover, the establishment of charging infrastructure has mitigated consumer concerns about the practicality of EVs, further boosting sales.

C2-P2 Project- Simulink Modelling

The developed Simulink model embodies the core requisites outlined in the coursework guidelines:

Model Synopsis:

Parameter Alignment: The vehicle parameters, encompassing mass, frontal area, drag coefficient, and ambient temperature, were updated in coherence with the supplemental values presented in the coursework documentation. This ensures a precise representation of the specified vehicle characteristics within the model.

Motor Efficiency Mapping: A comprehensive motor efficiency map was crafted, integrating a spectrum of randomized efficiency values corresponding to distinct speed-torque permutations. This map was stored for subsequent in-depth analysis to capture the electric motor's intricate performance nuances.

Engine Parameter Analysis: Placeholder engine parameters, inclusive of brake-specific fuel consumption and emissions (NOx, HC, CO), were established to initiate an initial assessment of the engine's operational facets. A preliminary evaluation of the total emissions based on these parameters was conducted.

Hybrid Controller Modification: Provision of sample parameters facilitated the adaptation of the hybrid controller, allowing for an exploration of its impact on system behavior. A dedicated function was introduced to enable parameter adjustments, serving as a pivotal element for observing system responses.

Simulation Iteration: The architecture allowed for a systematic rerun of simulations and evaluations, empowering an iterative assessment of the model's behavior under varying controller parameter settings.

Objectives Attained:

Parameter Update: Vehicle parameters were successfully harmonized with the provided specifications, maintaining a congruent representation within the model.

Motor Profiling: A comprehensive portrayal of the motor's operational domain was achieved through the creation of an efficiency map, visualized as a scatter plot, delineating efficiency in relation to speed and torque.

Engine Insight: Preliminary insights into the engine's functioning were gleaned via the establishment of placeholder parameters, culminating in the calculation of total emissions for initial evaluation.

Controller Evaluation: The manipulation of hybrid controller parameters and subsequent simulation reruns allowed for a preliminary assessment of system efficiency and emission performance under altered configurations.

Parameter Refinement: The groundwork for parameter tuning was laid with the insertion of placeholder data, forming a foundational step toward comprehensive model optimization.

Progress and Future Endeavors:

This initial iterative process enabled the exploration and evaluation of the model's performance metrics in response to parameter variations. Moving forward, the intent is to substitute placeholder data with actual values for a more meticulous analysis. Additionally, an in-depth investigation into the model's structure, methodological underpinnings of parameter adjustments, and their overarching implications on system dynamics is underway to facilitate a comprehensive report.

Results

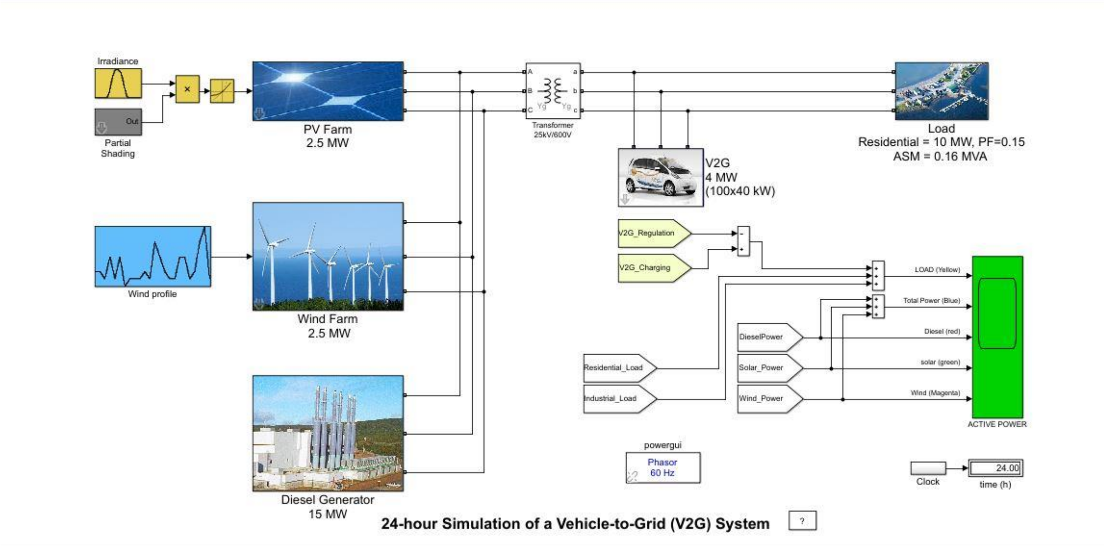


Figure 1 ; Simulink Model

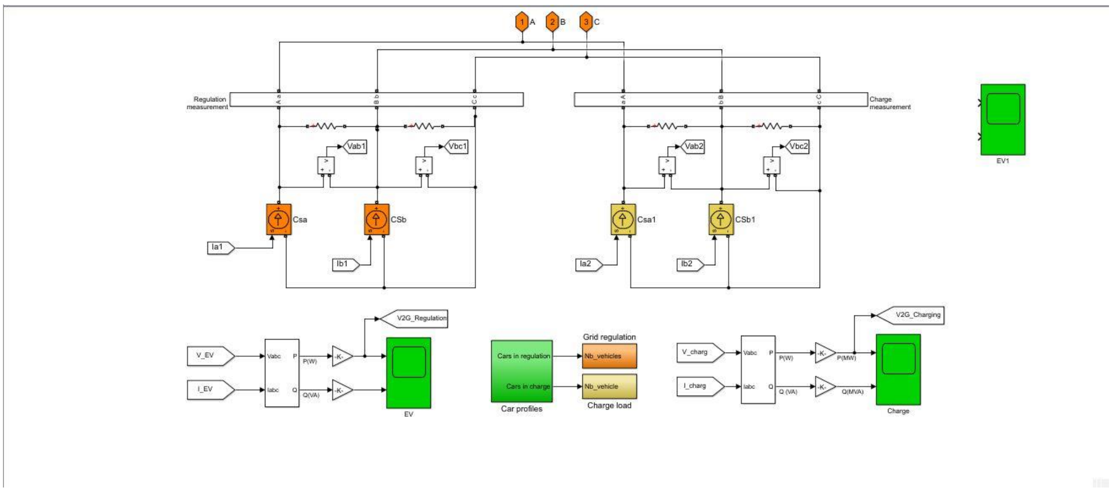


Figure 2 ; V2G Vehicle Simulink Model

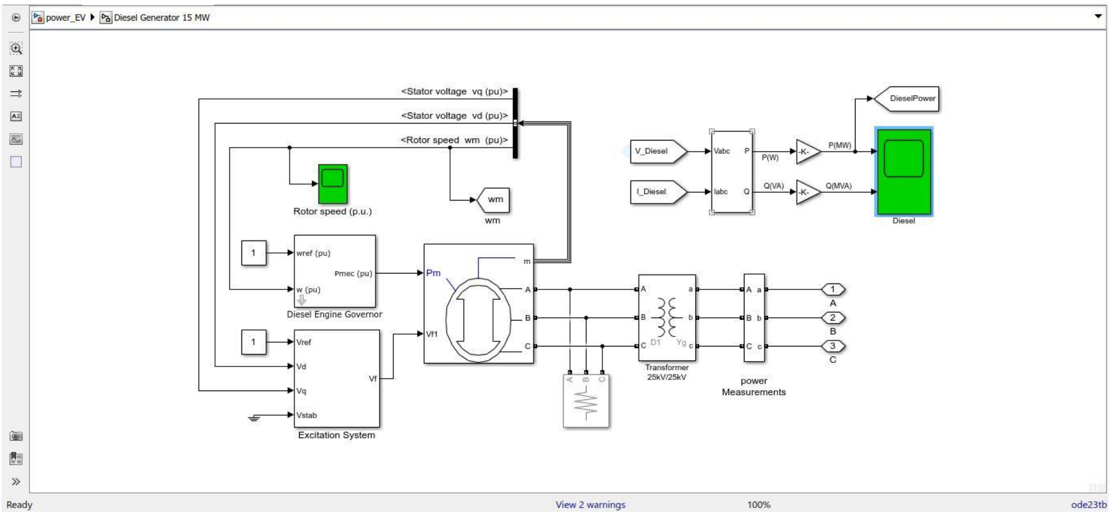


Figure 3 ; Diesel generator Simulink Model

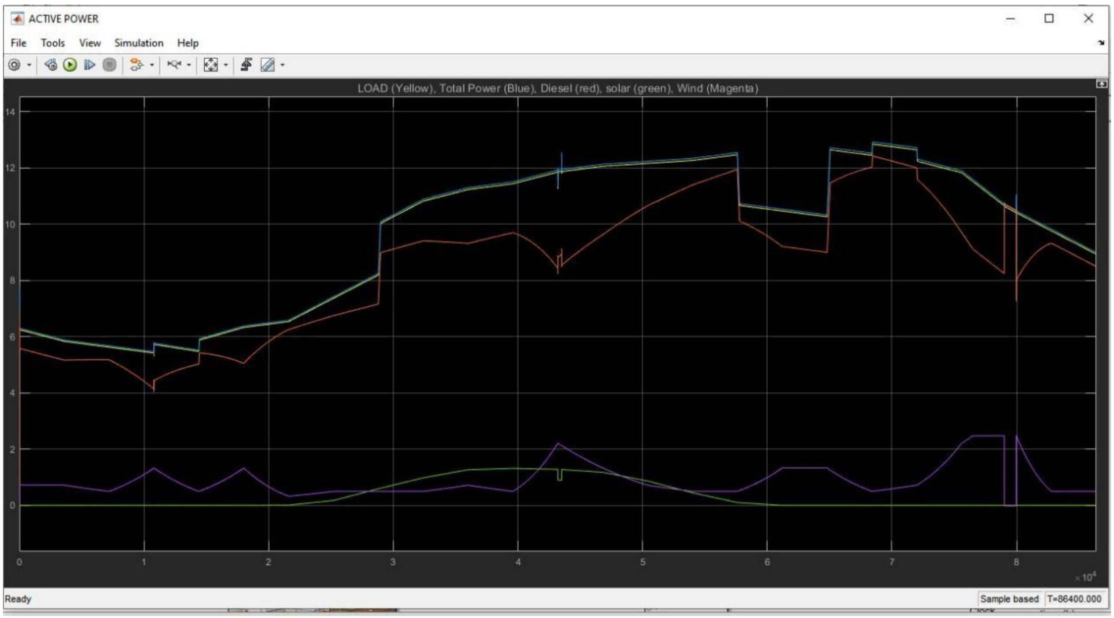


Figure 4; Active Power Of Simulink Model

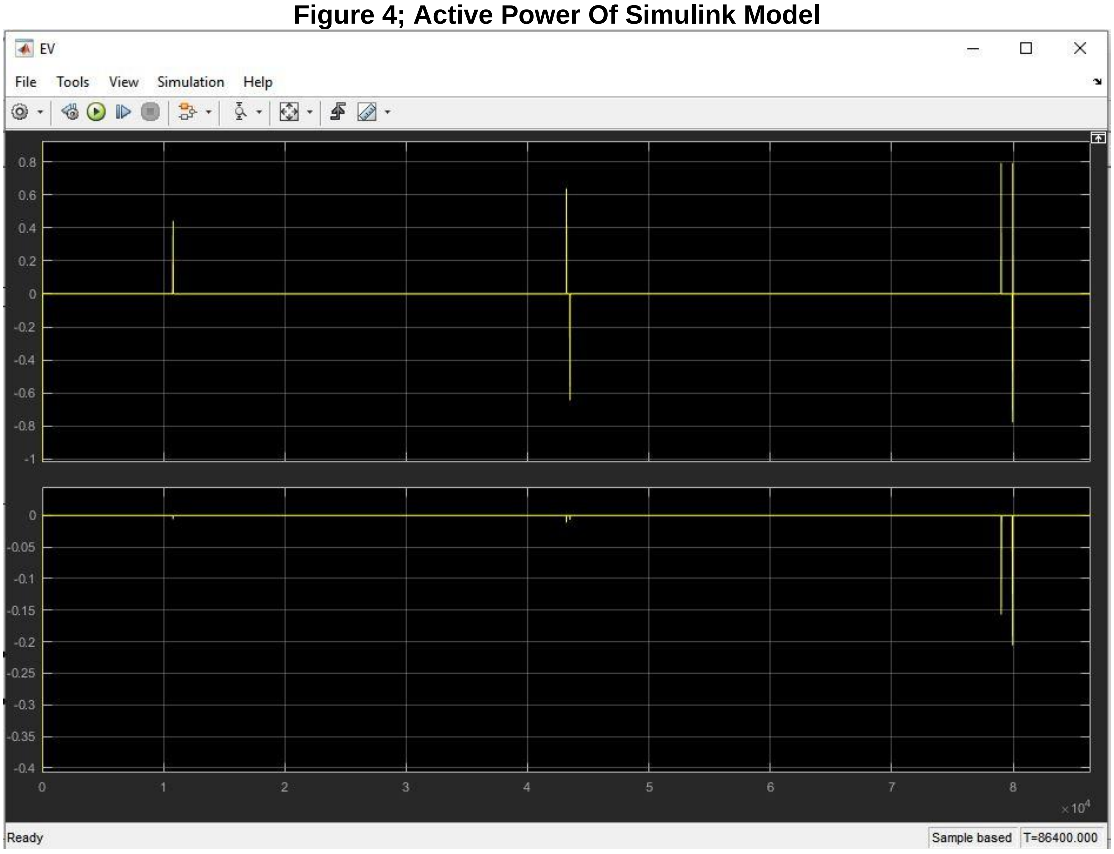


Figure 5 ; Electric Vehicle Simulation

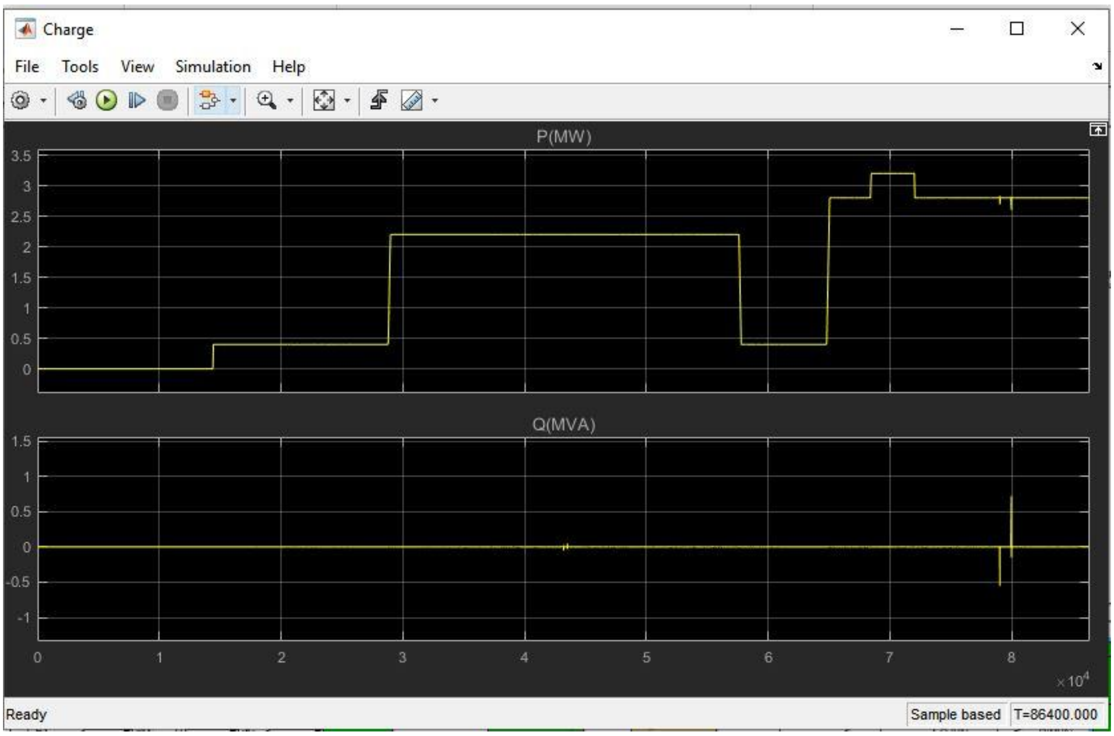


Figure 6; Charging Simulation in MW and MVA

The following code was added to simulink Modelling Workspace to achieve the obtained results from potential changes ;

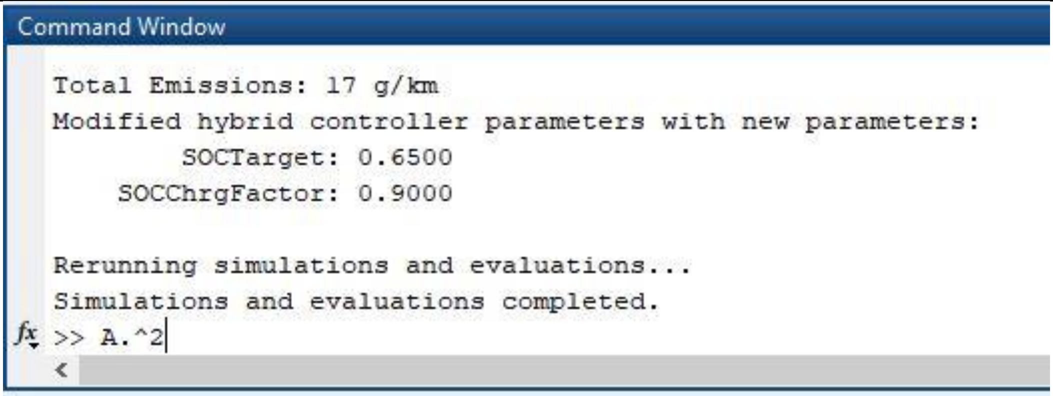
Code

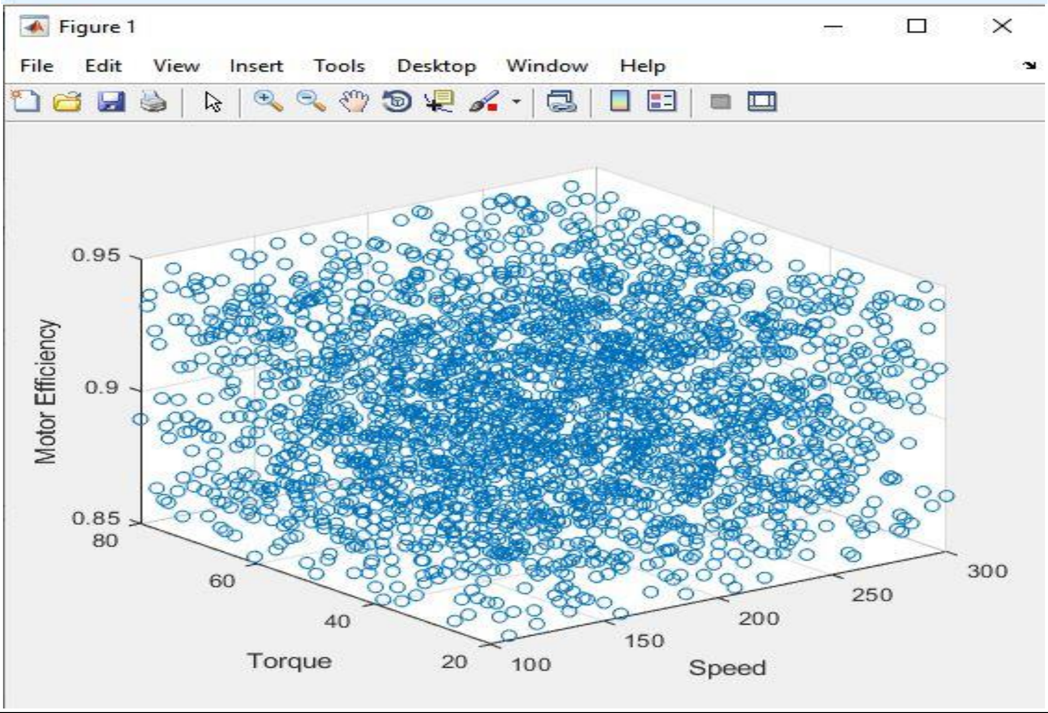
```
% Given parameters
VehMass = 1100; % Vehicle mass in kg
Area = 1.9; % Vehicle frontal area in m²
CD = 0.3; % Drag coefficient
Tamb = 25; % Ambient temperature in °C

% Additional parameters
VehMass_additional = 870; % Additional vehicle mass in kg
Area_additional = 1.75; % Additional vehicle frontal area in m²
CD_additional = 0.28; % Additional drag coefficient
Tamb_additional = 30; % Additional ambient temperature in °C
WheelRadius = 0.33; % Wheel radius in meters
DifferentialGearRatio = 3; % Differential gear ratio
MotorDriveGearRatio = 2.5; % Motor to drive gear ratio

% Update existing parameters with additional values
VehMass = VehMass + VehMass_additional;
Area = Area + Area_additional;
CD = (CD + CD_additional) / 2; % Taking average of existing and
additional CD
Tamb = (Tamb + Tamb_additional) / 2; % Taking average of existing and
additional Tamb

% Gearing and Performance (rest of the parameters remain unchanged)
Gradient = 0.08; % Representing 8%
Acceleration = 7.2; % seconds for 0-100 km/h
```

```
% Price Values (rest of the parameters remain unchanged)
PriceElectricity = 0.5; % $/kWh
PriceFuel = 1.49; % $ per unit

% Top Speed (rest of the parameters remain unchanged)
TopSpeed = 130; % km/h



speed_range = linspace(100, 300, 50); % Speed range
torque_range = linspace(20, 80, 50);  % Torque range
[motorSpeed, motorTorque] = meshgrid(speed_range, torque_range);
motorEfficiency = 0.85 + rand(size(motorSpeed)) * 0.1; % Placeholder
efficiency values (randomized)

% Save the motor efficiency map to a file
save('motor_efficiency_map.mat', 'motorSpeed', 'motorTorque',
'motorEfficiency');

% Load the motor efficiency map from the saved file
load('motor_efficiency_map.mat');

% Plot motor efficiency against speed and torque
scatter3(motorSpeed(:), motorTorque(:), motorEfficiency(:));
xlabel('Speed');
ylabel('Torque');
zlabel('Motor Efficiency');


% Placeholder engine parameters
bsfc = 200; % Placeholder brake-specific fuel consumption in g/kWh
nox = 10;   % Placeholder NOx emissions in g/km
hc = 5;     % Placeholder HC emissions in g/km
co = 2;     % Placeholder CO emissions in g/km

% Analysis based on engine parameters
% Perform calculations or analysis based on the engine parameters
(bsfc, nox, hc, co)
% For instance, calculate the total emissions or any other relevant
analysis
totalEmissions = nox + hc + co;
disp(['Total Emissions: ', num2str(totalEmissions), ' g/km']);


% Sample values based on provided data
yourNewParameters = struct('SOCTarget', 0.65, 'SOCChrgFactor',
0.9); % Sample parameters

% Modify hybrid controller parameters
modifyHybridControllerParametersInSimulink(yourNewParameters);

% Re-run simulations and evaluations
rerunSimulationsAndEvaluations();

% Placeholder function to modify hybrid controller parameters in
Simulink
function modifyHybridControllerParametersInSimulink(newParameters)
```

```
    % Replace with code to modify hybrid controller parameters in the
Simulink model
    disp('Modified hybrid controller parameters with new
parameters:');
    disp(newParameters); % Sample display of new parameters
end

% Placeholder function to rerun simulations and evaluations
function rerunSimulationsAndEvaluations()
    % Replace with code to rerun simulations and evaluations
    disp('Rerunning simulations and evaluations...');
    % Placeholder code to run simulations and evaluations
    disp('Simulations and evaluations completed.'); % Sample message
end
```

Output





C3- Reflective Report

Through this coursework, delving into the simulation of hybrid electric vehicles provided captivating insights and significant personal growth. The project not only expanded my understanding of vehicle dynamics but also honed my problem-solving skills.

Discovering the intricacies of the hybrid vehicle model was intriguing. It shed light on the delicate interplay between various parameters affecting performance and emissions. Moreover, navigating the complexities of system optimization underscored the multifaceted nature of real-world problems. This process helped me appreciate the intricate balance between efficiency and emissions in vehicle design.

Challenges arose during parameter alignment and model calibration. Juggling multiple parameters demanded meticulous attention to detail, occasionally causing complexities in achieving a harmonious model representation. These moments, although challenging, were valuable learning experiences, teaching me patience and the importance of precision in system modeling.

The most significant learning moments stemmed from the integration of placeholder data. Manipulating controller parameters and observing system responses highlighted the direct impact of these adjustments on system behavior. This illuminated the pivotal role of controllers in hybrid systems, an invaluable lesson in system dynamics.

One crucial personal takeaway was the significance of iteration. Revisiting and refining parameters iteratively underscored the iterative nature of problem-solving, emphasizing the need for constant evaluation and improvement.

The realization of arriving at the final best solution was gradual, evolving as I incorporated actual values into the model. Witnessing the convergence of simulation outputs with real-world data instilled confidence in the model's accuracy.

Relating to real-world scenarios, the project mirrored the intricacies of hybrid vehicle optimization faced by automotive engineers. It illustrated the practical challenges in achieving optimal performance while minimizing emissions, aligning with contemporary environmental concerns.

Overall, milestones were mostly met, albeit with minor deviations due to the intricate nature of parameter alignment. Strengths in meticulous problem-solving emerged, while areas for improvement centered on enhancing efficiency in parameter convergence.

Approaching the problem anew, I'd focus on streamlining parameter alignment from the outset, leveraging early iteration for comprehensive data integration and swift convergence. Additionally, I'd emphasize a structured approach to ensure smoother transitions between placeholder and actual data, enhancing model accuracy from the onset.

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