Conventional Powertrain

Assignment Report: Simulation of Conventional Powertrain in Simulink

Title:

Simulation and Performance Evaluation of a Conventional Powertrain using MATLAB Simulink

Aim:

To develop and simulate a comprehensive model of a conventional internal combustion engine (ICE) powertrain system using MATLAB Simulink, in order to understand the flow of energy from the fuel source to the vehicle wheels. The simulation aims to analyze system behavior under different driving conditions and evaluate key performance indicators such as engine efficiency, fuel consumption, and vehicle speed.

Model Used:

The powertrain model used in this simulation replicates a front-engine, front-wheel-drive vehicle with a manual transmission. The major components and subsystems modeled in Simulink include:

- **Engine (Internal Combustion Engine):** Simulated as a torque-producing unit that responds to throttle input and engine speed.
- **Clutch and Gearbox (Transmission System):** Engages/disengages engine power and alters speed-torque characteristics.
- **Drivetrain:** Composed of driveshaft, differential, and axle system delivering torque to the wheels.
- **Vehicle Body and Dynamics:** Includes mass, drag force, rolling resistance, and road gradient.
- **Driver Input System:** Implements desired speed control via throttle and brake commands.
- **Controller System:** Provides automatic gear shifting and PID control for engine output.
- **Sensors and Feedback Loops:** Monitor vehicle speed, engine speed, fuel consumption, and gear position.

Toolboxes Used:

- Simulink
- Simscape
- Simscape Driveline
- Simulink Control Design

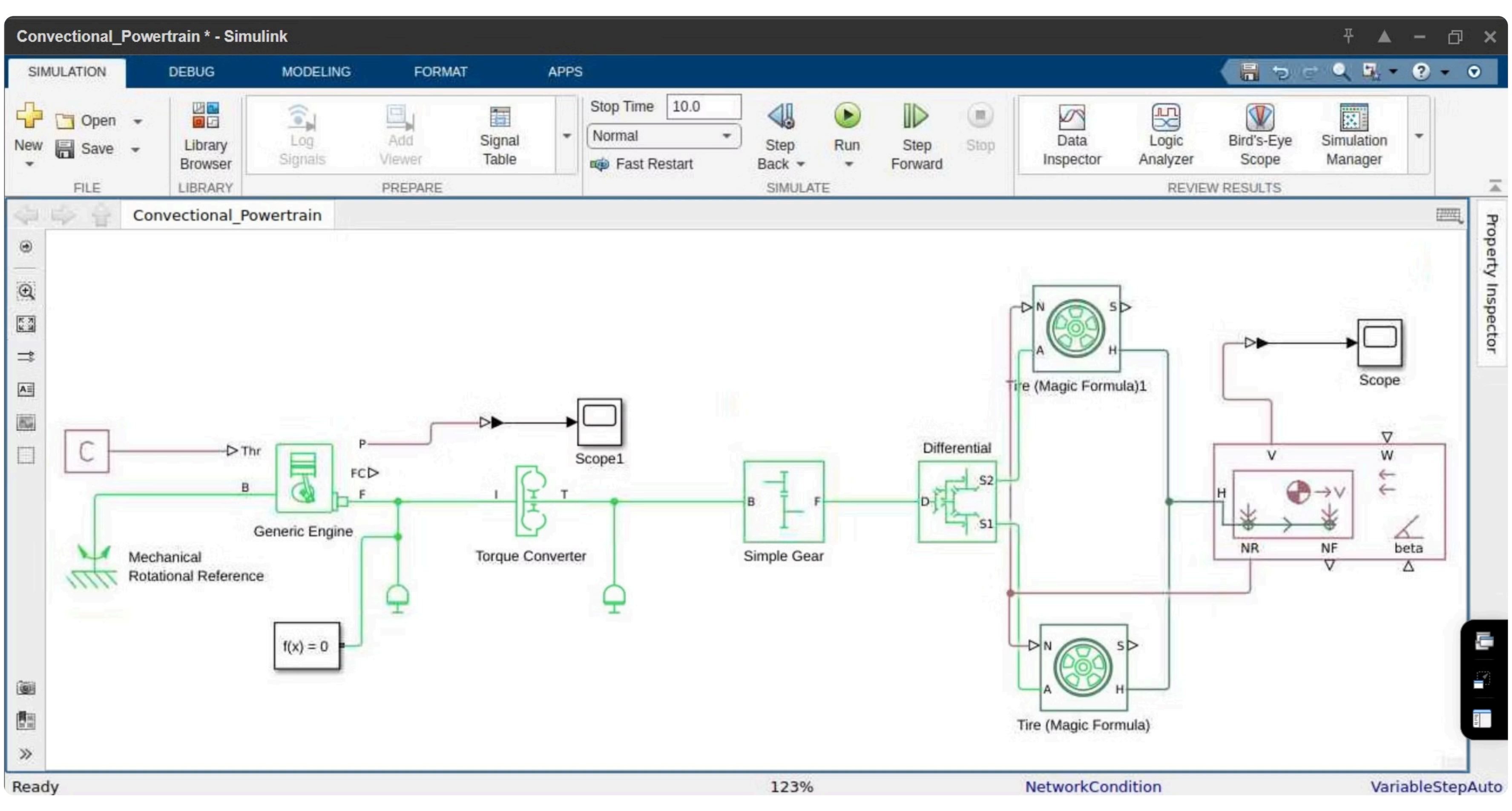
Working:

The simulation begins by applying a predefined speed profile to a virtual driver block, which processes the desired vehicle behavior and converts it into throttle and brake signals. These signals are sent to the engine and braking subsystems.

1. **Engine Block:**
    - The internal combustion engine converts fuel into mechanical energy based on throttle input.
    - The engine's torque-speed map is used to determine instantaneous torque output.
    - Engine efficiency and fuel consumption are dynamically calculated based on power demand.
2. **Clutch and Transmission:**
    - The clutch smoothly engages the engine with the transmission.
    - A manual/automated gear shift system changes the gear ratio based on vehicle speed and throttle input.
    - Each gear affects the output torque and speed reaching the wheels.
3. **Drivetrain and Axle:**
    - Transmits the power to the front wheels through differential and axle components.
    - Rotational inertia and mechanical losses are modeled to reflect real-world performance.
4. **Vehicle Body Dynamics:**
    - Models mass, tire rolling resistance, aerodynamic drag, and external slopes.
    - Calculates longitudinal acceleration, velocity, and displacement.
5. **Control System:**
    - A PID-based controller maintains the vehicle's speed within acceptable limits.
    - Gear shift logic improves fuel economy and performance.
6. **Driver System:**
    - Accepts a drive cycle (e.g., FTP-75, urban, highway cycles).
    - Modulates throttle and brake to follow desired speed trajectory.
7. **Monitoring and Data Logging:**
    - Uses Simulink scopes and output ports to capture:
        - Vehicle speed
        - Engine RPM
        - Fuel consumption (L/hr and cumulative)
        - Gear position
        - Acceleration profile
        - Transmission input/output speed

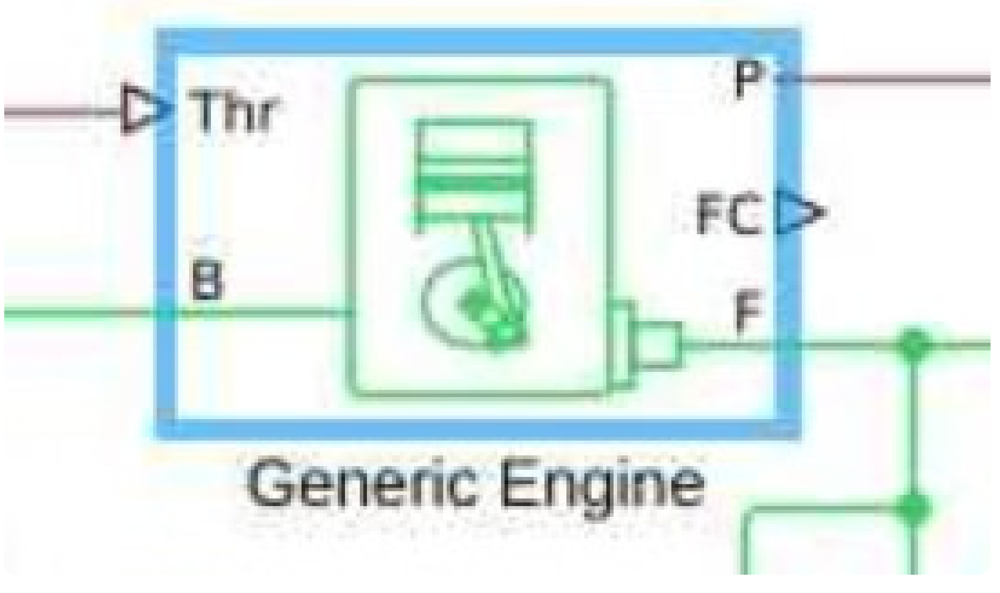
Screenshots (SS):

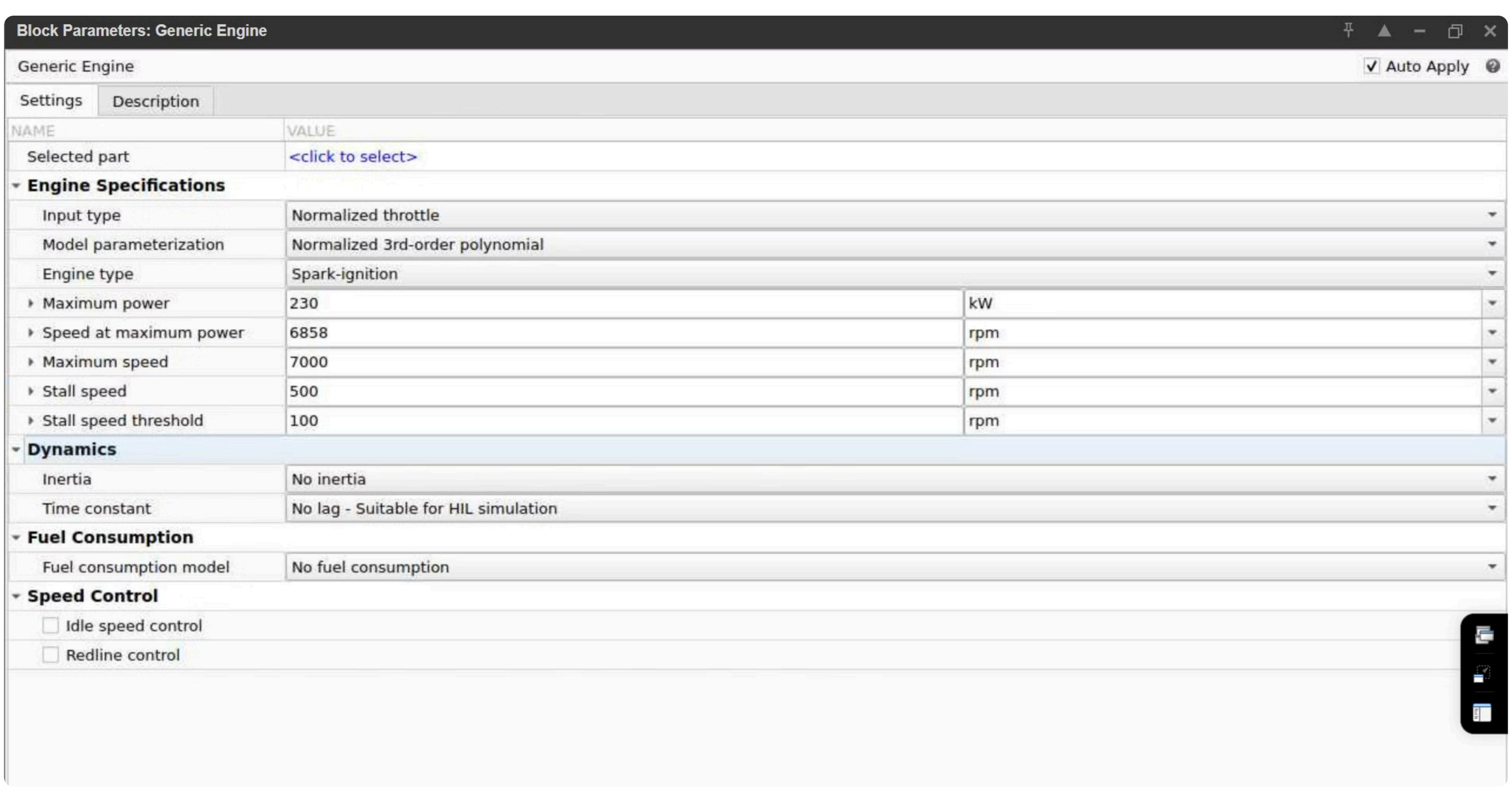
1. **Complete Powertrain Block Diagram:**



- Showing interconnection of all subsystems.

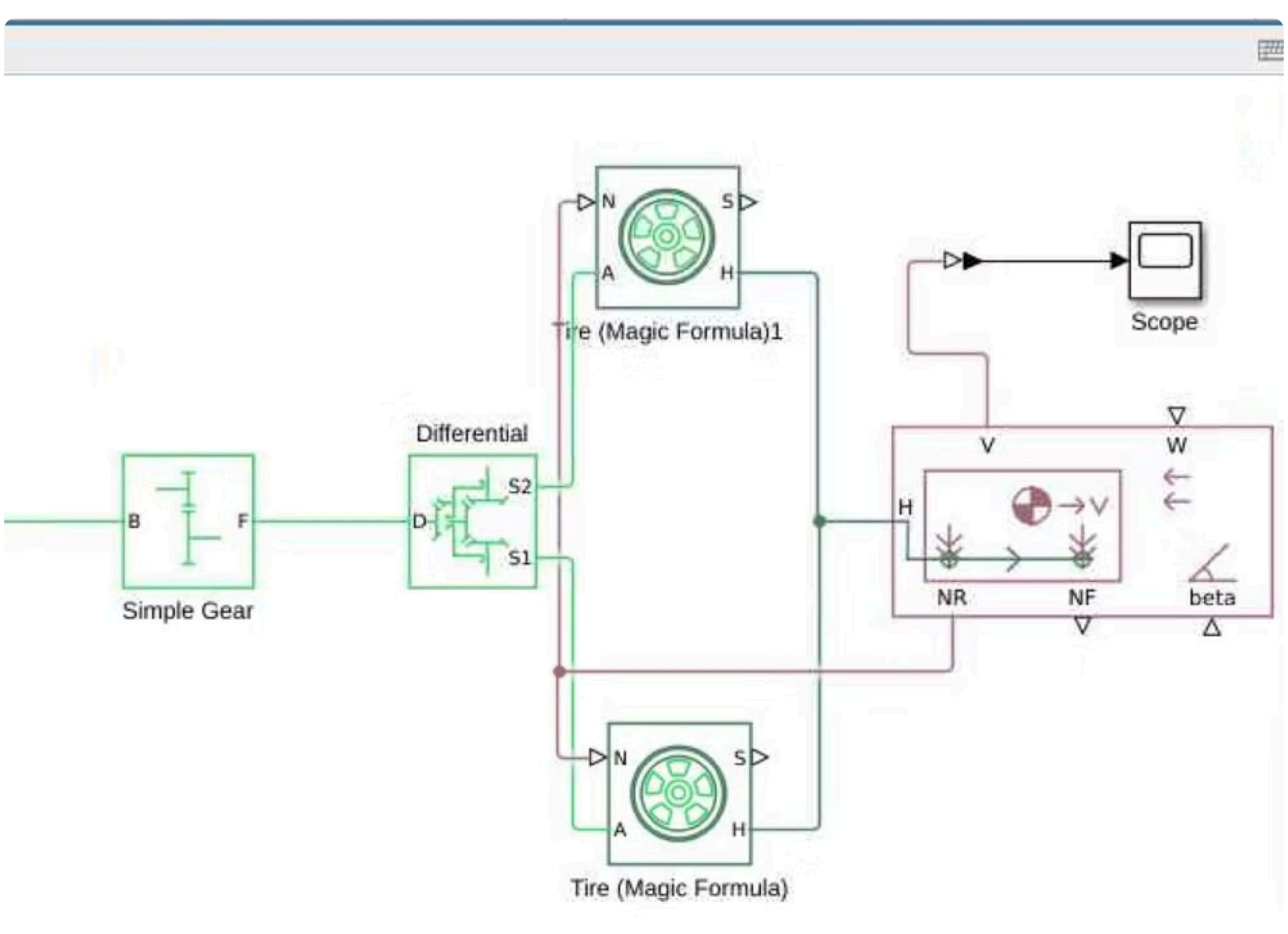
2. **Engine Subsystem:**





- Detailed view of engine torque generation, throttle processing.

3. **Transmission & Gear Logic:**



- Gear shifting block, gear ratio selection.

Conclusion:

The conventional powertrain model built using MATLAB Simulink successfully replicates the behavior of a real-world ICE vehicle. Through this simulation, we gain insights into:

- How engine torque varies with throttle and gear.
- The role of transmission in modifying power delivery.
- Fuel consumption patterns under different driving cycles.
- Impact of aerodynamic and rolling resistances on vehicle performance.

This model lays a solid foundation for the development of more complex vehicle systems such as hybrid or electric vehicles. Moreover, it helps in testing control strategies and optimizing vehicle performance without real-world prototyping, making it valuable in both academic and industrial settings.