

Multi-domain system modeling & simulation
using Amesim

An Active Suspension system with voltage generation from road profile input

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Introduction:

Vehicle dynamics is a crucial part of the vehicle performance and reliability. The robustness of the vehicle chassis contributes to the dynamic balance of the vehicle. Suspension system must support the ride handling and ride quality. Handling and quality are at odds with each other as there will be certain amount of trade-off between the two. It is always important for the suspension to keep the wheels in contact with the road for better handling.

An active suspension system is a reliable technique that uses sky-hook principle and controls the vertical movement of wheels relative to chassis and road surface. It uses actuators with effective damping that eliminates body roll and pitch variation during cornering, accelerating and braking.

An attempt is made in this assignment to model and simulate the suspension system with a proposed idea of generating potential due to the suspension action and road profile variation. The principle in the voltage generation involves controlled conversion of translational motion due to hydraulics to rotational motion which is coupled to the synchronous motor followed by potential voltage storage in the battery.

An Active Suspension system with voltage generation from road profile input

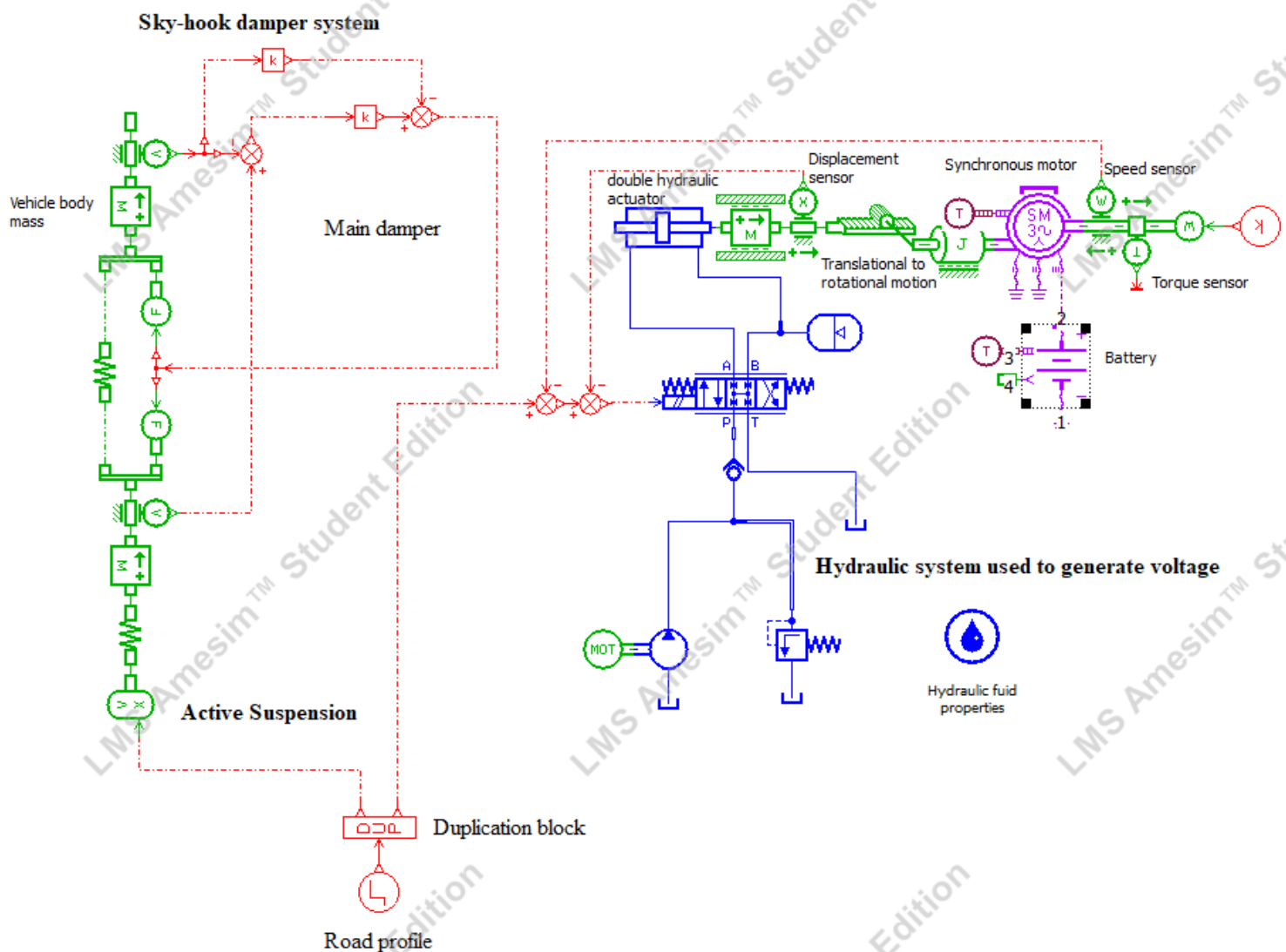


Fig 1: Multi-domain system model using LMS Amesim - student version

Mechatronics system design:

The mechatronics system design uses the damping system to neutralize the vehicle body pitch and roll. The velocity sensor sends a feedback to the damping system which acts as a closed feedback mechanism. The road profile acts as an input and is replicated using the duplication box. An auxiliary subsystem is created in the model above which uses this dynamic data and replicates the result in the hydraulic system. The hydraulic system includes a pump driven by the motor. The pressure relief valve controls the pressure in the system. The servo-valve takes input from the road-profile and controls the motion of double actuated hydraulic piston. The intermittent piston motion due to road profile input is used to convert the translational motion into rotational motion generating torque to drive the synchronous motor. The motor then creates an emf stored in the battery as voltage. This voltage stored in the battery can be used for the electricity consumption in the vehicle.

System Parameters:

The suspension system is the representation of quarter car, as four such systems are comprised in the vehicle. The body mass is 400kg as it is a quarter car suspension and the car is assumed to be at rest initially and hence the velocity and displacement is zero.

# AS Body velocity	0 m/s
# AS Body displacement	0 m
mass	400 kg
inclination (+90 port 1 lowest, -90 po...	-90 degree

The fluid properties used are the default values for the advanced fluid as provided by AmeSIM.

type of fluid properties	advanced
index of hydraulic fluid	0
temperature	40 degC
name of fluid	unnamed fluid
General properties	
density	850 kg/m**3
bulk modulus	17000 bar
slope of bulk modulus [bar] in fun...	0 null
absolute viscosity	51 cP
Aeration	
absolute viscosity of air/gas	0.02 cP
saturation pressure (for dissolved...	1000 bar
air/gas content	0.1 %
polytropic index for air/gas/vapor ...	1.4 null
Cavitation	
(advanced user) high saturated v...	-0.5 bar
(advanced user) low saturated va...	-0.6 bar
(advanced user) absolute viscosit...	0.02 cP
(advanced user) effective molecu...	200 null
(advanced user) air/gas density a...	1.2 kg/m**3

Battery properties are the default values for the vehicle with functional capacity of up to 94%.

number of cells in series in one branch	6
number of branches in parallel	1
nominal capacity	70 Ah
filtering capacitance	50 F
open circuit voltage [V] as a function ...	\$AME/libemd/data/BAT_Pb_ocv1cell.data
ohmic resistance [Ohm] as a function...	0.00225

Result:

The active suspension system results are as below:

The damping factor in the system shows that the vehicle stabilizes in a controlled manner as the road profile varies. The velocity and displacement graph shown below entails the variation of the velocity of the body mass depending on the body mass. The vertical displacement in the suspension system also varies in a controlled manner to provide better handling and ride quality.

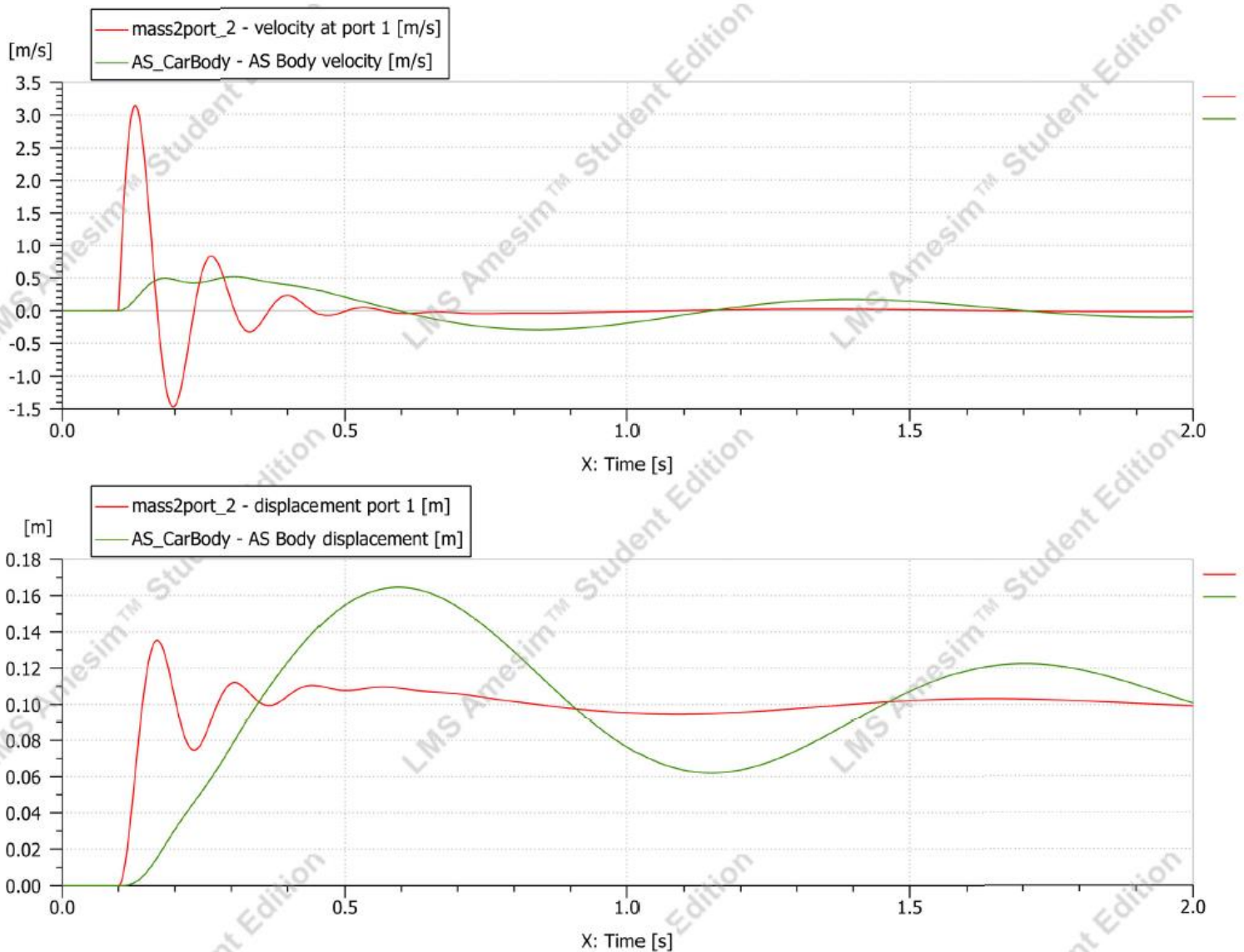


Fig 2: Velocity and displacement graph in the active suspension system

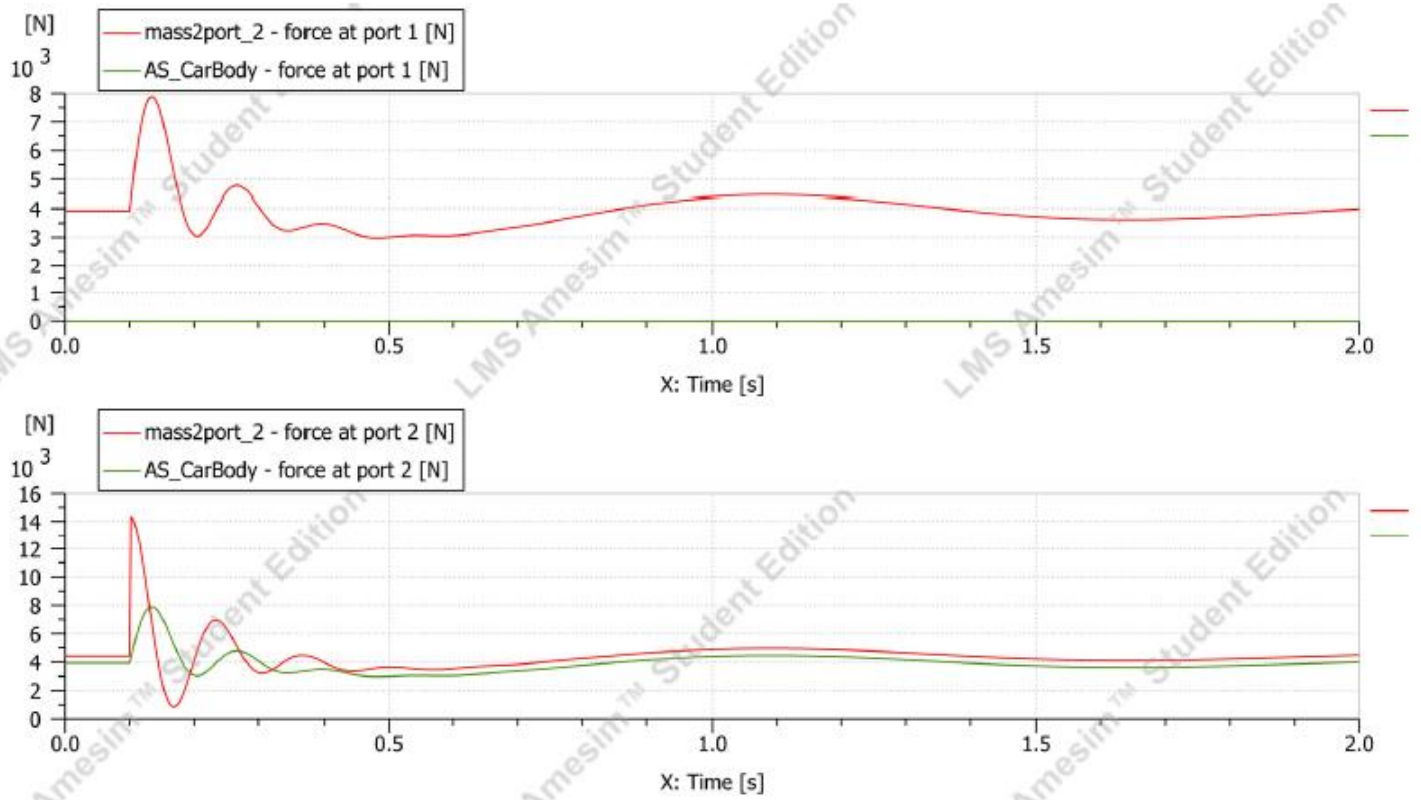


Fig 3: Force variation graph of car body in the active suspension system

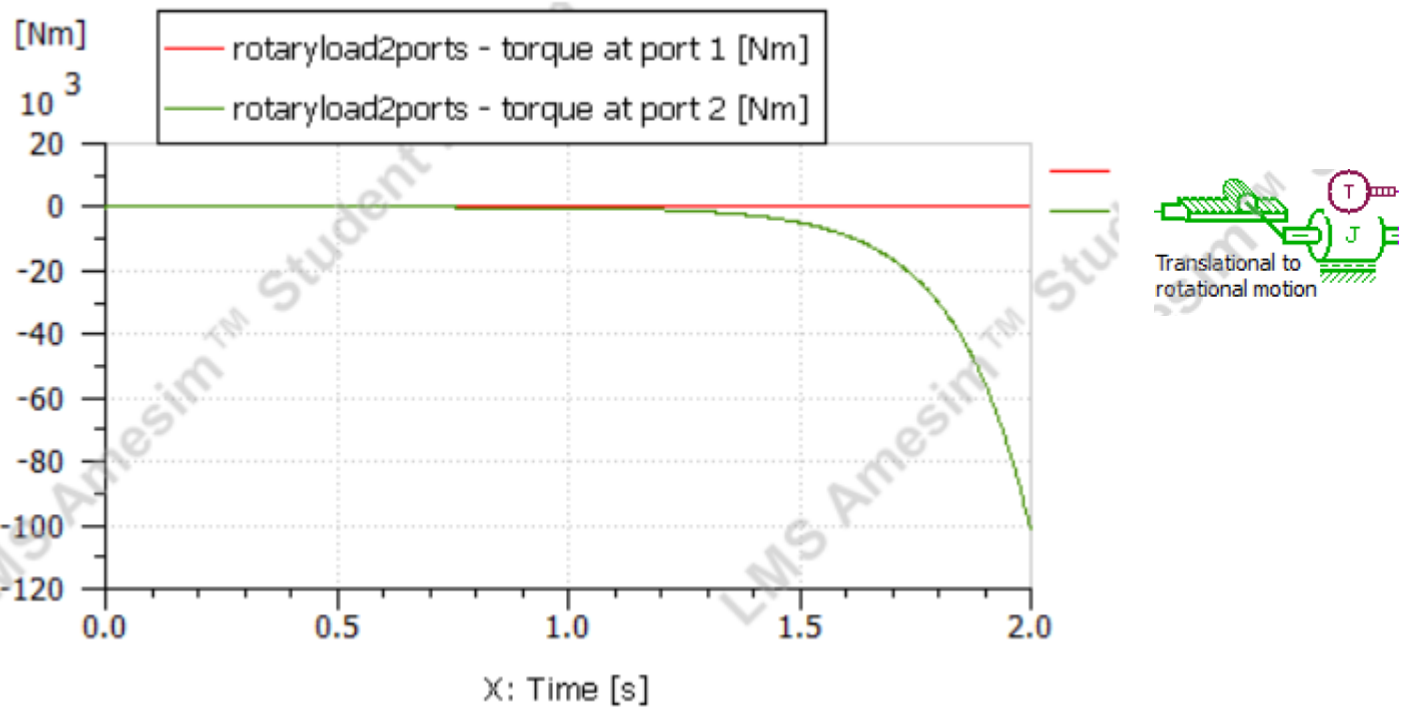


Fig 4: Torque at input and output port during conversion of translational to rotational motion

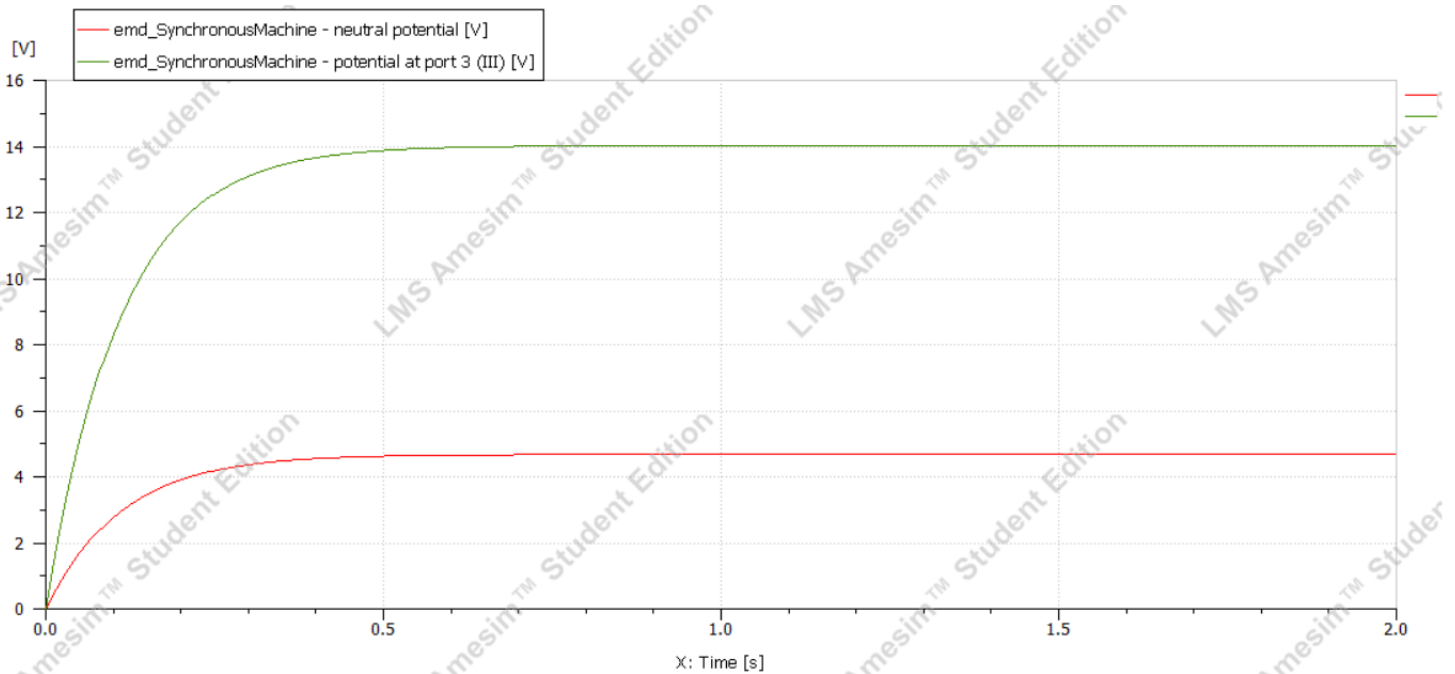
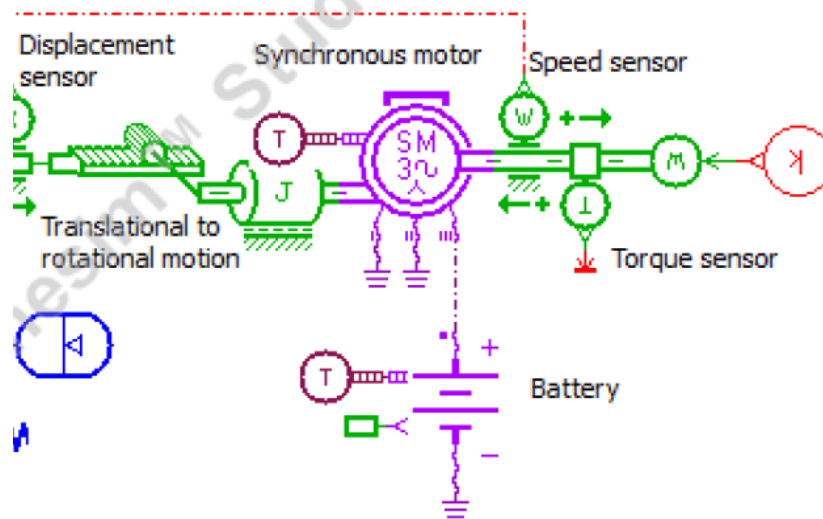


Fig 5: Potential generated and stored in the battery (14.0242 V)

Conclusion:

The multi-domain system developed is an effort to generate voltage while the vehicle suspension is activated. This is just an idea that has been replicated in the form of model and simulation. Further scope of improvements includes system refining with accurate sensor feedback mechanism. System properties with accurate values from the testing will give better result in the process. The model and simulation are a novel method of using the vehicle mass vertical movement to regenerate the potential which can be further used for accessories, infotainment, lights and charging power system in the vehicle.