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Simulink Model of a Regenerative Shock Absorber

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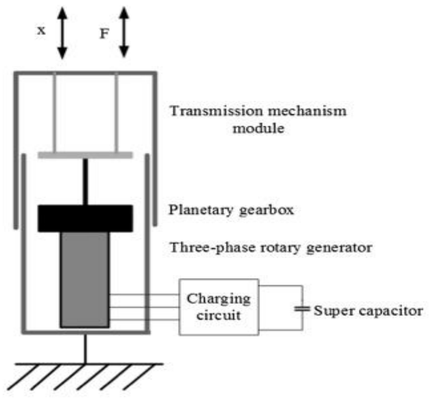
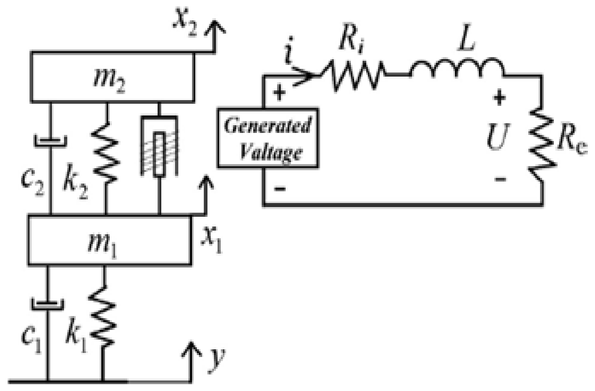
Abstract. In this paper the attention is focused on a Mechanical Regenerative Shock Absorber (MRSA), which converts its vibration - induced by the road roughness - in electrical energy. The vibration is transmitted to an electric generator through a mechanical component. The produced energy can be stored in a super capacitor for a future use. The paper proposes a Simulink-based model of this MRSA and compares the energy performance when the vehicle travels roads with different roughness, scientifically defined by means of the International Roughness Index (IRI).

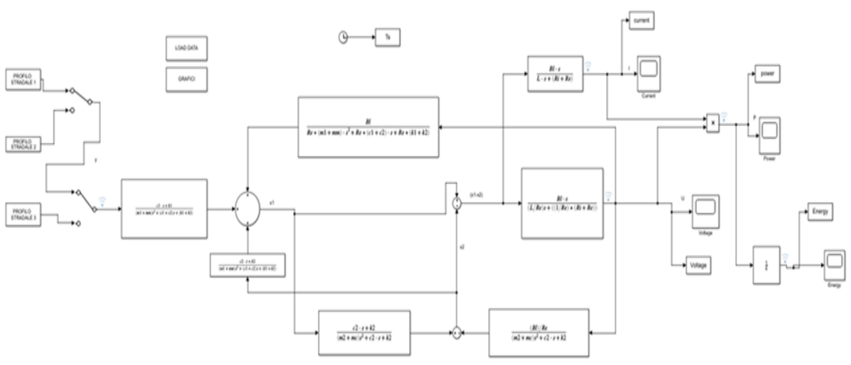
Scheme of MRSA ----- Quarter-car absorber and regenerative absorber





Mathematical and Simulink model --- IRI values

$$\begin{cases} (m_1 + m_m)\cdot\ddot{x_1} + (c_1 + c_2)\cdot\dot{x_1} - c_2\cdot\dot{x_2} + (k_1 + k_2)\cdot x_1 - k_2\cdot x_2 - c_1\cdot\dot{y} - k_1\cdot y - \dfrac{BlU}{R_e} = 0 \\ (m_2 + m_c)\cdot\ddot{x_2} + c_2\cdot(\dot{x_2} - \dot{x_1}) + k_2\cdot(x_2 - x_1) + \dfrac{BlU}{R_e} = 0 \\ Bl\cdot(\dot{x_1} - \dot{x_2}) - L\cdot\dfrac{\dot{U}}{R_e} - \dfrac{U}{R_e}\cdot(R_i + R_e) = 0 \end{cases}$$

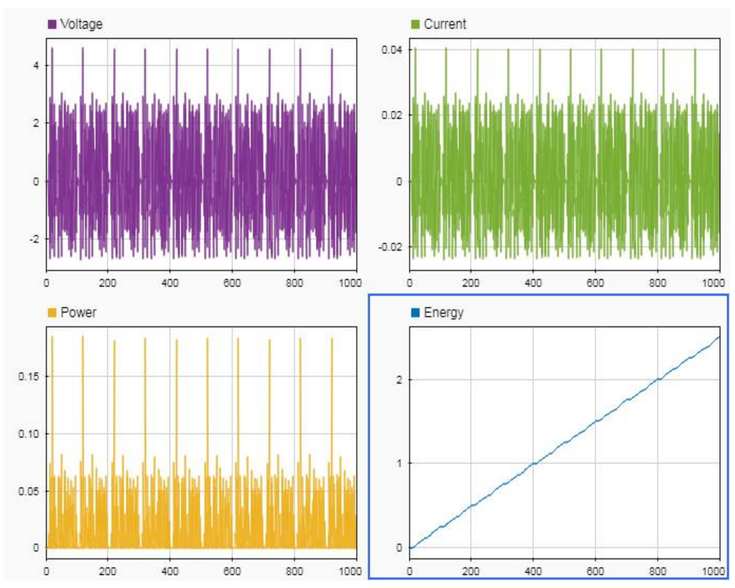


IRI for different roads		
	Parameter	Value
Highway	IRI	2 m/km
Old pavement	IRI	5 m/km
Rough road	IRI	11 m/km

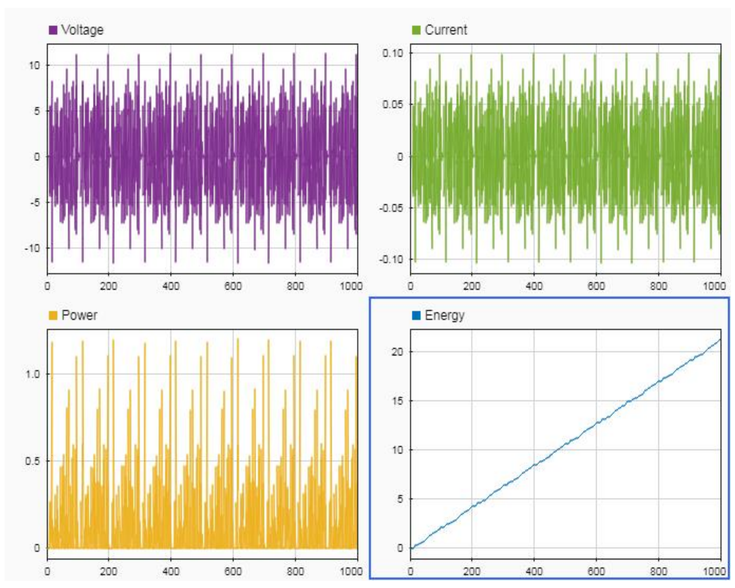
	Parameter	Value
Wheel assemly mass	m_1	40 kg
Quarter veichle mass	m_2	260 kg
Tyre stiffness	k_1	130.000 N/m
Supsension stiffness	k_2	26.000 N/m
Tyre damping	c_1	264.7 Ns/m
Absorber damping	c_2	520 Ns/m
Electromagnetic coupling	Bl	6.5Tm
Coil resistance	R_i	113Ω
Load resistance	R_e	113Ω
Coil inductance	L	94μΩ

Results

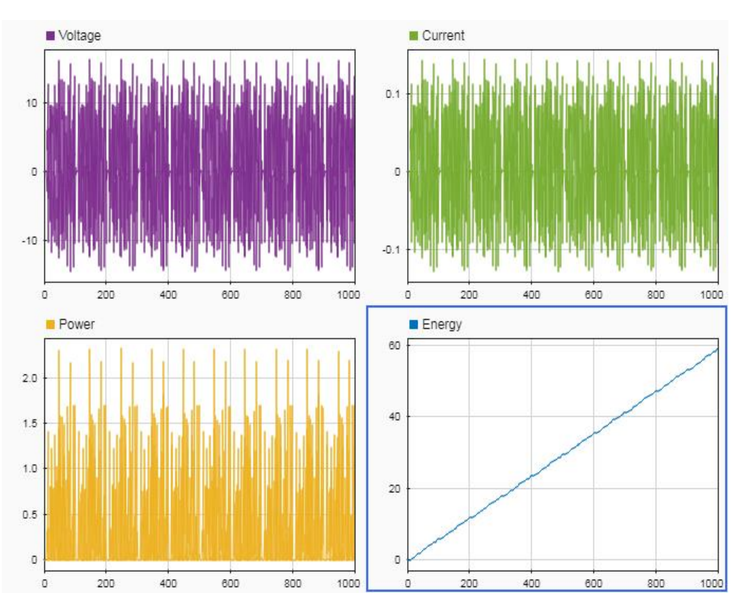
Highway: IRI = 2 m/km



Old pavement: IRI = 5 m/km



Rough road: IRI = 11 m/km



Comparison of the power and energy produced in the three cases

	Voltage[V]			Current [A]			Power [W]	Energy[Ws]
	Max	Min	RMS	Max	Min	RMS	Mean value	Max
Highway	4.573	-2,705	0.639	0.041	-0.024	0.006	0.004	2.507
Old pavement	11.193	-11.646	1.921	0.099	-0.103	0.017	0.032	21.247
Rough road	16.189	-14.456	3.208	0.143	-0.128	0.028	0.091	59.100

Conclusions

1. An electro-mechanical system that converts the vibrations, caused by the roughness of the road, into electrical energy, which, on its turn, supplies the electrical devices of the vehicle is discussed.
2. The proposed Simulink model considers the classification of the roads based on IRI, an index that measures the amount of roughness per km.
3. Three cases with different IRI values are studied: highway, old pavement and rough road. The latter one produces the maximum energy.
4. The proposed Simulink model can be used to study other mechanical solutions that double the inductive effect for a single vibration.