Self-Powered Dynamic Systems

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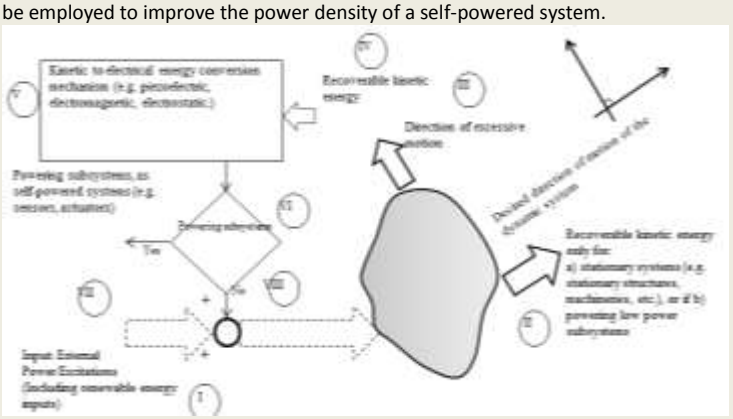
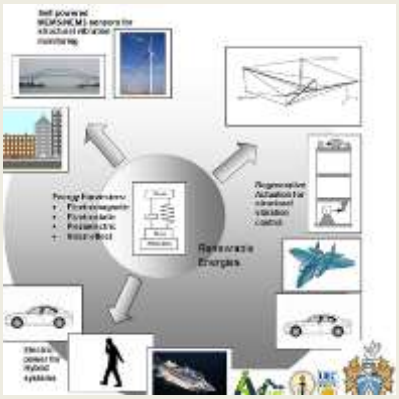
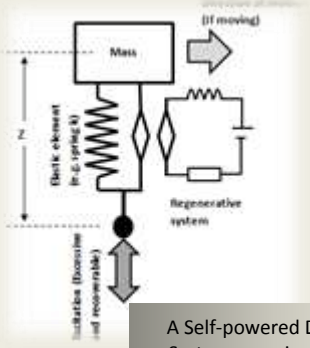
Abstract: A self-powered dynamic system [1]-[4] is defined as a dynamic system powered by its own excessive kinetic energy, renewable energy or a combination of both. The particular area of work is the concept of fully or partially self-powered dynamic systems requiring zero or reduced external energy inputs. The technologies explored can be associated with self-powered devices (e.g. sensors), regenerative actuators, and energy harvesting. The power produced by human motion can be considered as a potential energy input to mechanical devices. A fully solar powered air vehicle is an example of a self-sustained system. A bio-inspired design using biomimetics can be employed to improve the power density of a self-powered system.

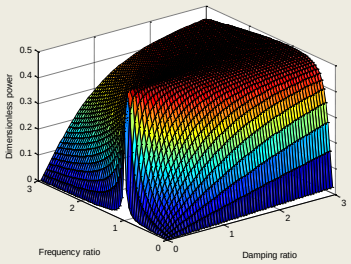






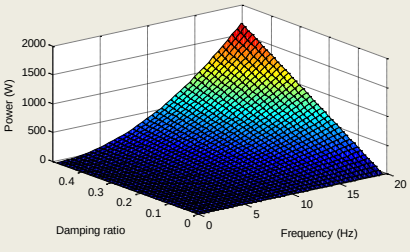
A Self-powered Dynamic System experimental rig

The combination of buoyancy and solar energy make this UAV more energy efficient than similar size vehicles for various duty cycles and operations



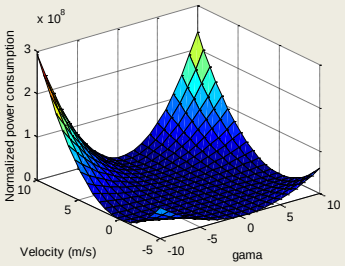
$$P_d = \frac{P}{m\omega^3 Y Z_{max}} = \frac{\zeta.\eta}{\sqrt{(1-\eta^2)^2 + (2\zeta\eta)^2}}$$

Dimensionless power versus frequency ratio and damping ratio



$$P = \frac{cm\omega^4 Y Z_{max}}{2\sqrt{(k-\omega^2 m)^2 + c^2\omega^2}}$$

Harvested power versus frequency and damping ratio



$$P_c = V_p i = \left(\frac{\tau F + k_a \dot{z}}{k_a}\right)\frac{F}{k_a}$$

Power consumption and power generation by a regenerative system

References:
[1] Self-Powered Dynamic Systems, Farbod Khoshnoud, David Dell, Y.K. Chen, R.K. Calay, Houman Owhadi, Clarence W. de Silva. Munich: Aeronautics and Space Sciences, 1-5 July 2013.
[2] Energy harvesting from suspension systems using regenerative force actuators. Farbod Khoshnoud, D. B. Sundar, N. M. Badi, Y. K. Chen, R. K. Calay and Clarence W. de Silva. s.l. : International Journal of Vehicle Noise and Vibration, 2013.
[3] Energy regeneration from suspension dynamic modes and self-powered actuation, pitch and roll modes of vibrations. Farbod Khoshnoud, Y. Zhang, R. Shimura, A. Shahba, Y.K. Chen and Clarence W. de Silva. IEEE/ASME Transaction on Mechatronics, 2015.
[4] Farbod Khoshnoud, Clarence W. De Silva, et al., Mechatronics: Fundamentals and Applications, (Chapter 6: Self-powered and Biologically Inspired Dynamic Systems), Taylor & Francis / CRC Press, 2015.