

MEMS INERTIAL POWER GENERATORS

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To avoid battery replacement or recharging in mobile or autonomous devices, methods for parasitic energy extraction from the environment are very attractive. MEMS solutions are of particular interest where space is constrained, e.g. in medical applications, and MEMS inertial generators are receiving increasing interest. These devices are driven by motion or vibration of the “host” structure, and typically use a proof mass mounted within a frame on a spring suspension, with energy extracted by an electric damping mechanism which may be electromagnetic, electrostatic or piezoelectric. Most MEMS generators reported elsewhere have been mechanically resonant structures; for this reason they are not well suited to the low frequencies of human powered applications.

At Imperial College we have pioneered a new device type using nonlinear, intermittent motion, which we call a Coulomb-force parametric generator. This device has a 3-layer construction, in which the central layer contains a silicon proof mass, forming one plate of a variable capacitor. At its lowest position, where the variable capacitance is maximum, this moving plate contacts charging studs on the lower plate. Application of a charging voltage creates a holding force between the moving and fixed plate. When the acceleration reaches a sufficient level, the mass separates from the charging plate and is pulled across the gap at constant charge. As the capacitance drops, the voltage rises proportionally, so the stored energy ($CV^2/2$) increases by the ratio of the initial to final capacitance. It then discharges into the load circuit. The device produces a net generated power of ~ 120 nJ per cycle, well above previously reported values for MEMS electrostatic generators, which are typically a few nJ/cycle or less.

This talk will introduce and compare the main variants of MEMS motion-scavenging generators, and describe fabrication and testing of our parametric device, including design of the required power processing circuitry. Future prospects for such generators will be discussed.

Professor Eric M. Yeatman graduated from Dalhousie University, Canada, with a B.Eng in engineering physics, and an M.Sc. in physics, in 1985 and 1986 respectively, and received his Ph.D. from Imperial College London in 1989. Since then he has been a member of academic staff in the college, acting as deputy head of the Optical and Semiconductor Devices Group since 1996. He has published around 90 papers on integrated optics, MEMS and ultrasonics, and several patents, and is co-founder and chairman of Microsaic Systems Ltd., a MEMS product development company spun-out of Imperial College. His current research interests are in radio frequency and photonic MEMS devices, and energy scavenging for wireless sensor nodes.