Energy Harvesting for Automotive Applications

Energy harvesters do not necessarily make sense in all potential applications where a battery is replaced. Battery technology is continuously advancing and due to volumes achieved, the price points reached are at levels where harvesters cannot compete. That is not always the case though as, energy harvesting is well fitted to niche markets where battery replacement is not an option. Continuous operation of sensors or operation in inaccessible environments makes it cost intensive or even impossible to replace drained batteries.

Autonomous wireless sensors at IMEC
The approach at IMEC is tackling the issue from both the energy consumption side as well as the energy generation side. On the energy consumption side, IMEC is developing micro-modules that consume minimal amounts of energy. On the energy generation front, the approach is to develop micro-machined energy harvesters in combination with an energy storage component. Their autonomy will allow such wireless sensors to operate for an almost indefinite time without worries of battery charging or connection to a power grid.

Micro-machined energy harvesters
A micro-sized piezoelectric transducer has so far shown the best result at IMEC. It consists of a cantilever with one or several piezoelectric layers sandwiched between metallic electrodes forming a capacitor. At the tip of the cantilever, a seismic mass captures the vibrations of the machine to which the harvester is attached.

IMEC's new vibration harvester consists of a piezoelectric capacitor formed by a Pt electrode, an AIN piezoelectric layer (initial versions used PZT), and a top Al electrode.

The resulting harvester delivers energy that has constantly been improving in the past few years of development. At the current level of output power, IMEC's harvesters are already powerful enough and are harvesting energy in meaningful frequencies in order to drive simple wireless sensors that intermittently transfer sensor readings to a master, which is the case in tyre pressure monitoring systems (TPMS) being developed at IMEC.

TPMSs are becoming standard on new vehicles. Specific issues that need to be dealt with in this type of application relate to the fact that a vibration harvester needs to be optimized to a vibration that is available at most speeds. Also, the modules must withstand shocks of several 100g which calls for extremely reliable sensors and components.

Thermoelectric Generators for Vehicles

Thermoelectric energy harvesting has never received accolades for its efficiency (its theoretical maximum is over 20% although nothing more than a few percent has ever been achieved in practice). But in specific cases where adequately large temperature differentials are achieved, one can envisage adequate power outputs. An interesting example relevant to automobiles is harvesting waste heat at exhaust pipes, where temperatures can go up to a few hundred degrees.

Thus, recovery of waste heat using thermoelectric generators (TEGs) is another interesting application in the automotive environment, with work undertaken on this field by companies like Volkswagen and BMW. BMW developed a prototype vehicle with a TEG in 2007 with a power output of 200W and demonstrated a 300W TEG in 2009. This year, a 500W TEG will be shown in a BMW X6 prototype within a project funded by the US Department of Energy. BMW took the lead in developing TEGs for automotive application together with various development partners from industry and research (e.g. NASA-JPL) Also in 2009 Volkswagen developed a TEG that claimed a 300W output during driving on a motorway, leading to reduced mechanical load and fuel consumption reduced by 5%.

Researchers from the Berner Fachhochschule and EMPA, a Swiss research and services group, are developing a thermoelectric generator for vehicle waste heat recovery that is integrated in the muffler, rather than being installed as a separate TEG unit on the exhaust line.

This type of technology would also make sense in hybrid cars, that combine an internal combustion engine and an electric motor, but the lack of an internal combustion engine in fully electric vehicles makes this type of technology

incompatible, the temperature differences in an EV are nowhere near as high as at the site of the exhaust.

For more information on the integration of energy harvesters in automobiles, don't miss the opportunity to attend Energy Harvesting Europe in Munich, Germany, on the 21st and 22nd of June 2011. A demonstration of the BMW TEG on an engine as well as presentations from IMEC, the Eindhoven University of Technology and progress with thermoelectrics and vibration harvesting from Marlow Industries and the Fraunhofer IKTS are just some of the highlights of the event.

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