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INTEGRATION OF ENERGY HARVESTING SYSTEMS

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Figure 1: Installation of tracking modules with Energy Harvesting power supply on railway containers

Figure 3: BlueTEG sensor with thermoelectric power supply

OVERVIEW

Electronic circuits and systems have to be powered with electrical energy. This energy is usually provided with a power cord from the grid or is stored in batteries in the device, which have to be recharged from time to time. This limits the mobility of the user or causes installation or maintenance costs. The technology of Energy Harvesting converts ambient energy like heat, light or motion into electrical energy to supply electronic devices. This way, operation and standby times can be increased or even be unlimited. Shrinking the battery size or even removing it completely is a further cost-saving benefit of Energy Harvesting power supplies. Using typical energy sources which are present in the natural environment, several hundred microwatts up to some milliwatts of electrical energy can be generated from one cubic centimeter size of an Energy Harvesting transducer.
Typical application devices for this kind of power supplies are low-power sensors, actuators, micro controllers and wireless transceivers. Application fields are building automation, structural health and condition monitoring, logistics, consumer products and household appliances.

System Architecture

Figure 2 shows the block diagram of a generic Energy Harvesting powered device. Important functional components of self-powered systems are the energy transducer, energy storage element (like a battery or capacitor), power management unit and application module, represented by e.g. a sensor, an actuator and a wireless communication module.

Energy Transducer

Different kinds of transducers that are able to convert ambient energy into electrical energy became popular in recent years. The specific energy transducer to be used depends on the given application and the ambient energy available. Solar cells convert light into electrical energy. Plane areas with sufficient illumination and a proper orientation are required to achieve best performance. They are already available in flexible designs and at different prices and efficiencies. Thermoelectric generators use thermal gradients to provide electrical energy. Based on the Seebeck effect, they produce constant currents at very small voltages, depending on the temperature differences applied. Often heat sinks are required to maintain the thermal gradients. Kinetic harvesters based on the electrodynamic, electrostatic and piezoelectric principle use motion and vibration to provide electrical energy. Due to the specific form of energy, they produce pulse currents and need a rectifier circuit.

Power Management

One major challenge in Energy Harvesting arises from the very low output power delivered by the Energy Harvesting transducers in typical applications. The power management unit adapts the electrical energy obtained to the requirements of the application device or voltage storage element. This often means converting the voltage level or rectifying and filtering pulse currents. Special care must be taken in matching the internal resistance of the transducer and the power management or the load to maximize the harvested electrical energy. Besides passive matching, active techniques like maximum power point tracking (MPPT) and non-linear circuits can be used to achieve this goal with maximum efficiency. A major obstacle is the power consumption and start-up voltage of the power management unit itself. The storage element must not consume a significant part of the overall power available and save enough for the main application. With maximum efficiency of the power management unit, the energy transducer can be minimized allowing an optimized design in terms of volume and cost.

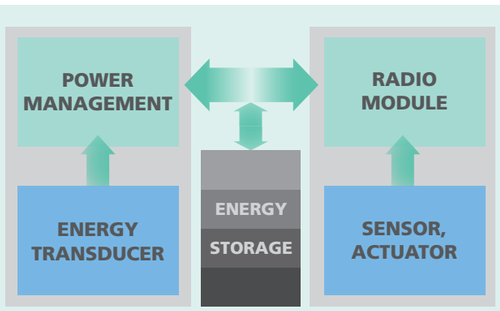

Figure 2: Block diagram of a generic Energy Harvesting device

Energy Storage

An energy storage element – battery or capacitor – is usually required in an Energy Harvesting power supply since ambient energy is variable and not always present. It permanently accumulates the available energy to power the application device, even if the device is powered-off for a given time period. Furthermore, if excessive power bursts are required, e.g. during application start-up or during transmission timeslots, they can be drawn out of this energy buffer. Numerous communication devices – like wireless transmitters – operate in time-division multiplex mode. Thus, high currents are required only for small periods of time and for the remaining longer standby periods power in the order of micro- or nanowatts is required to supply microcontrollers or timers.

Radio Module, Sensors and Actuators

Depending on the application and the sensors or actuators, various communication principles and standards are applicable. They differ in data rates, transmission range, and power consumption. Also, various sensors and actuators can be powered with Energy Harvesting. Typical examples measure temperature, light, oxide, gas, acceleration or moisture. Applications with actuators are door locks or heating valves. Sophisticated systems employ GPS modules or displays.

Special attention must be given to the power consumption, which can be reduced with the appropriate power management, shutting off the sensors or actuators in inactive times.

Application Areas

- Condition monitoring
- Structural health monitoring
- Home automation
- Logistics and security
- Smart wearables
- Consumer products
- Industrie 4.0
- Internet of Things

Advantages of Energy Harvesting Power Supplies

- Unlimited operation and standby times
- Shrinking or replacement of batteries
- No cable or connectors for power supply
- No installation or maintenance effort
- Supply of electronic system in inaccessible, remote locations
- High temperature range

SERVICES

- Technical consulting
- Feasibility and system studies
- Evaluation and characterization of devices
- Research and development projects
- Prototypes of power management circuits and Energy Harvesting systems
- Customizing and licensing of available components and modules