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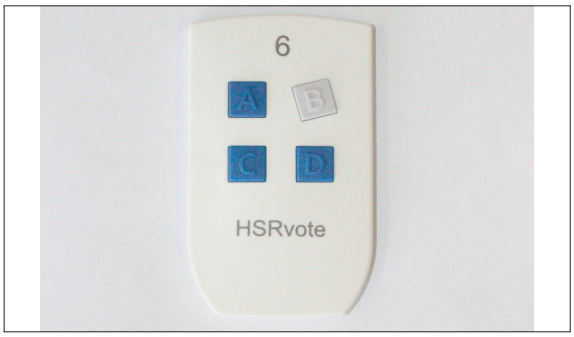
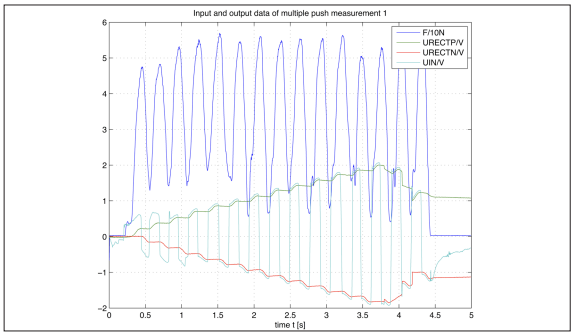
Subject Area	Mobilkommunikation

Energy Harvesting for HSRvote

Using the piezoelectric effect



The HSRvote



A plot of the charging and transmission process: input voltage (turquoise), buffered voltage (green – red), applied force (blue)

Introduction: There is a fast-spreading interest in the process of energy harvesting in contrast to centralized respectively localized power plants that generate large amounts of energy. Energy harvesting exploits the behaviour of a device operator or the device itself and stores small amounts of energy generated from kinetic, thermal, or any other ambient energy to operate a low power device. One possible way to transform kinetic into electrical energy is piezoelectricity. The piezoelectric effect is best known for its use in gas grills, camping stoves and lighters, where a great amount of force is generated by a mechanic shock which causes a deformation of the piezoelement. The element in turn accumulates an electrical charge, which is then used to ignite the gas. Another well-known application that uses the electromechanical effect in the reverse direction is the piezo buzzer which generates sound. This effect is mostly used in sirens and fire alarms.

Objective: The objective of this thesis is a high efficiency discrete circuit design that exploits the potential of piezoelectric energy harvesting to power a wireless radio frequency (RF) transceiver developed by the Institute for Communication Systems (ICOM), the HSRvote. The device is used for multiple choice tests or voting and has four buttons. It is desired that, by pushing either of these buttons, the energy that is necessary to start the controller and transmit the information to the receiver is generated and buffered. In addition to the energy supply, the buttons are still to be used as the source of information as to which button was pushed. In order to decrease the energy usage of the device, modifications of the software are also to be undertaken, but the controller is not to be replaced.

Result: Since the energy output of piezoelements is extremely small, it was essential that every element of the circuit lay in the nanopower range. Therefore a special self-supplying active rectification circuit was designed which implemented the function of diodes with far superior efficiency compared to conventional rectifiers. In order not to lose energy through the HSRvote before the desired upper threshold voltage in the storage capacitors was reached, a voltage supervisory circuit was designed. This system connects the HSRvote to the buffer capacitors as soon as a sufficient energy level is reached. Although integrated circuits that implement that very behaviour are available at a very low power level, this power level is unfortunately still too high for this application. Also a discrete implementation of a Schmitt-Trigger circuit was impossible on account of the very low and inconstant supply voltage of the necessary voltage reference. Fortunately, another design idea with a voltage divider and a self-locking Metal Oxide Semiconductor Field Effect Transistor (MOSFET) circuit could be implemented that requires much less energy and thus renders the circuit significantly more satisfactory in terms of efficiency. Even though the energy consumption of the device was able to be reduced by more than 30% by software modifications and the circuit, it was not possible to generate enough energy by a single push of a button. Nonetheless it was possible to transmit the information by repeatedly pushing the button until the desired threshold was reached. Still, this thesis and the results presented therein serve as a deep and fundamental insight into the subject for future research. It might very well be possible to power the device by the piezoelectric effect, although significant changes regarding the circuit are in order. Mainly the controller would have to be replaced by another device which requires a smaller energy supply, for example an MSP430 controller in combination with a designated RF transmitter. Additionally, the harvesting circuit would have to be implemented as an Application Specific Integrated Circuit (ASIC), which would need to be matched to the piezo source. By designing an ASIC, the behaviour of the circuit could notably be improved regarding its precision and efficiency, which is undoubtedly crucial for this remarkable application.