Poster: Exploring Energy Harvesting Possibilities in Embankment Dams

Axel Lundberg, William Järvström
Uppsala University
axel.lubg@gmail.com, mr.jarvstrom@gmail.com

Luca Mottola, Thiemo Voigt
Uppsala University and RISE Computer Science
luca.mottla@it.uu.se, thiemo.voigt@it.uu.se

Erik Westman
Vattenfall
erik.westman@vattenfall.com

1 Overview

Hydropower and dams play a vital role in the electricity supply in many countries in the world. For example, in Sweden hydropower stands for around 45% of the total produced electricity per year. Around 40% of all dams structures in Sweden are embankment dams [1].

Embankment dams are a type of eart-filled barrage that contains a layer of moraine, material left behind by a moving glacier, surrounded by rocks. Moraine exhibits waterproof properties and therefore holds the water back. However, as the moraine is not perfectly waterproof, some water always flows through it, washing away particles in the moraine. Therefore, the structural integrity of embankment dams must be constantly monitored. Of particular interest is the detection and quantification of moraine displacements. As the layer of moraine may be buried beneath rocks, it may be hard to examine the status of the moraine.

Ideally, the monitoring should be achieved remotely by sensors embedded within the moraine. Sensors installed inside a dam are, however, difficult to reach, hence battery-powered systems are not applicable. An alternative are systems that harvest energy from the environment. The most common energy source, solar radiation, is not viable for sensors embedded within a dam. Other harvesting sources [3] include temperature differences, vibrations and radio-frequency (RF). We argue RF harvesting may be the most viable option since sustained thermal gradients are hard to find in dams and vibrations in embankment dams are small. Dedicated RF transmitters may be placed outside the dam where there are no restrictions in size and power.

We devise an experimental setup based on standard components to explore the possibility of RF energy harvesting in dams, using materials similar to what embankment dams consist of, shown in Figure 1. We use a USRP B210 software defined radio with an RF amplifier of 33 dBm gain and an 868 MHz whip antenna with a gain of 3 dBi for generating and transmitting radio waves. We equip a P2110 Powerharvester Evaluation Board [2] with another 868 MHz whip antenna, also with a gain of 3 dBi. The P2110B is an RF energy harvesting device designed to convert RF to DC used by others as well [4, 5]. Our results indicate that an RF source with an output power of 33 dBm using standard antennas both at the transmitter and receiver is able to charge a capacitor through more than half a meter of materials similar to those in embankment dams.

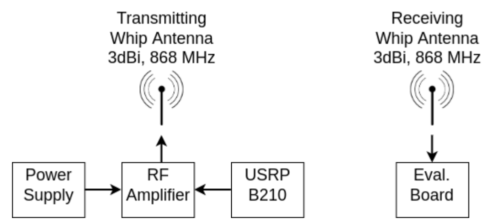

Figure 1: Harvesting system consisting of standard components

2 Results

We perform tests in a lab setting and in a real scenario. The two setups are different in that in the lab, RF propagation happens through the air, as opposed to the real scenario where that happens through some solid material.

Lab experiments. The purpose of the experiments is to verify the setup, that is, to confirm that we can generate enough RF power to charge a 1000 μF capacitor at a reasonable distance. This setup also helped explore the choice of different components before settling on the setup of Figure 1.

Figure 2 shows the results in terms of average harvested power and time to charge the capacitor. As expected, the average power that is harvested decreases exponentially with the distance. Consequently, the time required to charge the capacitor increases exponentially.

Real-world experiments. We investigate how much energy we can harvest within solid materials, as it would be in a dam. We select materials that are part of embankment dams, such as gravel and sand.

We use the setup of Figure 3. We 3D print a simple casing to protect the harvesting device. The casing has holes for the antenna connection and cables to connect the device to the external measurement circuit. We dig a 60 cm-deep hole, sufficient to fit the casing and the receiving antenna. The