Radio Frequency Energy Harvesting

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INTRODUCTION

Radio Frequency (RF) energy harvesting enables wireless power delivery to many electronic devices from a single source. Key components of this technology are the **antenna** and the **rectifying circuitry** that converts the RF signal into DC power. RF powered devices may be part of passive radio frequency identification (RFID) **[1]**, Wireless Sensor Networks (WSN) **[2]**, biomedical implants, Unmanned Aerial Vehicles (UAVs) **[3]**, smart meters, telemetry systems and may even be used to charge mobile phones.

A variety of different RF signal sources exist which are suitable for harvesting energy, such as Digital Video Broadcast (DVB), GSM downlinks, Medium Wave (MW) broadcast, Wi-Fi access points etc. (Fig.1).

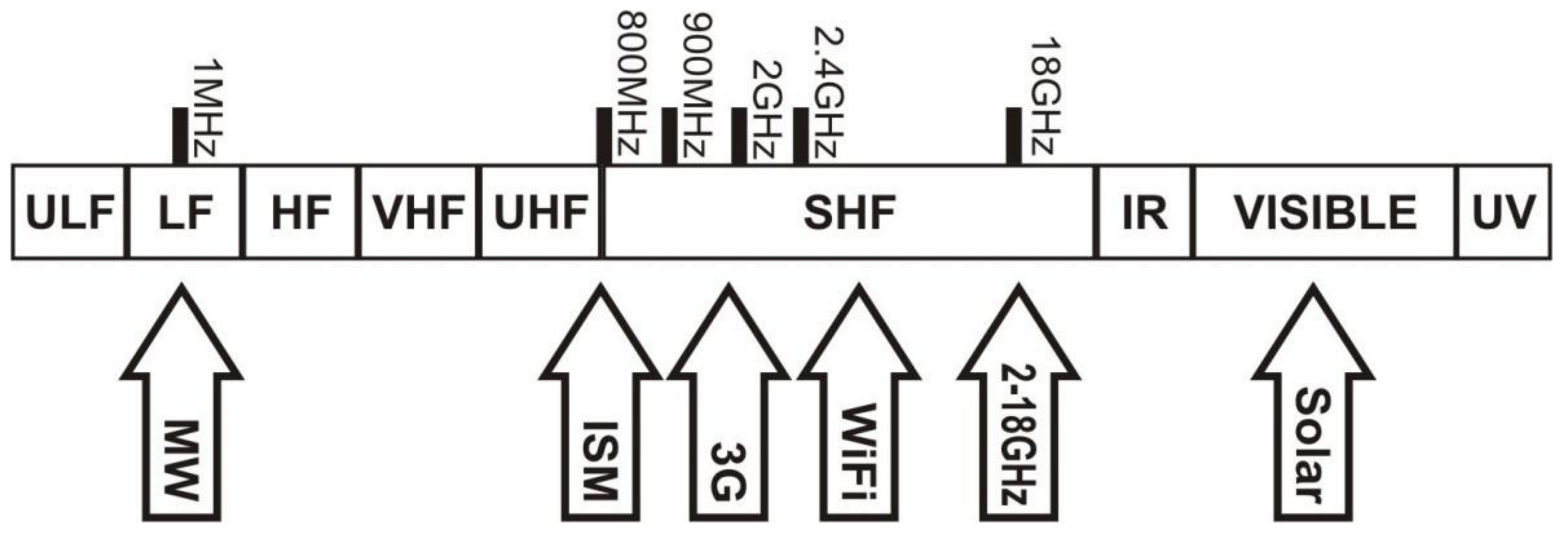

Fig.1. Sources of RF energy

RECTENNA DESIGN

A number of antenna designs for a range of frequencies bands have been simulated and created in order to investigate their suitability in real world conditions, (Fig.2). For RF harvesting, very low power levels are usually received and a precise matching of antenna impedance to input impedance of the rectifier is indispensable **[4]**. RF-to-DC conversion efficiency, or the ratio between harvested DC power and input RF power to the rectifier, is also very important for optimal power transmission.

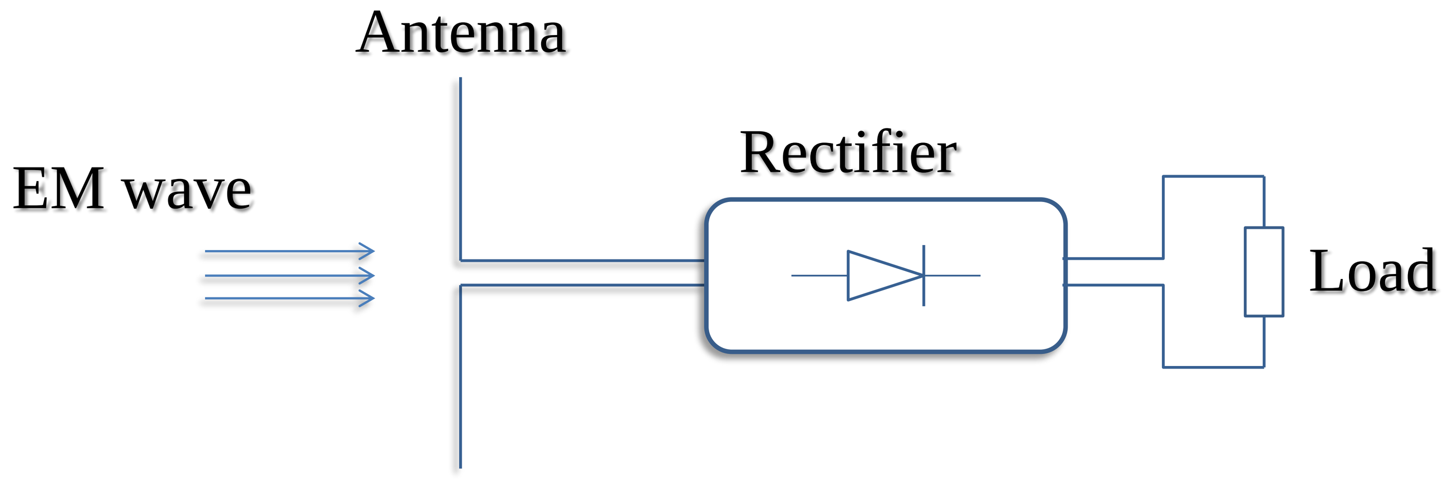

Fig.2. Key components of this technology are the antenna and the rectifying circuitry that converts the RF signal into DC power.

A detailed study on the effect of the nonlinear load with complex impedance that varies with frequency and input power level to overall efficiency has been conducted. Several approaches for increasing the efficiency of the rectenna has been proposed:

- Forming groups of phased antennas and combining their rectified DC voltages;
- Using several types of rectifiers optimised for different input levels;
- Choosing an efficient DC-DC converter capable of handling low input voltages (<<0.1V).

An example of a potentially useful RF energy source is VHF paging transmissions in the 150MHz band (in the UK). In this case, measuring the transmit duty cycle in the conventional way is not applicable for RF energy harvesting performance analyses. The bandwidth of a paging transmission is much smaller than the actual RF energy harvester's bandwidth, so we could use several paging transmissions in order to increase RF energy density (Fig.3).

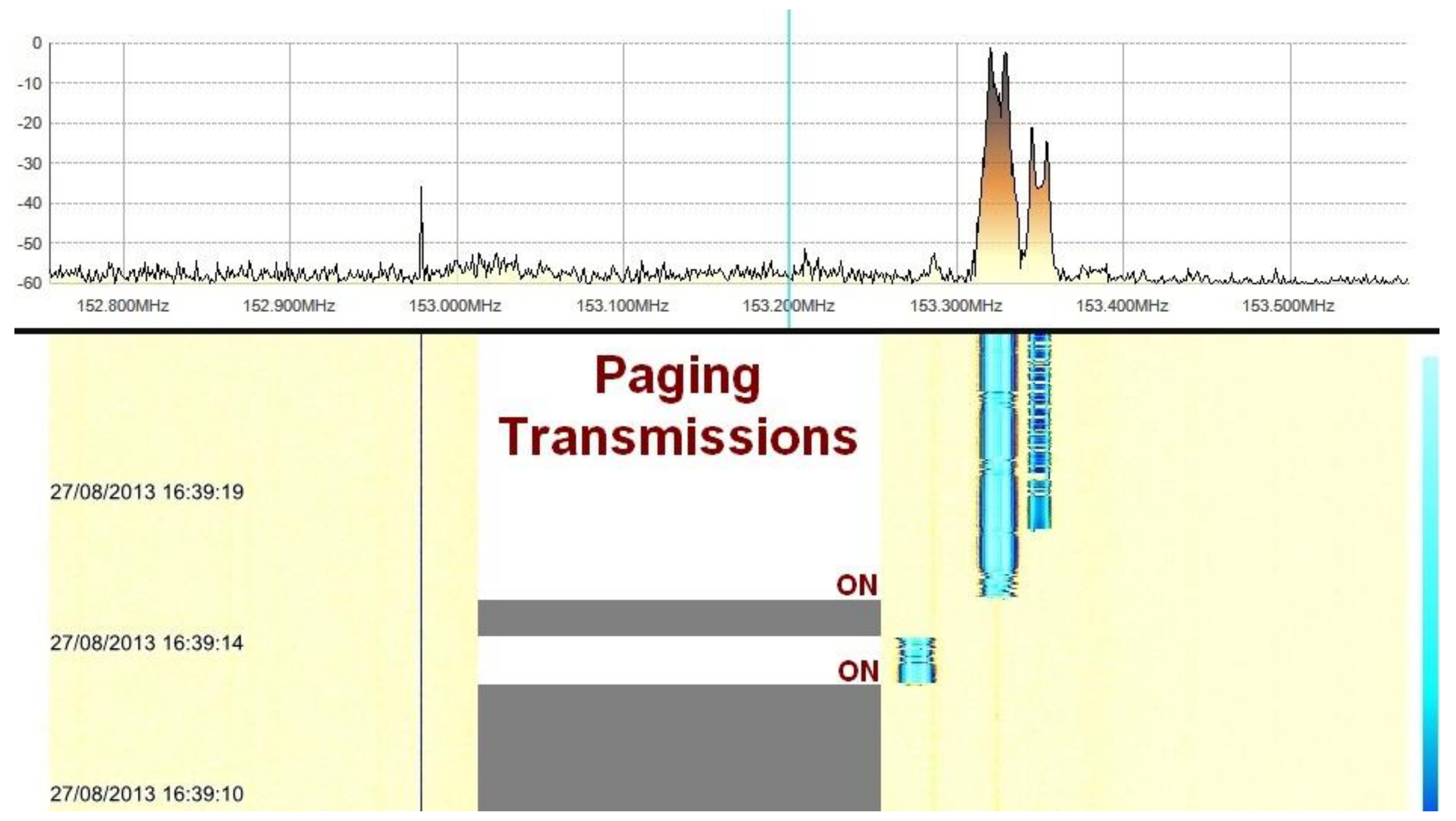

Fig.3. Spectrum and waterfall display of paging transmissions at the 153MHz band.

RECTIFIER DESIGN

Using diodes in the rectifier circuit is not an efficient method for RF-to-DC conversion. The maximum achieved efficiency levels are not more than 40% for input power of 10dBm, which is not suitable for rectenna design where the harvested energy rarely exceeds 0dBm. However, there are some very promising alternatives for rectification of such low level signals, such as Zero Drop Voltage rectifier.

Another way of optimising the rectification process is implementing a technique called Maximum Power Point Tracking (MPPT) in the rectenna. This method of improving the power efficiency is already popular in other energy harvesting methods, such as solar.

The next steps for improving the overall efficiency would be incorporating polarisation effects within the proposed models and conducting measurements in more realistic environments.

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