Concept for Harvesting Low Ambient RF-Sources for Microsystems

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Abstract: This paper presents a Concept for rectifying low ambient radiation sources to supply Microsystems. A radiation source with the power of 2.5 μWatt (-26dBm) and an Impedance of 50 Ohm by 900 MHz was used. By well matching of the impedance and a resonance circuit transformation with a high quality factor in front of a Schottky-Diode a charge pump with the factor of 28 was realized.

Key Words: Micro-Energy-Harvesting; Wireless Energy Transfer; Rectifying RF-Sources.

1. INTRODUCTION

The idea of wireless transmission supply is not new. Approximately hundred years ago Nikola Tesla already makes an attempt to transfer low-frequency energy over long distances. In the 50's of the last century rectification of microwave signals has been proposed and researched in the context of high-power beaming [1]. In the near zone wireless transmission of energy is omnipresent. Each passive RFID-Tag functions on this principle [2]. Because of the limited near zone and the range of the induction field, it is worthwhile to find alternatives to supply Microsystems in the far field with energy too.

As receiving antenna a dipole antenna was used, which receives the power of 2.5μWatt (-26dBm) with an impedance of 50 Ohm on 900 MHz. Directly behind the antenna is the matching circuit. Without this matching for power before the diode, hardly energy would be transported through the diode. The goal is to transport all of the energy or as much as possible on a certain frequency through the diode. It is also possible to match the diode for a wide-band antenna. Although the diode would be badly matched, RF-energy could be collected on different frequencies but with a low Q factor and a bad efficiency factor [3]. This paper presents a concept for rectifying low ambient radiation sources on a firm Frequency. A schematic view of the RF-Energy-Harvesting-System is shown in Figure 1.

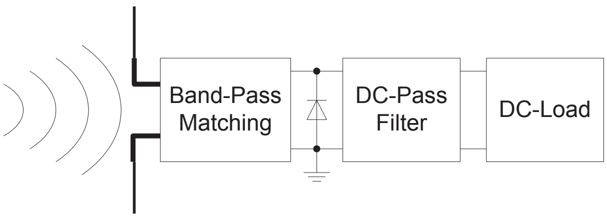

Fig. 1: Schematic view of the RF-Energy-Harvesting-System.

2. SIMULATION

For the nonlinear simulation of the matching circuit (Fig.2) behind the antenna, the program ADS (Advanced Design system) was used.

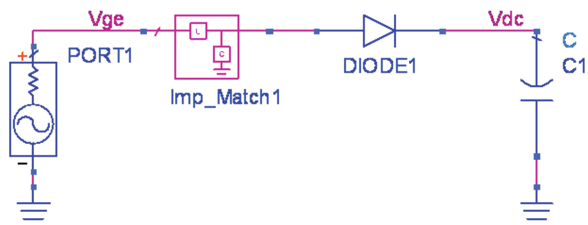

Fig. 2: Schematic of the nonlinear "Harmonic Balance" Simulation.

The nonlinear Model (Harmonic balance) makes it easy to match the resonance circuit transformation with the LSSP (large signal S-parameters) (Fig.3, 4 and 5). The Impedance Matching Unit (see Fig.2) in front of the diode contains passive devices like coils and capacitances.

Parameter	Value
f_0	900 Mhz
C_1	100 pF
R_g	50 Ohm
P_{RF}	2.5μW

Table 1: Simulation Parameter.

This Unit is matching the impedance and works like a charge-pump for the diode. It is a resonant structure with complex impedance. The Value and the arrangement of the devices change the frequency on which the diode is matched concerning power.

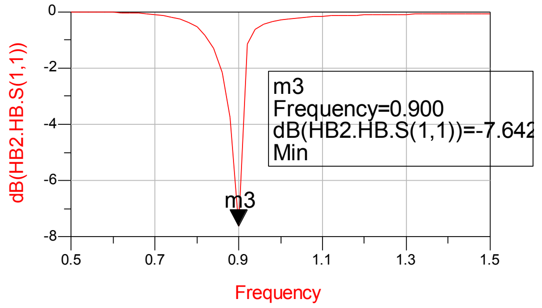

Fig. 3: Parameter S11 over the frequency [GHz].

Results of the nonlinear simulation are illustrated in Figure 6 and Figure 7. Behind the Schottky-Diode HSMS2850 is a rectified DC-Voltage of 344 mV (Fig.6 and Fig.7). Fig. 3 shows S11 the reflection factor. At 900 MHz S11 is -7.6 dB.

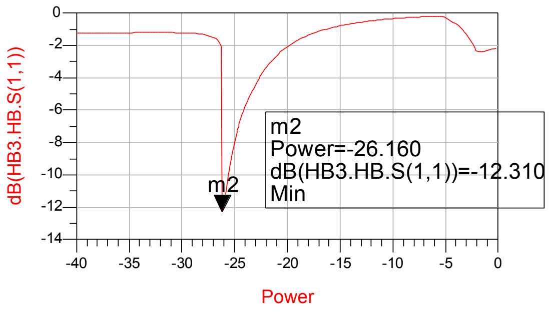

Fig. 4: Parameter S11 over the power [dBm] at 900 MHz.

Fig.4 shows S11 at 900 MHz over a power range from -40 dBm to 0 dBm.

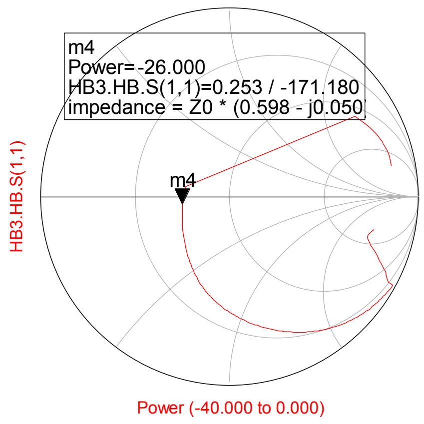

Fig. 5: Impedance on 900 MHz (m4) in a Smith Chart.

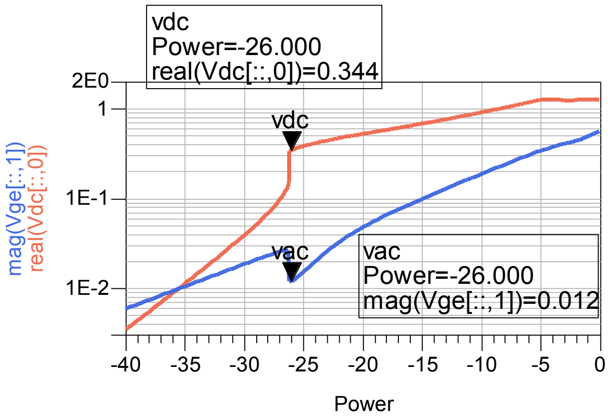

Fig. 6: DC component (vdc) after the diode HSMS2850 and magnitude (vac) of fundamental tone after the antenna over all swept power [dbm] values.

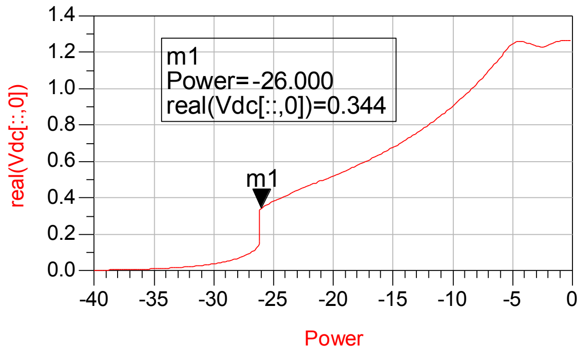

Fig. 7: Open circuit DC voltage transfer of the Harvesting-System.

3. DISCUSSION

In this paper, the diode was matched in a narrow bandwidth. The nonlinear simulation could also be used for matching broadband applications. For broadband applications it is necessary to have a broadband antenna and a broadband matching unit for the diode. It is possible to match the impedance on a broadband. For the charge-pump we need a resonant circuit with a high Q factor. It is not possible to have a broadband characteristic and a high Q factor without bad efficiency factor.

4. CONCLUSION

It was shown that a Schottky diode can work with an alternating voltage (a.c.) of 12mV (2.5μWatt) without additional energy supply. This solution is valid over a very large dynamic range. After a power of 2.5 μW the diode starts to rectify AC to DC with an output of over 300 mV. The Boost Converter TPS61200 from Texas Instruments starts boosting with an Input Voltage of 300mV. With this presented Ambient RF- Harvesting System and a commercial Boost Converter it is possible to charge an accumulator and supply a Microsystem after a period of harvesting.

REFERENCES

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