Keysight Technologies

STMicroelectronics & ESEO Use ADS To Design a 2.45 GHz Wireless Power Scavenging Circuit

Case Study

Challenge

- Design an antenna matching circuit for the "rectenna" (rectifier + antenna) system
- Achieve the needed impedance transformation for the antenna

Solution

- Co-simulated the circuit design for optimal performance using Keysight ADS software
- Employed diode package parasitic models to minimize parasitics
- Tuned the distance between the matching capacitor and SMA connector

Results

- Obtained DC power at threshold value of –20 dBm
- Achieved maximum efficiency of 68% at an input power of 20 dBm

The Internet of Things (IoT) fulfills a promise of a more efficient and connected world. But with dozens of devices per household, battery management must become wireless and autonomous. This problem is now being solved through power harvesting, which enables a circuit to power itself from energy in the environment.

For this task, the microwave band is important because it has more ambient RF energy floating around at 1.8 GHz (e.g., GSM1800 from cell towers) and 2.45 GHz (from WiFi), than 24 MHz. However, moving from 24 MHz to the higher frequencies poses special challenges.

STMicroelectronics (ST) and Ecole Supérieure d'Electronique de l'Ouest (ESEO) used Keysight Technologies' Advanced Design System (ADS) software to design a 2.45-GHz wireless power scavenging or rectifying circuit. With its co-simulation capabilities, ADS made optimizing the "rectenna" (rectifier + antenna) a straightforward task.

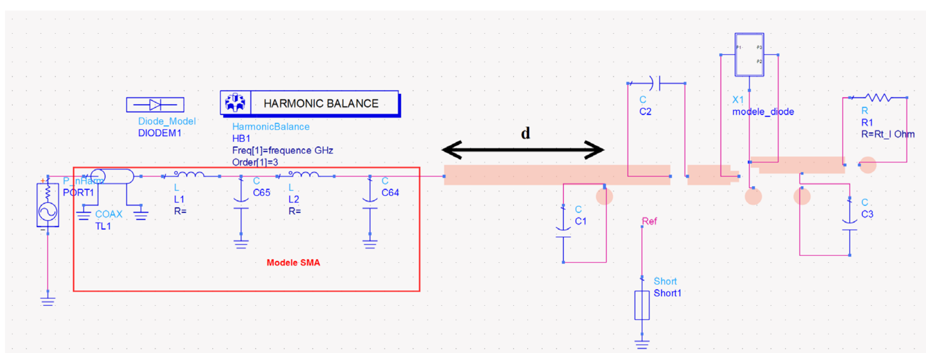

Figure 1. The distance between the matching capacitor and SMA connector can be easily tuned using Keysight ADS.

"ADS co-simulation of the Momentum EM field solver with the Harmonic Balance circuit solver helped us combine the antenna and rectifier into an optimized rectenna."

Prof. Mohamed Latrach
Head of the Radio-Frequency & Microwave research group, ESEO

KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights

Challenge

In the wireless power scavenging circuit, the rectenna converts electromagnetic energy into DC electricity. It comprises an antenna and rectifier made up of a Schottky diode, load resistor, input matching circuit, and output bypass capacitor. The challenge here is that rectifying the ambient RF/microwave energy requires the input matching circuit to output a voltage across the rectifying Schottky diode, which exceeds its forward voltage drop of about 0.3 V. Since the antenna gathers less than a microwatt of power, a big impedance transformation is needed from the antenna impedance (a few tens of ohms) to several kiloohms. An additional challenge is the impedance of the diode varies with the amplitude of the input voltage.

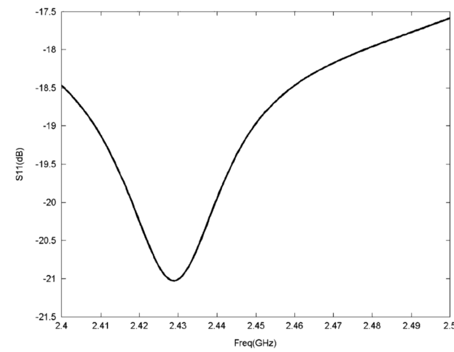

Figure 2. Simulated input return loss versus frequency for the rectifier using one HSMS2820 Schottky diode.

Solution

Dealing with these challenges requires an EDA tool that allows designers to fully optimize the rectifying circuit, since it's key to improving transmission RF-DC conversion efficiency. To do that, ST and ESEO first had to properly design and simulate the rectifying circuit. For that task, designers turned to ADS with its co-simulation capabilities.

Co-simulation enables designers to create physical parts and add them to a circuit simulation. In this case, ST and ESEO used ADS co-simulation to optimize the rectenna design. The ADS Momentum 3D planar field solver was used for passive modeling and analysis of the rectifying circuit, while the ADS Harmonic Balance circuit solver provided a frequency-domain analysis technique for simulating the circuit. Unlike AC analysis in ordinary SPICE, Harmonic Balance takes the nonlinear characteristic of the diode into account. Diode package parasitic models were used to ensure parasitic effects in the circuit were minimized and that ST and ESEO could achieve good correlation between simulation and measurement results. ST and ESEO designers also tuned the distance "d" between the matching capacitor and the SMA connector to optimize the circuit's convection efficiency (see the arrow labeled 'd' in Figure 1).

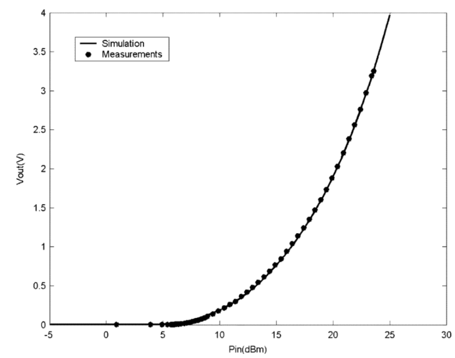

Figure 3. Simulated RF-dc conversion efficiency versus input power for the rectifier using one HSMS2820 Schottky diode.

Results

With this approach, ST and ESEO designers developed a 2.45-GHz wireless power scavenging. Using a patch antenna with dimensions of about 20 mm on a side to test and validate the rectenna system, designers obtained DC power at threshold value of –20 dBm. Maximum efficiency was 68% at an input power of 20 dBm.

More Information

To learn more about how ST and ESEO designed a 2.45-GHz wireless scavenging circuit using Keysight ADS, go to:

An Experimental Evaluation of Surrounding RF Energy Harvesting Devices and ***Hybrid Rectenna and Monolithic Integrated Zero-Bias Microwave Rectifier.***

Learn how ADS can help you in your power electronic designs by clicking ***here*** for a free trial.

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Published in USA, June 7, 2017
5992-2395EN
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