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# Design of Rectenna for Wireless Energy Harvesting

PRADEEP CHANDRAKANT DHANAWADE[1], SHIVAJIRAO M. SANGALE[2]
[1]*PhD Candidate, Department of Electronics Engineering, Shivaji University, Kolhapur, Maharashtra, India*
[2]*Research Supervisor, Department of Electronics Engineering, KBP College of Engineering, Satara, Maharashtra, India*

***Abstract- A two-diode series-shunt rectifier operating at 2.1 GHz was designed, fabricated, and experimentally characterized for wireless power transfer. The circuit uses SMS7630 low-barrier Schottky diodes, distributed microstrip matching sections, a 1.0 µF output capacitor, and a resistive load. Harmonic-balance analysis was performed with a 2.1 GHz single-tone source, while scattering parameters were evaluated from 2.0 to 2.2 GHz. Input power was swept from −25 to +25 dBm and commercially available load resistances from 1 to 10 kΩ were examined. Simulation predicted a maximum RF-to-DC conversion efficiency of 27.7% at +5 dBm with a 5.6 kΩ load. Under the same nominal input-power and load conditions, the fabricated rectifier achieved a measured peak efficiency of 26.9%. The close agreement supports the two-diode series-shunt topology for targeted WPT at moderate RF input power.***

***Keywords—RF-To-DC Conversion, Schottky Diode, Series-Shunt Rectifier, Wireless Power Transfer.***

## I. INTRODUCTION

Wireless power transfer (WPT) can provide controlled energy to low-power electronic systems where battery replacement is difficult. Its receiving stage requires an RF rectifier that converts alternating radio-frequency energy into a usable direct-current (DC) output. Conversion performance depends on input power, impedance matching, diode threshold and parasitics, output filtering, and load resistance [1]–[3].

Rectifier studies have investigated SMS7630-based implementations [4], inverse class-F networks [5], full-wave arrangements [6], voltage-doubler circuits [7], and waveform optimization [8]. These approaches seek to improve conversion efficiency and sensitivity while controlling harmonic and mismatch losses. Reliable comparison requires the input-power reference plane and load condition to be stated explicitly.

This work focuses on a two-diode series-shunt circuit designed at 2.1 GHz using distributed microstrip sections. The contribution is the fabrication and conducted experimental characterization of the rectifier, together with a direct comparison of simulated and measured efficiency over input-power and load variations. Since maximum efficiency occurs at +5 dBm, the demonstrated operating range is intended for targeted WPT rather than unrestricted ambient RF harvesting.

## II. RECTIFIER DESIGN AND EXPERIMENTAL METHODS

### 2.1 Circuit topology

The conversion circuit comprises two SMS7630 low-barrier Schottky diodes, distributed microstrip sections, a 1.0 µF output capacitor, and a variable resistive load. D1 is placed in the series RF path and provides the principal rectification. D2 forms a shunt branch that conducts during the opposite half-cycle and establishes the waveform reference. This arrangement is therefore identified as a two-diode series-shunt rectifier.

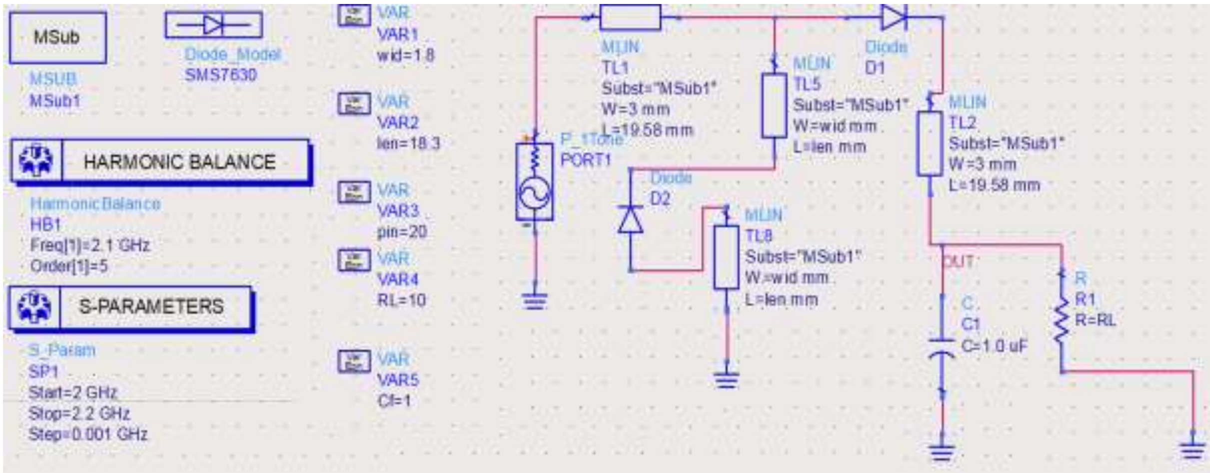

Figure 1. ADS schematic of the two-diode series-shunt rectifier operating at 2.1 GHz.

Advanced Design System (ADS) harmonic-balance analysis used a 2.1 GHz single-tone source. Scattering parameters were calculated from 2.0 to 2.2 GHz in 1 MHz increments while the microstrip dimensions were adjusted for resonance and RF-to-DC conversion. The load sweep covered commercially available resistances from 1 to 10 kΩ with input power fixed at +5 dBm. A separate input-power sweep extended from −25 to +25 dBm in 5 dB increments with RL fixed at 5.6 kΩ.

$$\eta_{RF-DC} = (P_{DC} / P_{in}) \times 100 = [V_{DC}^2 / (R_L P_{in})] \times 100 \quad (1)$$

In (1), $\eta_{RF-DC}$ is the RF-to-DC conversion efficiency, $V_{DC}$ is the DC output voltage, $R_L$ is the load resistance, and $P_{in}$ is the net RF power delivered at the rectifier input reference plane. Simulated and measured efficiencies must use the same calibrated reference plane.

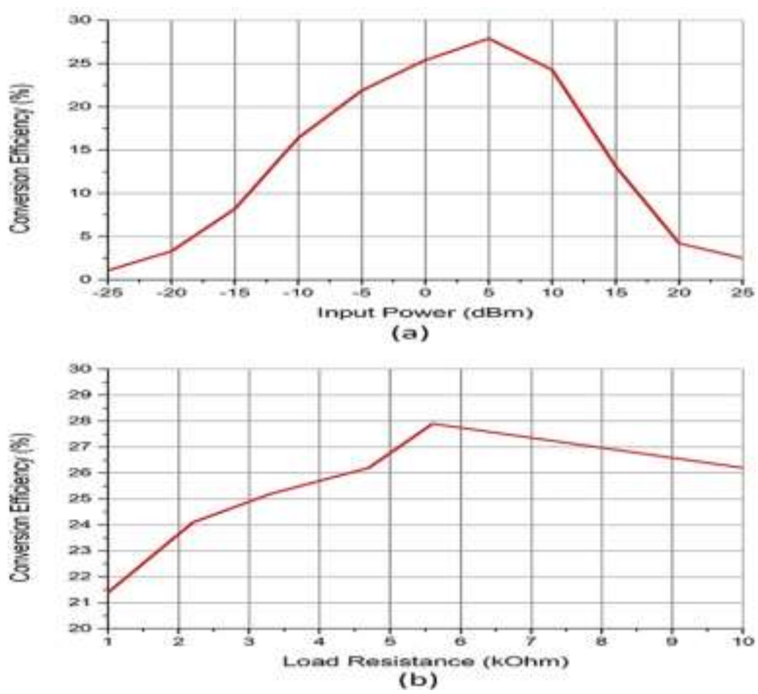

Figure 2. Simulated RF-to-DC conversion efficiency versus (a) input power at RL = 5.6 kΩ and (b) load resistance at Pin = +5 dBm.

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2.2 Fabrication and measurement
The optimized distributed circuit was fabricated and connected through an SMA input interface. Conducted measurements evaluated DC output and conversion efficiency against the specified input-power and load-resistance sweeps. The measured efficiency was calculated using (1), with Pin referenced to the rectifier input.

## III. RESULTS AND DISCUSSION

3.1 Simulated and measured conversion performance
The simulated efficiency increased with input power and reached 27.7% at +5 dBm for RL = 5.6 kΩ. At lower power, the RF voltage was insufficient to drive the Schottky diodes effectively. Beyond the optimum, nonlinear device behaviour and mismatch losses reduced conversion. The load sweep identified 5.6 kΩ as the best value among the commercial resistances evaluated.

The fabricated circuit achieved a measured maximum efficiency of 26.9% at +5 dBm with the same 5.6 kΩ load. The difference from the 27.7% simulated maximum is 0.8 percentage points, indicating that the harmonic-balance model captures the dominant circuit response near the optimum operating condition.

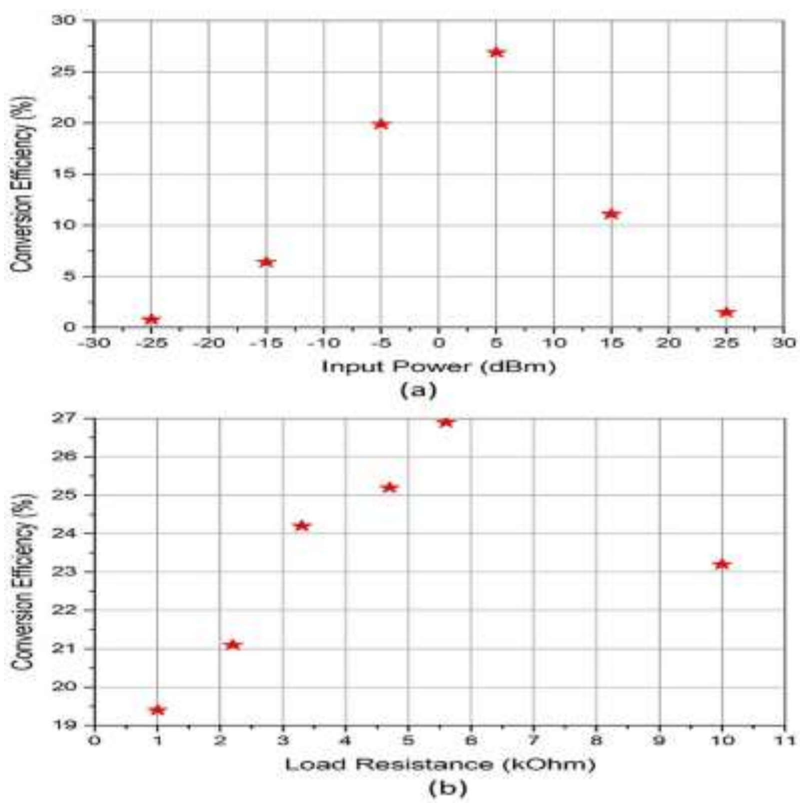


Figure 3. Measured rectifier conversion efficiency versus (a) input power at RL = 5.6 kΩ and (b) load resistance at Pin = +5 dBm.

3.2 Interpretation and limitations
Although the input sweep includes operation below 0 dBm, efficiency at the lowest power levels remains limited. The measured evidence therefore supports the circuit primarily as a moderate-input-power WPT rectifier. Further work should report direct input-plane power calibration, cable and connector losses, repeatability across multiple fabricated samples, and uncertainty over repeated measurements. Harmonic-control or band-selection circuitry may also be examined as a future extension; neither was included in the present prototype.

## IV. CONCLUSION

A 2.1 GHz two-diode series-shunt rectifier using SMS7630 Schottky diodes was designed, fabricated, and evaluated. Harmonic-balance simulation predicted 27.7% peak RF-to-DC efficiency at +5 dBm with a 5.6 kΩ load, while measurement gave 26.9% under the same nominal conditions. The 0.8 percentage-point difference demonstrates close agreement near the optimum operating point. The results support the topology for targeted WPT at moderate input power. Future characterization should include direct reference-plane calibration, repeated-prototype uncertainty, and evaluation of harmonic-control circuitry.

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