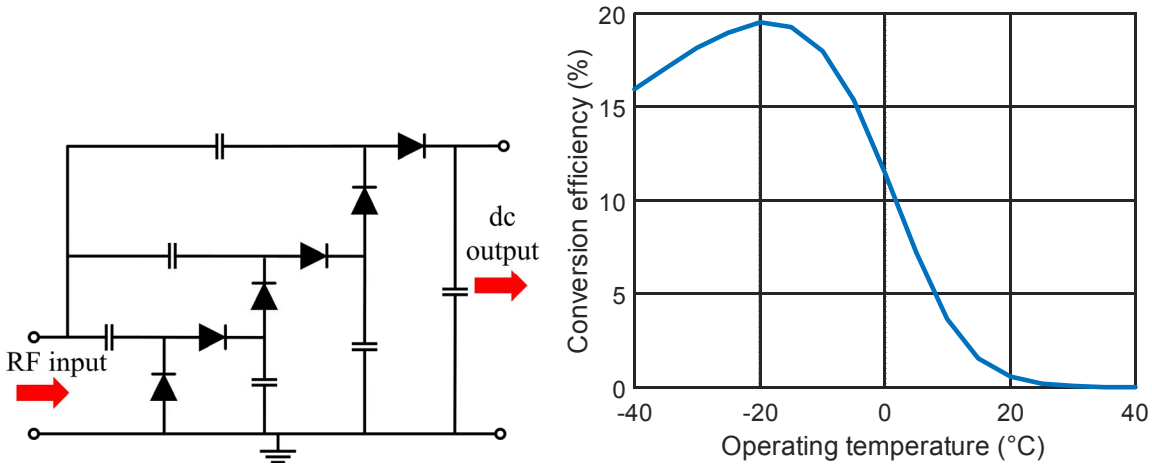
Conversion Efficiency Sensitivity of Multi-Stage Rectifier Over Temperature

Xiaoqiang Gu*(1), Simon Hemour(2), and Ke Wu(1)
(1) Poly-GRAMES Research Center, Polytechnique Montreal, Montreal, Canada
(2) IMS Laboratory, CNRS UMR 5218, University of Bordeaux, Talence, France

Battery-free devices or self-sustainable energy platforms are the foundation of the green Internet of Things (IoT) technology [1],[2]. Recycling ambient RF and wireless power in the free space offers a promising approach to energizing billions of geographically scattered but wirelessly interconnected sensing nodes or devices [3]. Typically, sensing nodes require a driving voltage of more than 1 V from dc power supply. Thus, multi-stage rectifiers transformed from Dickson's charge pump is introduced to leverage dc output voltage levels. As the dc power supply for self-sustainable sensing nodes, multi-stage rectifiers are expected to be highly stable and reliable. Hence, the conversion efficiency analysis and assessment of multi-stage rectifiers in an ever-changing environment are critical. Among multiple environmental factors, temperature/thermal effects have not been thoroughly investigated by researchers so far, especially on the multi-stage rectifiers. Featuring high reliability, low cost, and easy accessibility, Schottky diodes are the first choice for multi-stage rectifiers. Since Schottky diodes rely on thermionic emission, multi-stage rectifiers based on this technology are highly temperature-sensitive. In this work, the conversion efficiency of multi-stage rectifiers over temperature variation is discussed theoretically. The commercial ADS Harmonic Balance simulation tool is deployed for this parametric study. A sensitivity analysis demonstrates that the conversion efficiency of a 3-stage rectifier changes drastically over a range of −40 °C to +40 °C (Figure 1). This parametric range is selected based on practical temperature changes that most people would possibly experience throughout an entire year. Moreover, an optimum temperature corresponding to a peak efficiency is captured within the above temperature range. This work also indicates that temperature factors should be carefully considered for designing multi-stage rectifiers.



(a) (b)

Figure 1. (a) Diagram of a 3-stage rectifier based on diodes SMS7630 and (b) its simulation results of conversion efficiency results versus operating temperature in the range of −40 °C to +40 °C. Matching network influence is de-embedded. Operating frequency is 600 MHz, and load resistance is 5.8 MΩ.

References

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