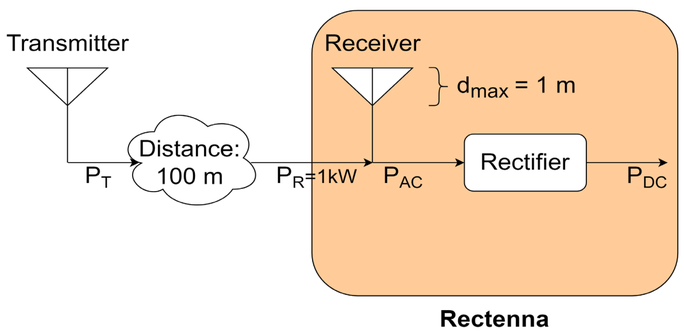
HSLU Hochschule Luzern

Technik & Architektur

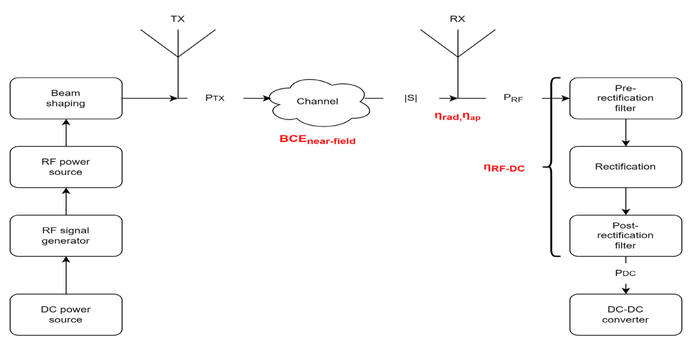
Master of Science in Engineering – Information and Communication Technologies

Rectenna Array for mm-Waves

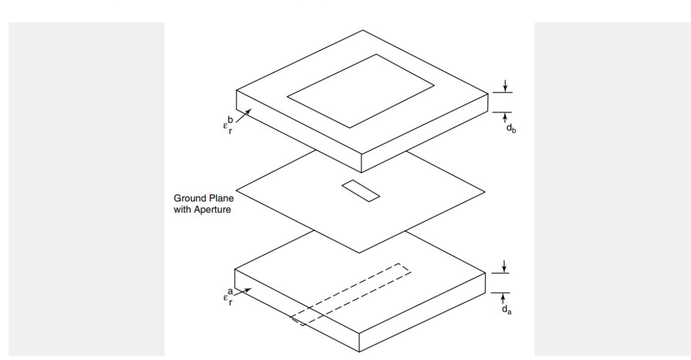
WPT system overview.



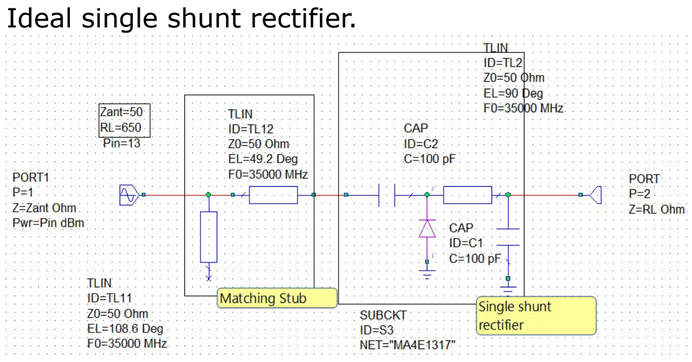
WPT system expanded overview.



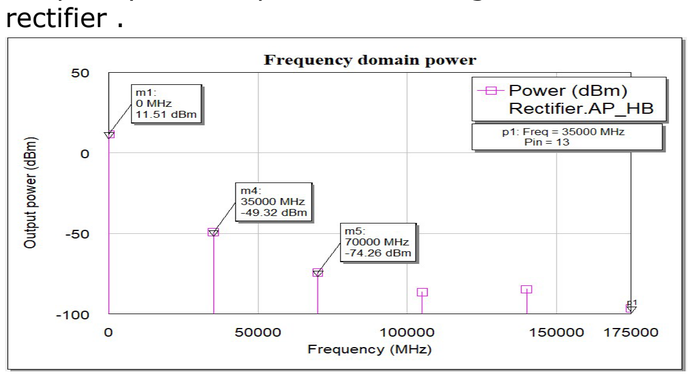
Slot coupled microstrip patch.



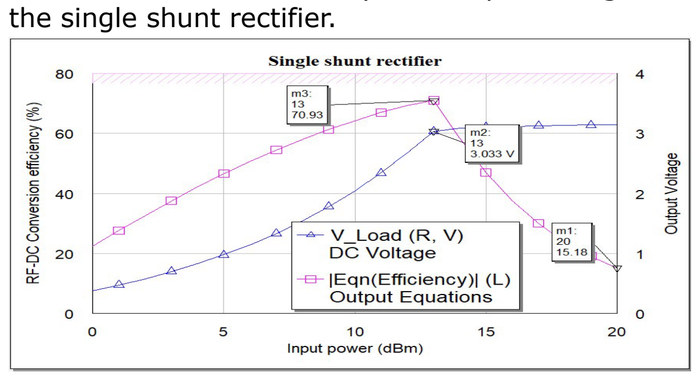
Ideal single shunt rectifier.



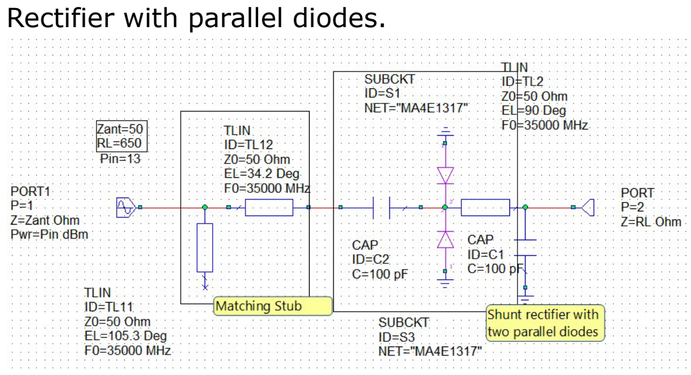
Frequency domain power of the single shunt rectifier .



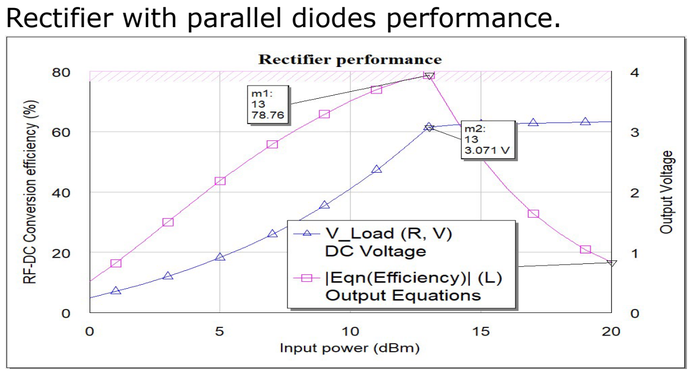
RF-DC conversion efficiency and output voltage of the single shunt rectifier.



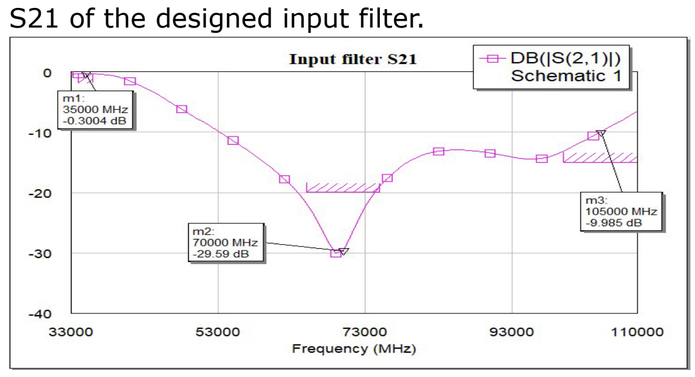
Rectifier with parallel diodes.

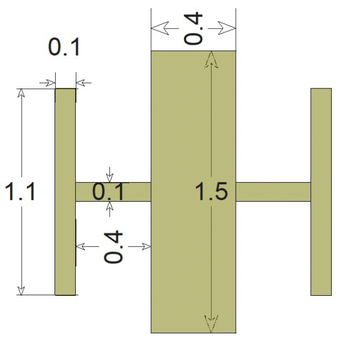


Rectifier with parallel diodes performance.

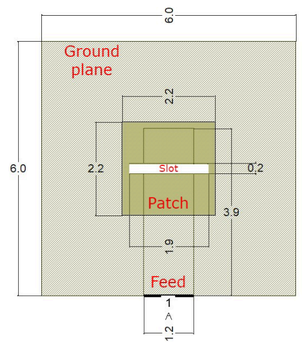


S21 of the designed input filter.

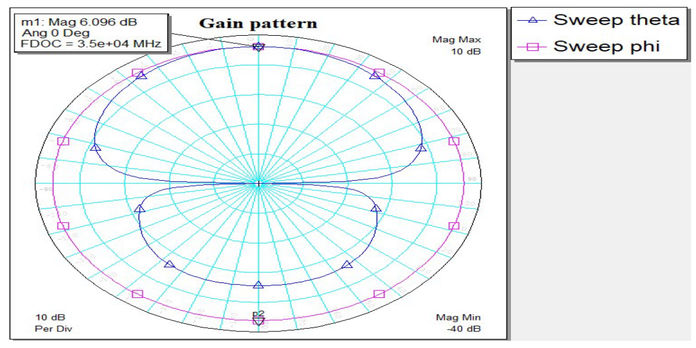




Dimensions of the input filter (mm)



Dimensions of the slot coupled microstrip patch antenna (mm)



Beam pattern of the slot coupled microstrip patch antenna. (G_{max} = 6.096 dBi)

Problem

Millimeter-wave technology allows us to transfer power wirelessly over long distances using compact antennas. However, at a frequency of 35 GHz, substrate and conductor losses are high.

To generate the highest possible DC power at the rectenna, it is of utmost importance that a highly efficient antenna and rectifier are designed.

The challenge is to design a highly efficient rectenna with a maximum area of 1 m^2, subject to 1 kW/m^2 of power density. Therefore, the following tasks need to be addressed:

1. Research passive and active mm-Wave rectifier circuits and design a rectifier with a 45% RF-DC conversion efficiency.

2. Research suitable antenna types for wireless power transfer applications and design an antenna in conjunction with the rectifier.

Solution

A highly efficient rectifier circuit with the diode MA4E1317 is proposed for further optimization and prototyping. A slot coupled microstrip patch antenna is designed as the antenna element. The antenna shows a gain of approximately 6.1 dB, which results in an input power of 13 dBm for the rectifier. Hence, the rectifier is optimized for maximum conversion efficiency at this input power.

43100 antenna elements plus rectifiers are needed to absorb 1 kW of power. Given the patch antennas size of 2.2 x 2.2 mm and an inter-element spacing of λ/2, it is possible to fit 230 x 230 antenna elements in a 1 m^2 area.

Finally, the rectennas can then be combined at DC to deliver the necessary power to a load.

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