Rectenna design

Overall system

The components in a rectenna system are:

- Antenna
- Matching network
- Rectifier

The antenna receives the power from RF signals. The rectifier turns the incoming AC voltage into a useful DC voltage. The magnitude of the AC voltage input into the rectifier should be as large as possible in order to maximize the time in which the voltage is greater than the turn-on voltage of the diode. In order to accomplish this, the input impedance of the rectifier should be large. The matching network is necessary to match the low output impedance of the antenna ($~50\Omega$) to the high input impedance of the rectifier ($~1k\Omega$).

Antenna design

See main article: Antenna design

Rectifier design

As mentioned earlier, the input impedance of the rectifier should be high to maximize voltage.

If the output port is matched,

$$Z_{in} = Z_{11} = \frac{V_1}{I_1}|_{I_2=0}$$

If the output port is not matched,

$$Z_{in} = Z_{11} - \frac{Z_{12}Z_{21}}{Z_{22}Z_L}$$

where Z_L is the load impedance at the output port.

Simulations

Simulations can be performed in Cadence Virtuoso to optimize the rectifier. Since the rectifier includes a diode, which is a nonlinear component, nonlinear simulations must be performed. The two nonlinear simulation types are:

- hb (harmonic balance), which
- hbsp (large-signal S-parameters), from which we can derive the input impedance.

1-tone test

For a 1-tone test, the following parameters can be configured:

- Frequency
- Number of harmonics (5 is a good number)
- Oversampling (can be set to 1 for sine wave inputs)

A node can be selected, and the magnitude of the voltage or power at that node can be plotted as a function of frequency or time. Keep in mind that power and voltage will vary for different values of load impedance.

Schottky diode modeling

The following parameters are important for Schottky diode modeling:

Semiconductor

- $C_{junction}$ - capacitor in metal-semiconductor junction
- $R_{junction}$ - resistance of metal-semiconductor junction - **dependent on V_D**
- R_{series} - resistance in series with metal-semiconductor junction

Parasitics

- $R_{contact}$
- $C_{contact}$

I-V characteristics

- I_{S} - reverse bias saturation current
- n - nonideality factor

Shockley diode equation

$$I = I_S[exp(\frac{V_D}{nV_{th}})-1]$$

References

- https://www.sciencedirect.com/science/article/pii/S1434841112002841