Wireless Sensor Network Utilizing RF Energy Harvesting for Smart Building Applications

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Introduction & Scope of the Present Work

Without a doubt Internet has created an evolution on how we interact, learn and acquire information.We are on the edge of a new evolution namely where everything will be connected. Sensors are going to be in the center of this evolution as they provide measures of the current state of the physical world as depicted in Fig. 1 for a smart city and a smart room scenario.

Motivation

- Large increase of connected devices – almost 25 Billion at the moment
- Radio frequency harvesting a viable approach for supplying power
- Rid need of batteries and cables to external power supplies
- "Free" input power

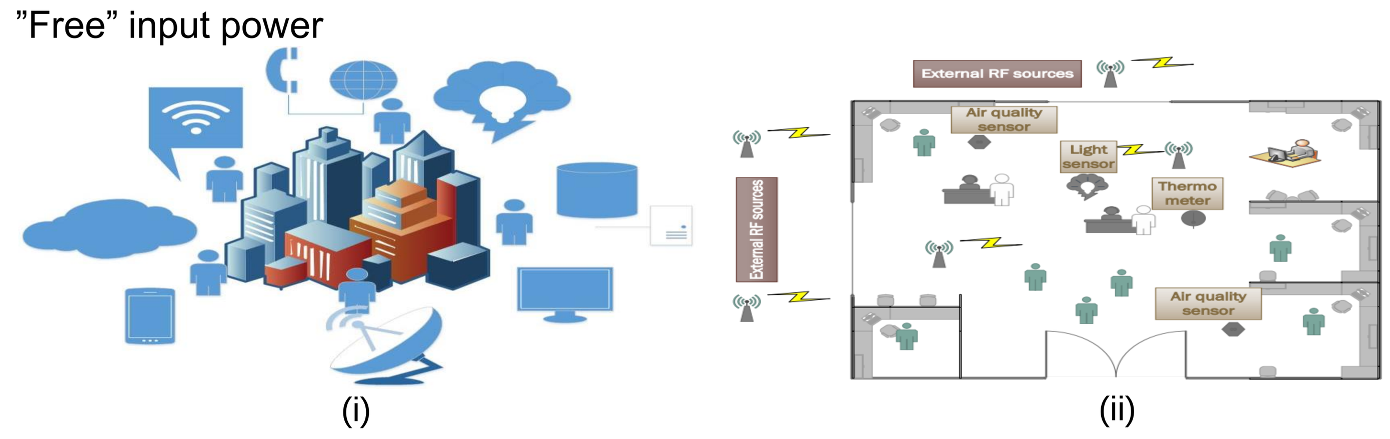


Figure 1. (i) Smart city scenario (ii) Smart room scenario

Field strength assessment in KTH campus

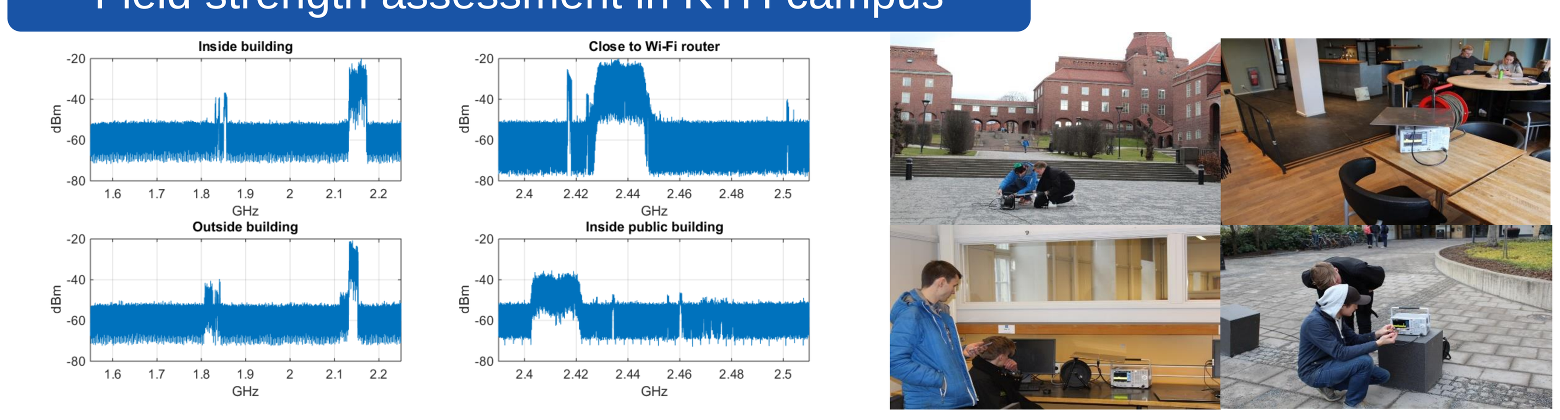
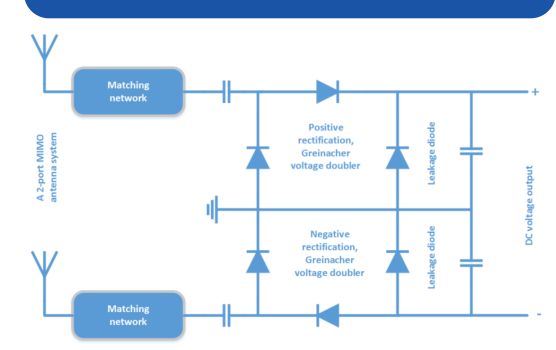


Figure 2. RF power level assessment for WiFi and cellular bands in different scenarios and photos during the measurement campaign

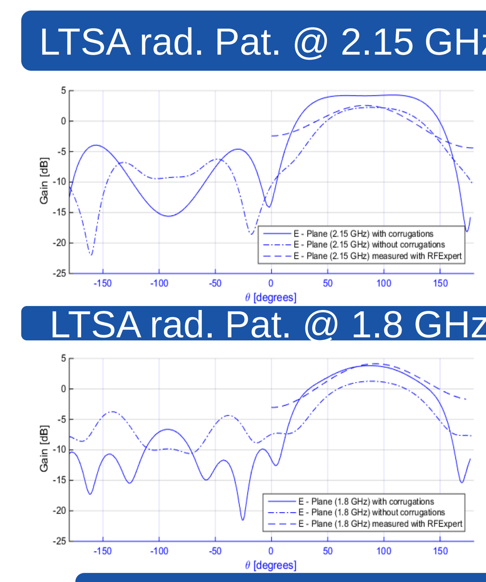
Scope of the work:
Develop a modular system able to adapt in different RF input signals and harvest the available ambient RF power. The harvested power will be utilized in small sensors

MISO differential rectification approach

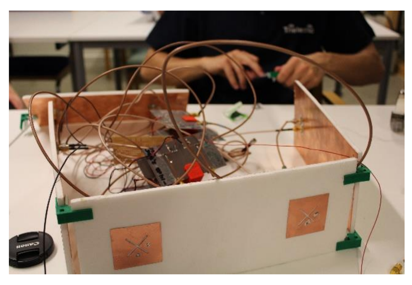


LTSA rad. Pat. @ 2.15 GHz

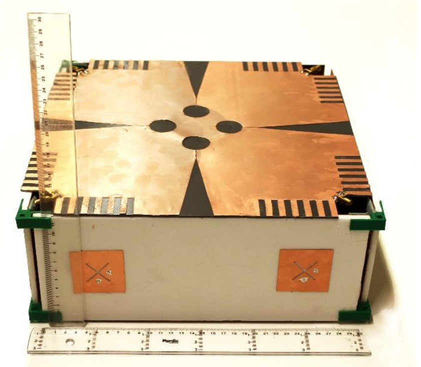
LTSA rad. Pat. @ 1.8 GHz



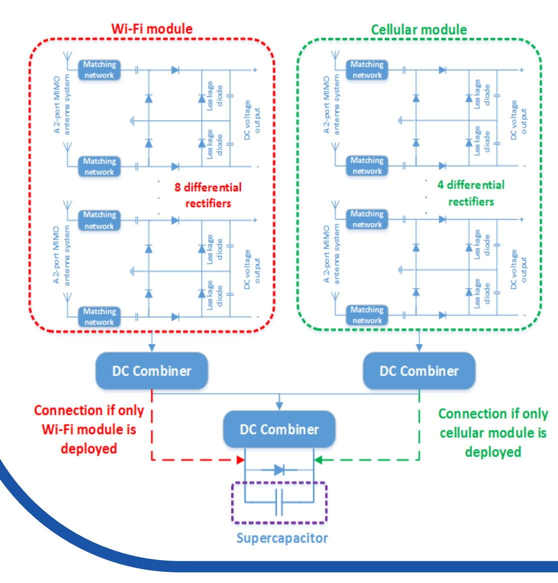
The developed system under construction



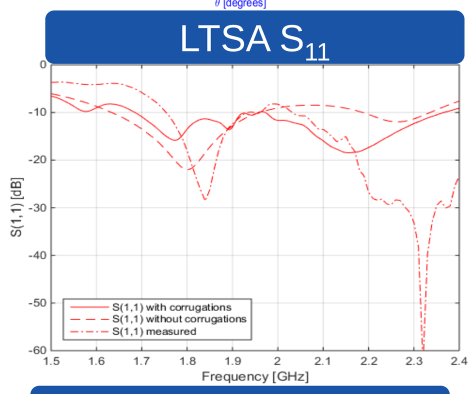
The developed harvesting system



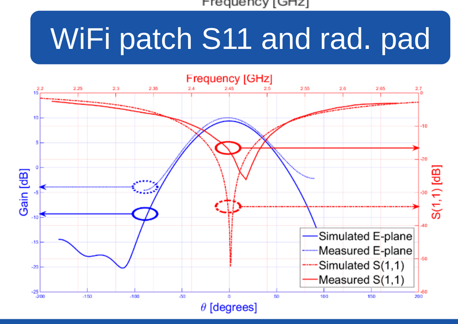
Overall system rectification approach



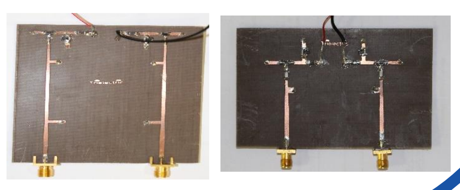
LTSA S_{11}



WiFi patch S11 and rad. pad

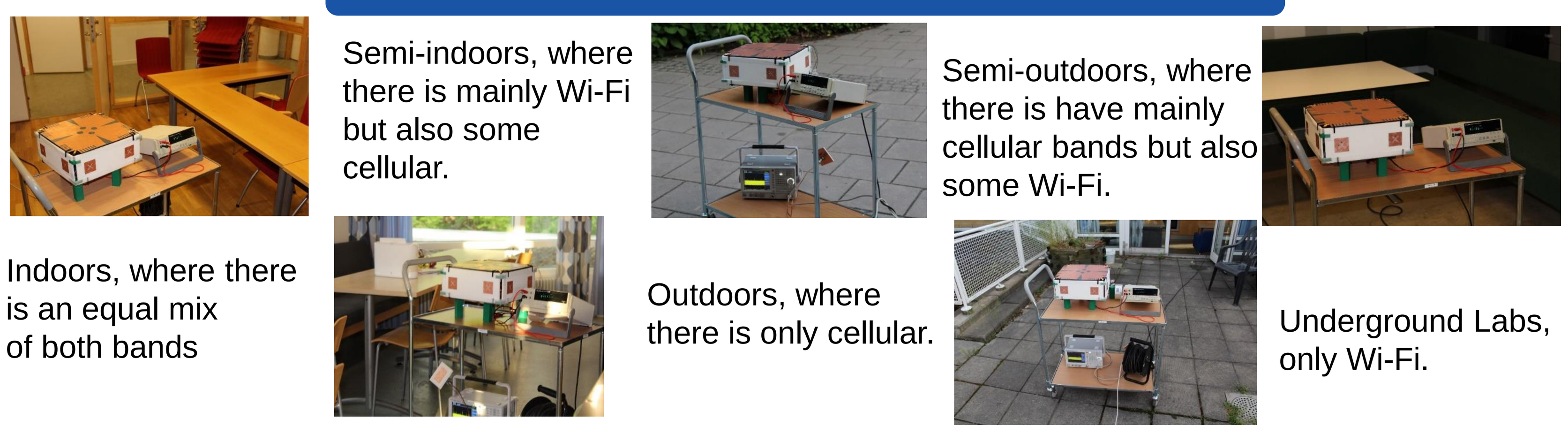


The developed rectifiers



Testing scenarios

Five tested scenarios



Semi-indoors, where there is mainly Wi-Fi but also some cellular.

Semi-outdoors, where there is have mainly cellular bands but also some Wi-Fi.

Indoors, where there is an equal mix of both bands

Outdoors, where there is only cellular.

Underground Labs, only Wi-Fi.

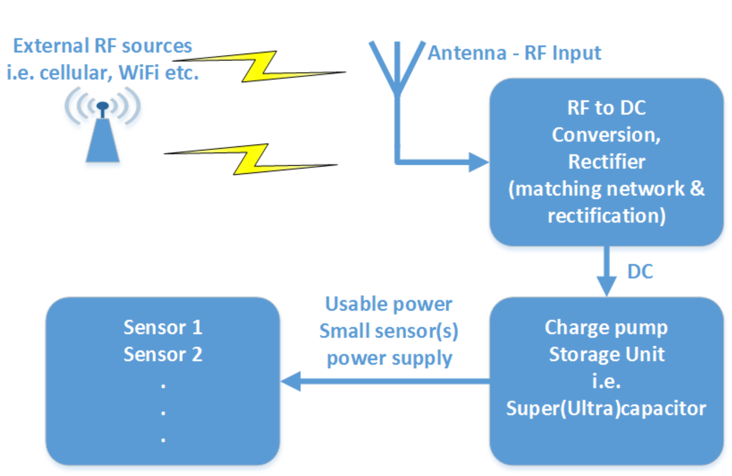
Table 1. System measurements for the tested scenarios, available input power and output voltage and power with 10KOhm load.

	WiFi dBm	Cellular dBm.	Voltage mV	Output Power µW.
Indoors	-22	-27	220	5.2
Semi – indoors	-30	-25	140	2.1
Outdoors	-	-20	130	1.7
Semi – outdoors	-40	-23	170	3.2
Underground	-20	-	210	4.6

Successful RF energy harvesting

System Description

- Designed for highest efficieny at KTH campus
- GSM, 3G and Wi-Fi target frequencies
- A total of 16 small, high gain antennas
- Modular system: WiFi subsystem and cellular subsystem
- Dual-band rectification for the cellular for the bands 1.8GHz and 2.15GHz
- 2.45 GHz WiFi band rectifiacation
- A novel MISO differential rectification approach.
- Leackage diodes to control voltage drops



Full system

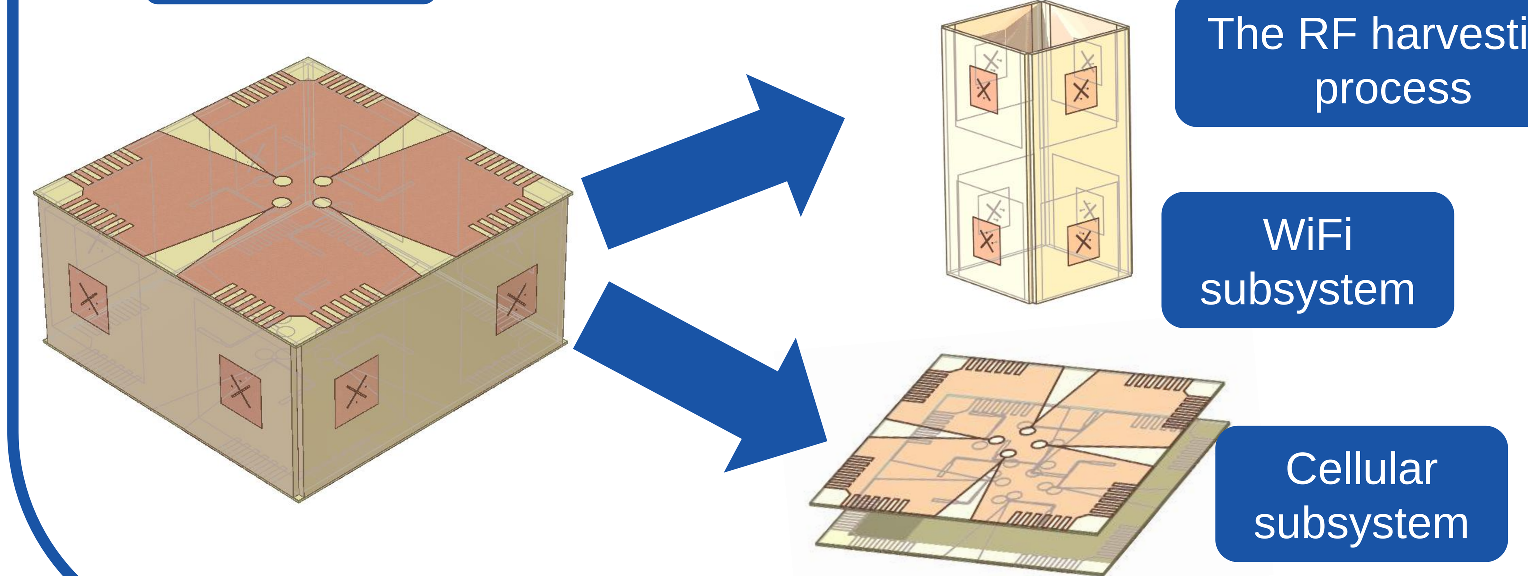


Figure 3. The developed system and the modular approach

Conclusions

- Developed an RF energy harvesting system as a power suply for small sensing devices
- Succesfull modularity for system adaptivity depending on the ambient RF input frequencies
- Five succesful tested scenarios for the developed system in KTH campus

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