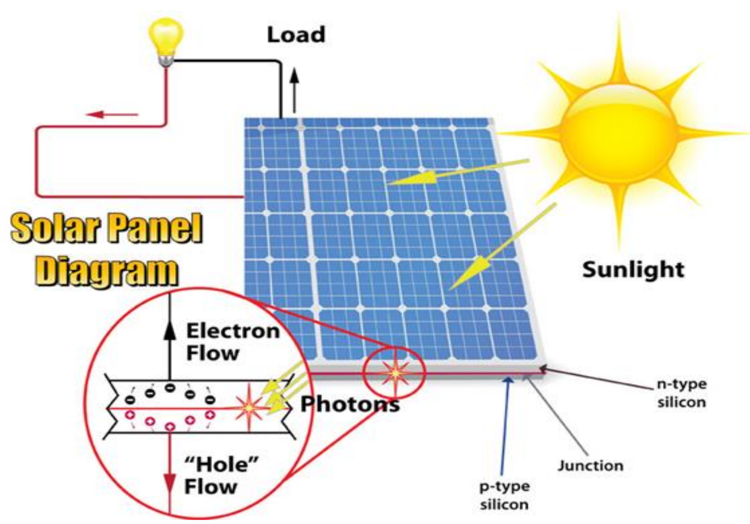
New Solar Cell

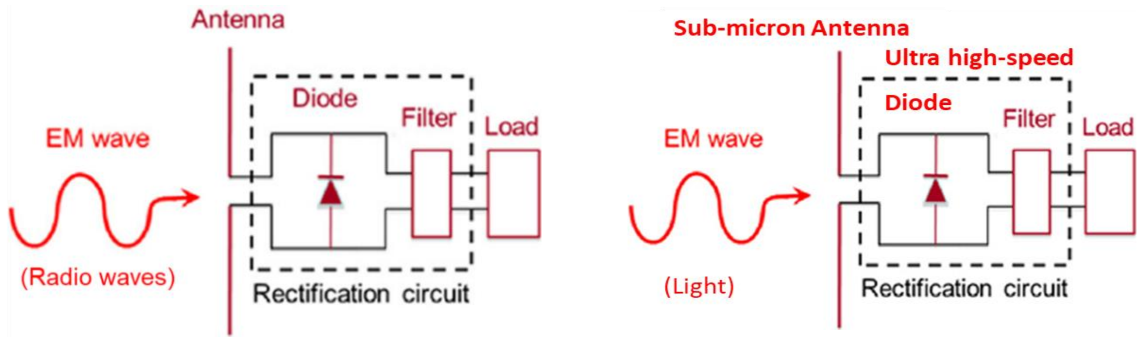
Nowadays semiconductor solar cells are widely used and commonly seen for many businesses. Mainly, it is targeted for lowering the electricity bill. That applies not only to the national power plants, heavy factory but to an individual household. A well-define conversion efficiency is at 44% for semiconductor solar cell due to their incapability of absorbing those low energy photons of the sun. The conventional solar cells are of 10% to 12% conversion efficiency or only 10%-12% of light energy can be captured for our daily use. Another interesting challenge about this technology is that how the disposal could be accomplished or managed after its useful life. In the next 20 to 25 years from now the waste of the huge amount of today semiconductor solar cells will impact our living environment and increase the challenge on addressing the global warming problem.

The rectennas, the antenna-coupled diode, theoretically 100% conversion efficiency of the receiving radio or electromagnetic waves to electrical power could be achieved. RFID is operating under the same concept except no AC to DC conversion. The antenna is printed on the thin-film metals and insulators on a variety of substrates which is inexpensive and widely available. The diode connects to the antenna for rectifying the captured radio waves to dc power.

The new solar cell, the optical rectennas, incorporates a submicron antenna and an ultra-high-speed diode. It converts the receiving light, the ultra-high frequency electromagnetic waves, to dc power which is the same technique as the rectenna converts radio wave to DC power. Illustrations on how semiconductor solar cell, rectennas, and optical rectennas operate are shown in Figure 1.



a) Conventional (Semiconductor) Solar cell



b) Rectennas c) Optical rectennas

Figure 1. a) In conventional solar cells each photon generates electron-hole pairs that provide electrical power. The antenna-coupled diode harvests electromagnetic waves and converts to electrical power in b) Rectennas, and c) Optical rectennas

Rectenna design and experiment results

An antenna with dual polarizations was designed for the experiment for 2.0GHz to 7.0GHz. For high conversion efficiency a full wave rectifier based on voltage doubler circuit was incorporated onto a printed antenna. The loads were varied in the experiment for the highest output DC power. The antenna is connected to the rectification circuit by a feed network which was designed and optimized for producing the highest conversion efficiency of the system. Modeling of the selected diode impedance was also simulated by an analytic tool. The arrangement for experimenting the conversion efficiency is shown in Figure 2.

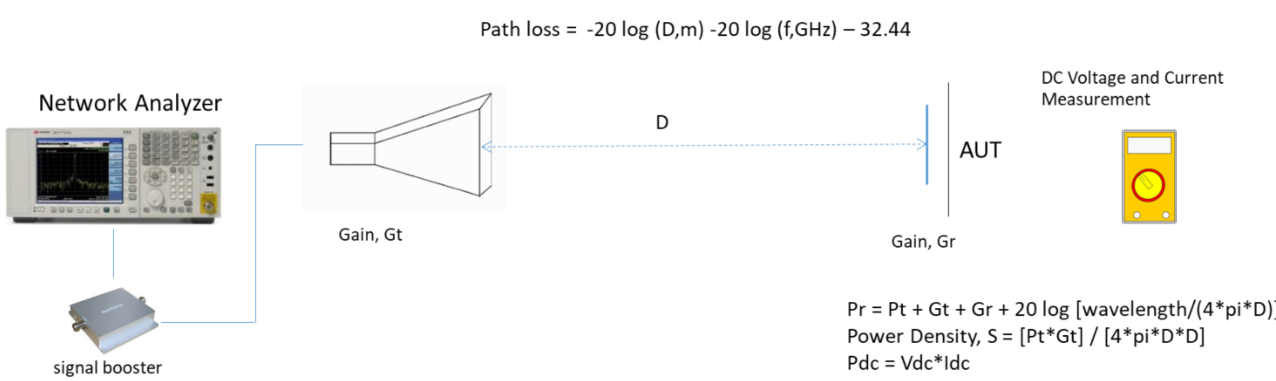


Figure 2. Conversion efficiency is derived from the collected power by the antenna and the system produced DC power

The VSWR performance of the designed antenna terminated with a 50 Ohm load over a ground plane is shown in Figure 3. Also, the incorporated voltage doubler full wave rectifier circuit changes the impedance matching profile of the system.

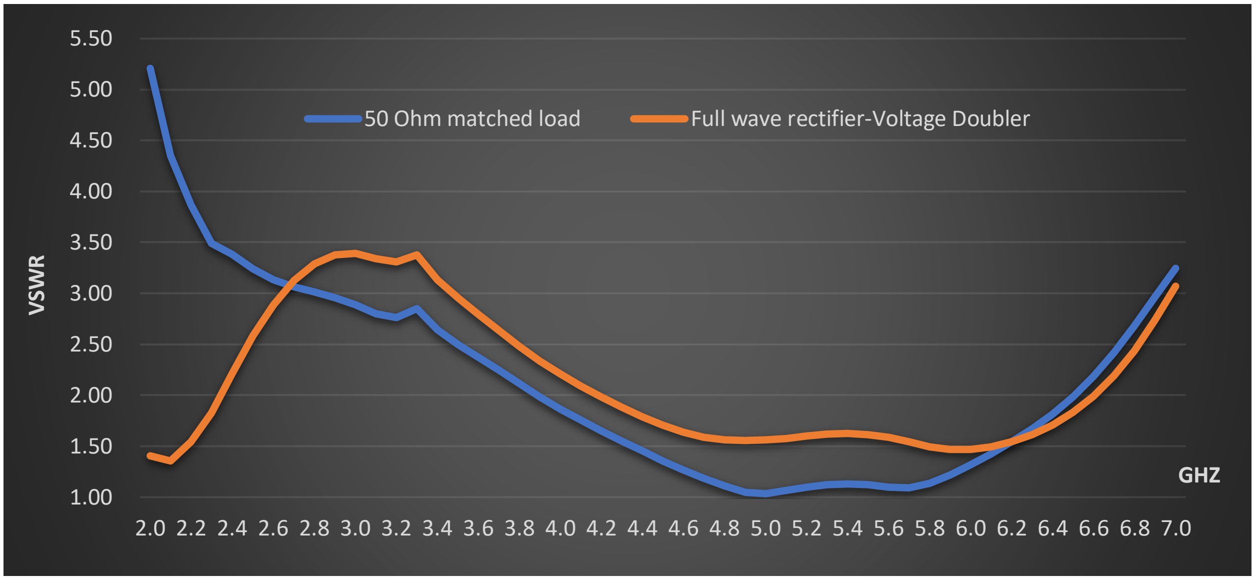


Fig. 3 A comparison between antenna and antenna incorporated with a full wave rectifier circuit on VSWR for 2.0 GHz to 7.0 GHz which was produced by an analytical tool.

The conversion efficiency based on Figure 2 arrangement was conducted for frequencies 2.4GHz, 2.5GHz, and 5.0 GHz to 6.0 GHz. The orientation of the antenna has been adjusted for the maximum read out on DC voltage and current. A varying load-resistor was tested in the DC part of the system and the highest delivered DC power was recorded. For 25 dBm to 32 dBm transmitted power 60%-70% conversion efficiency could be achieved and shown in figure 4.

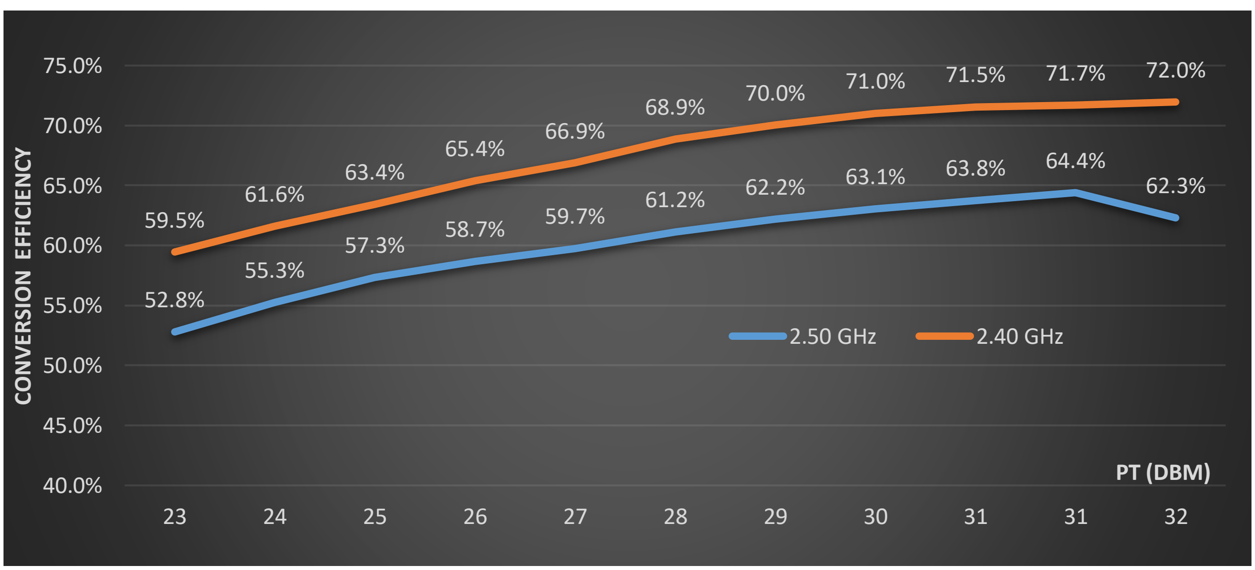


Fig. 4 Conversion efficiency is varied according to the changed on the transmitted power. High conversion efficiency in the order of 60% to 70% could be achieved for the designed system.

High conversion efficiency in the order of 50% to 70% is shown in figure 5 where impedance matching is achieved according to figure 3. The deviation on the frequency response is due to the permittivity of the substrate compared to air-substrate in the simulation and the alignment precision of the system i.e., antenna height above a ground plan, maximum radiation pattern.

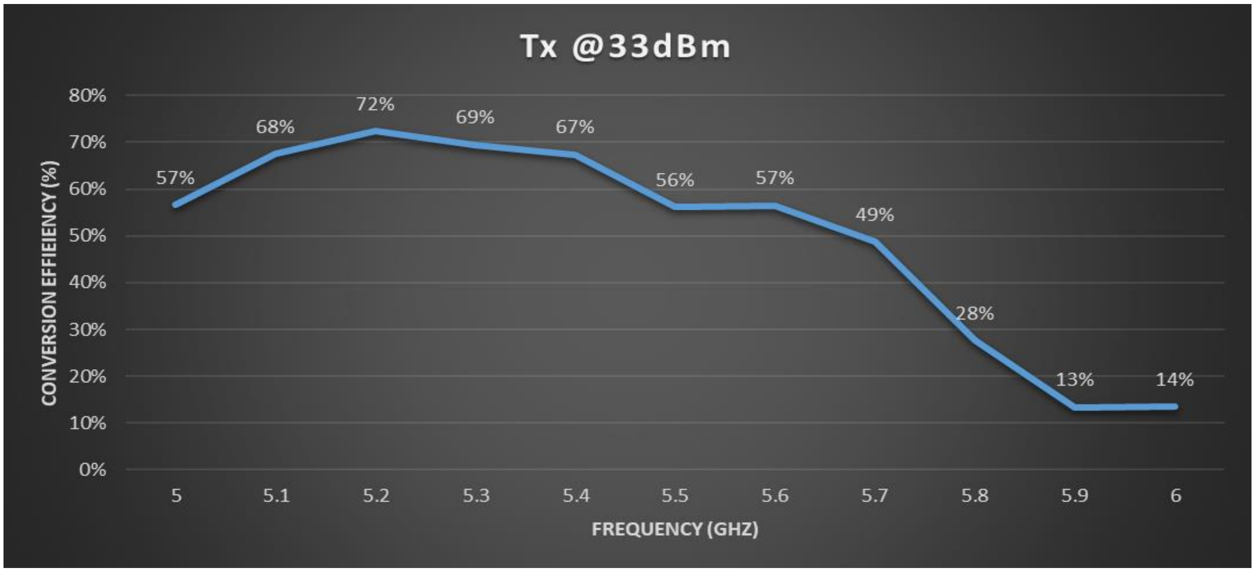


Fig. 5 Conversion efficiency for 5.0GHz to 6.0GHz for transmitted power of 33 dBm

The antenna and the system were designed under the most possible simplest form concept such as load matching is accomplished by changing the characteristic impedance of the antenna, its orientation within the array, a planar structure and printable on a substrate, and minimizing the number of diodes in the full wave rectifier circuit.

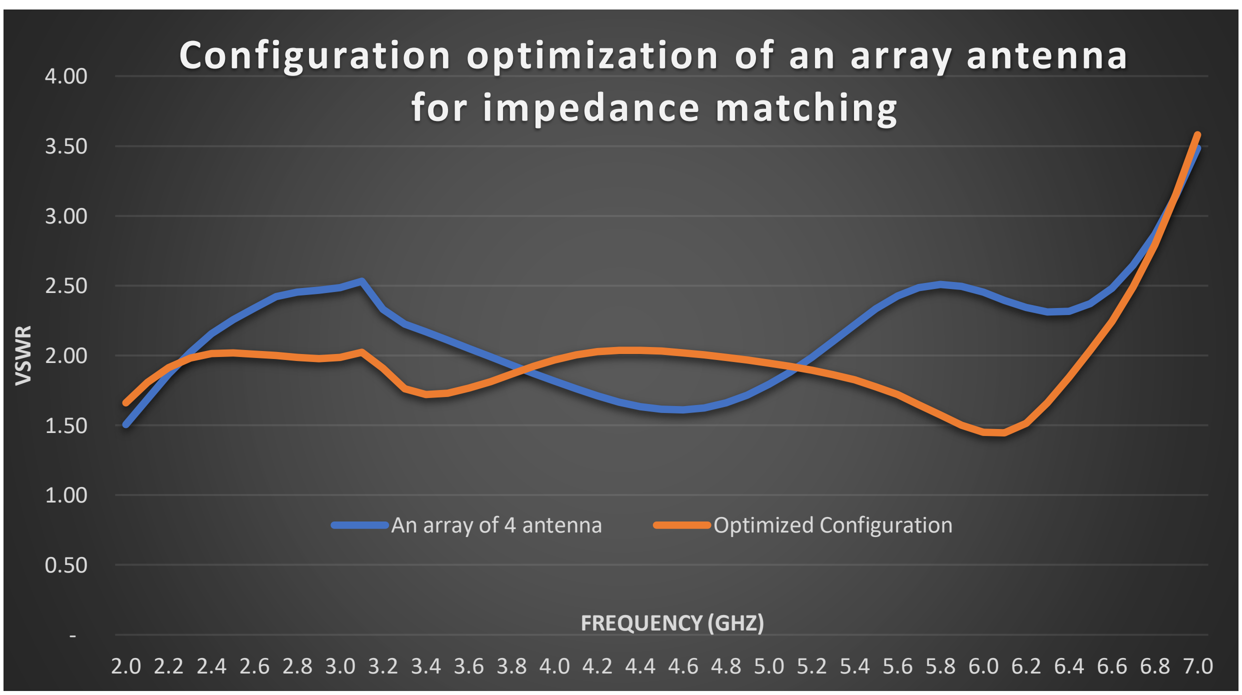


Fig. 6 By simulation tool, the impedance matching profiles of an array of 4 antenna which each of them incorporates rectifying diodes as part of the voltage doubler full wave rectifier circuit.

All in all, this is aiming for easing the implementation process at light spectrum. A demonstration on controlling the impedance matching profile of the antenna and the rectifying diode is shown in figure 6. After the optimization on the antenna configuration the return loss of the interconnected elements is decreased for operation frequencies from 2.0 GHz to 6.5GHz. Furthermore, by arranging this dual polarization antenna in an array form with different orientations the randomly polarized waves of the sun light can highly be harvested.

Implementation Plan

The energy of the solar spectrum spans from Infrared to UV which the visible and the near-infrared bands hold a major part of it. Silver and Aluminum nano-dipole antenna on glass (SiO_2) substrate were reported for the higher radiation efficiency compared to other materials such as Gold, Copper, and Chromium. Another report presented that Nickel is a perfect conductor at IR frequency and was used as the antenna material for incorporating the Metal-Insulator-Metal (MIM) rectifying diode. The total efficiency on energy harvesting and long wavelength IR detection (LWIR) were experimented. Nonlinearity and responsivity of the proposed MIM diode were demonstrated successfully for the operation at frequencies up to 30THz. Nevertheless, the impedance matching between the antenna and the rectifying diode is still being the biggest challenge in this field. Another promising for rectifying the transferred current from the optical rectennas, the Geometric diode, was experimented and reported for a superior performance over the MIM rectifying diode according to their lower RC time constant.