Photovoltaic Cell Antenna

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Photovoltaic (PV) cells are now common place in home appliances and consumer devices, such as wearable electronics, as a primary or alternative energy source. The metallic PV cell components can also be used as (parts of) an antenna for a radio frequency (RF) transceivers. In this work, both functions are combined to realize a novel PV cell antenna for increased compactness and reduced weight and cost.

It is typically desirable for miniature, low-power wireless systems to be compact and lightweight. This is particularly true in the case of e.g., wearables and aerospace applications. In such applications, combining the PV cell and the antenna offers potential advantages in terms of size and weight. However, the technical constraints of the PV cell on the one hand and wide range of different antenna solutions on the other hand poses significant challenges to their effective integration.

Most of the solutions published in the literature use an additional antenna element placed above the PV cell or integrated in the PV cell structure to radiate and/or receive electromagnetic (EM) waves in support of wireless communications. Many solutions use perforated metallic structures placed on top of the PV cell. Such solutions have shown low efficiency and are complex to implement. Furthermore, they may adversely impact the efficiency of the PV cell.

The solution proposed by CSEM leverages the direct current (DC) lines available in PV cells of all types and shapes. The PV cell is used as is, without any phisical modification (e.g., additional MS lines, ground plains). The DC lines can be seen as microstrip (MS) or coplanar waveguide (CPW) lines. Attached to the DC lines, the PV cell elements act as an antenna, which can be seen as load or a parasitic antenna element. Usually, Radio Frequency (RF) devices have a 50 ohm input / output circuit impedance. However, the length and shape of the PV cell impacts the impedance which influences the antenna resonance frequency. Consequently, fine tuning of the impedance matching circuit is essential.

A potential limitation of the proposed approach is that it leads to a relatively narrowband antenna. This is due to the matching circuit and the specific DC line topology. However, the antenna bandwidth limitation can be bypassed in the case of a PV cell array (e.g., PV cell elements not connected to antenna can be used as passive antenna components to improve the operational bandwidth).

In the context of an internal R&D project [1], a small flexible PV cell was used to test the resonance performance of the PV cell and evaluate the potential of using the cell as an antenna for wireless communication, as well as, a source for energy harvesting. The PV cell under test is depicted in Figure 1.

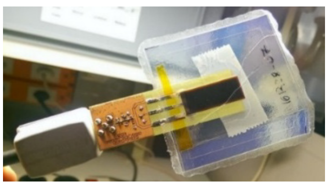

Figure 1: Solar cell element antenna prototype.

[1] C. Hennemann, *et al*., "GWAPO—Generic wireless autonomous conformable patch with display", CSEM Scientific & Technical Report (2016), 14.

An important advantage of the proposed solution is that no physical modification of the PV cell is required. A detailed block diagram of the photovoltaic cell antenna combined with a wireless transceiver is presented in Figure 2. In this block diagram, the PV energy harvesting is combined together with the RF communication. The harvested energy both from the PV cell and RF are stored in the battery to ensure stable wireless transciever operation.

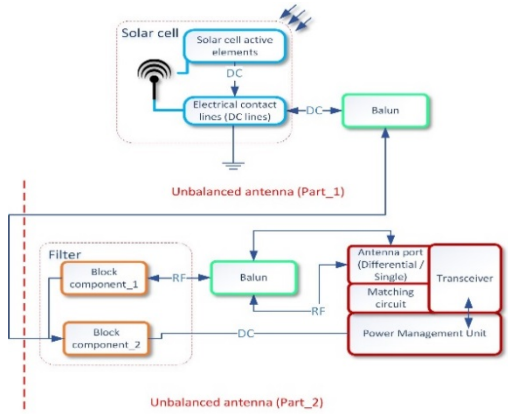

Figure 2: Block diagram of the proposed antenna system solution.

Current lab tests show that the PV cell can be used as an RF antenna together with a transceiver. Proposed antenna exhibits almost omnidirectonal radiation and has an operational bandwidth of about 30 MHz (i.e., when matched from 1.7 to 2.45 GHz) (Figure 3). The results demonstrate the potential for the integration of the antenna and the PV cell into a multi-functional hybrid PV/RF module: energy harvesting via the PV cell, RF communication (e.g., short range wireless, satellite, drones, smart straps), and device location estimation etc.

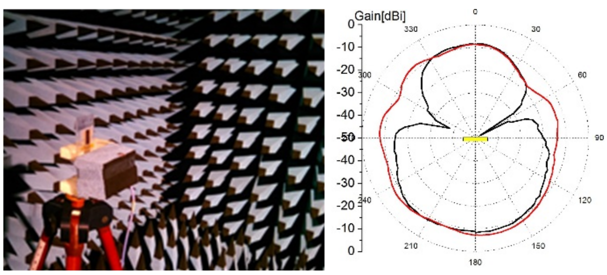

Figure 3: Antenna under test: radiation pattern measurements (CSEM anechoic chamber).

Such multi-function modules with integrated PV cell antennas are ideally suited to support sensing, actuation and remote management of autonomous devices in the future Internet of Things. Potential applications include e.g., connected cars, smart homes, wearables, security systems, and GPS, etc.