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Comparison between Fixed and Solar Oriented PV Modules' Energy Production using a Simplified PSIM Model

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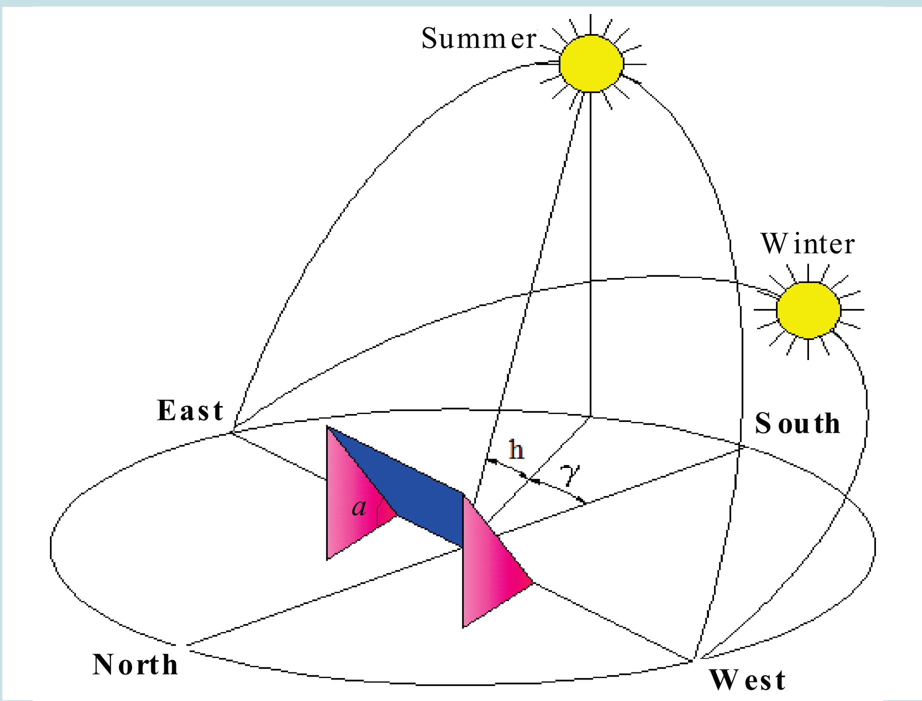
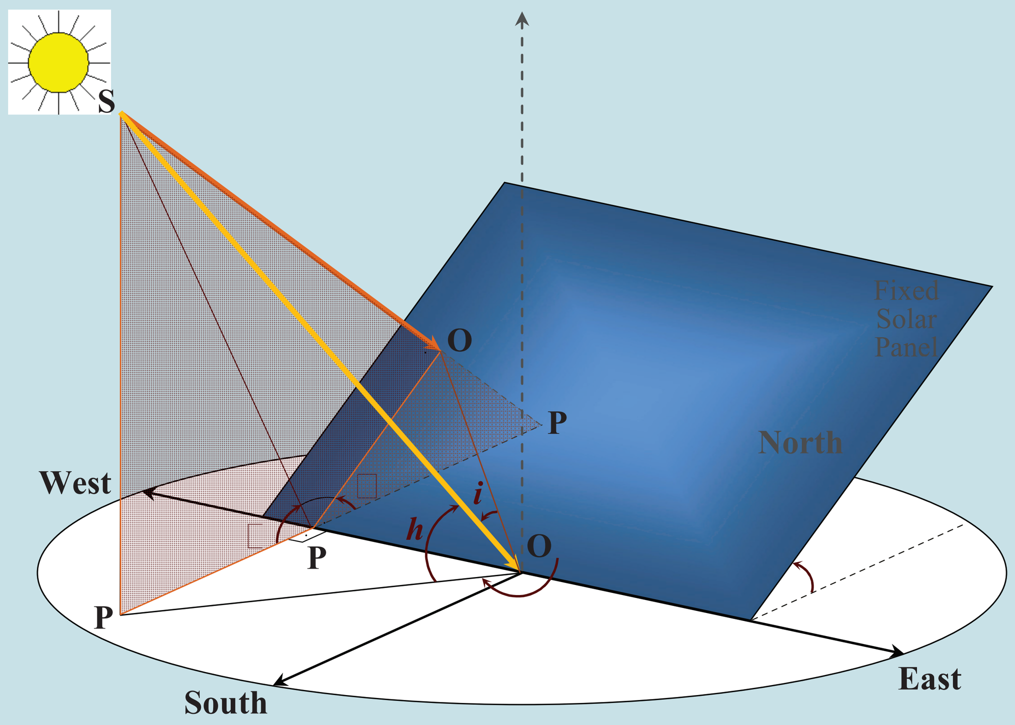
This paper presents a simplified Powersim (PSIM) model for simulating and estimating the power losses due to the change in the relative position of the sun to a fixed south oriented solar panel. The proposed equation used for describing the difference between the sun-tracking system and the fixed system is validated by testing a solar panel guidance system based on data provided by Stellarium software. The results obtained when using a fixed, a single-axis and a dual-axis tracking system are compared for different energy test reports. In summer time (Cluj-Napoca) if only the azimuth is respected, the energy production can be increased by 31%, and by 35% if the elevation is respected as well. This is compared to a fixed south oriented solar panel tilted at 45°.

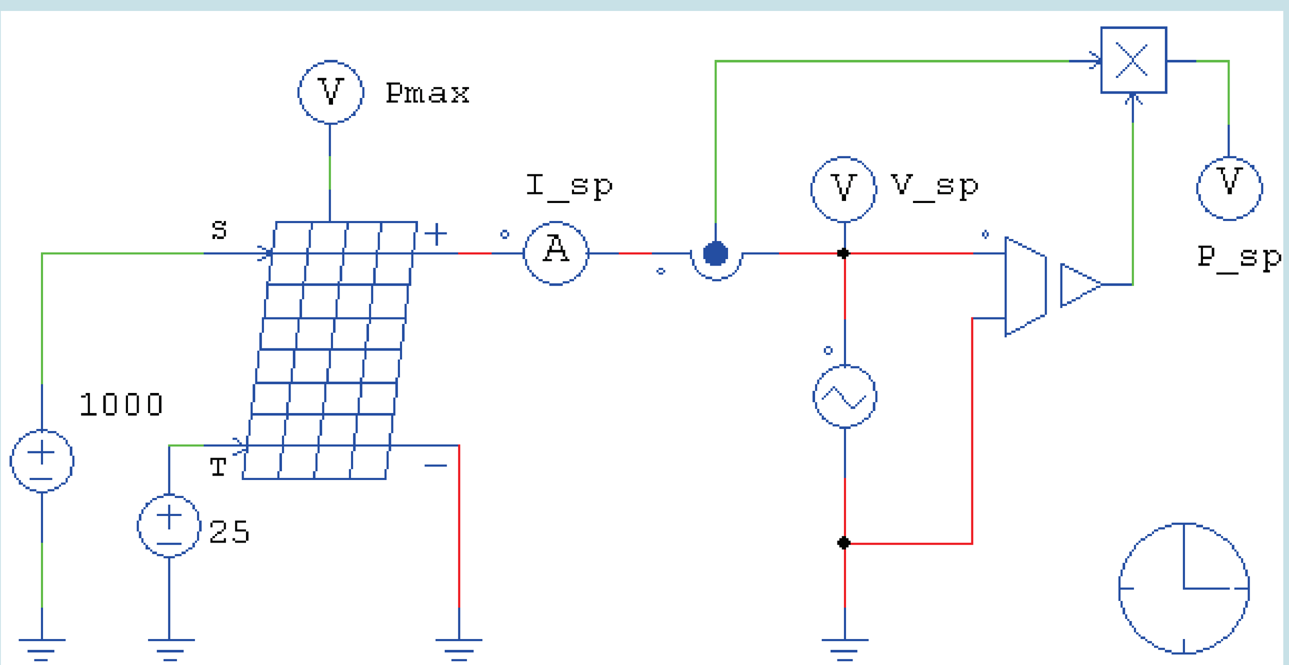


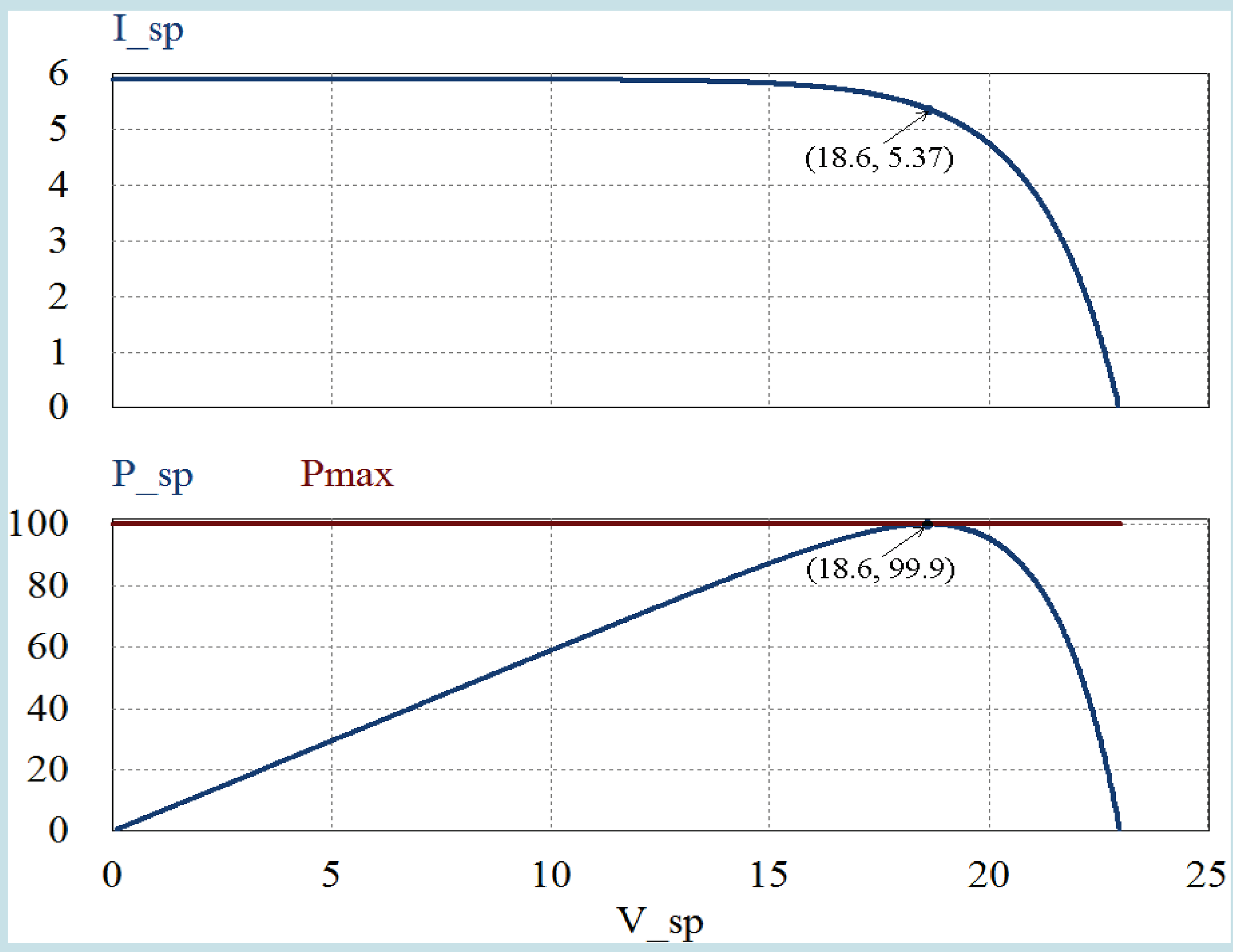


- α – tilt angle of the south oriented fixed solar panel;
- h – solar altitude or elevation angle;
- γ – solar azimuth or azimuthal angle;
- i – the incidence angle of the direct sun rays to the south oriented fixed solar panel;
- SO – the equivalent direct solar radiation on the sun oriented PV module;
- SO' – the equivalent direct solar radiation on the south oriented fixed PV module.

Figure 1. Schematic representation of a south oriented fixed solar panel and the main solar angles describing a Sun-Tracking System (STS).

$$\frac{SO'}{SO} = \frac{\sin(h)\cdot\sin\left(180-\alpha-\operatorname{arctg}\left(\frac{\sin(h)}{\cos(h)\cdot\sin(270-h)}\right)\right)}{\sin\left(\operatorname{arctg}\left(\frac{\sin(h)}{\cos(h)\cdot\sin(270-\gamma)}\right)\right)}$$





- Number of solar cells: N_s = 36 (4x9);
- Nominal maximum power: P_{MPP} = 100W;
- Maximum power voltage: V_{MPP} = 18.64V;
- Maximum power current: I_{MPP} = 5.36A;
- Open circuit voltage: V_{oc} = 22.73V;
- Short circuit current: I_{sc} = 5.9A

Figure 2. The simplified PSIM solar panel model (left) and the simulation results (middle) for the ODA100-18-M solar module (right).

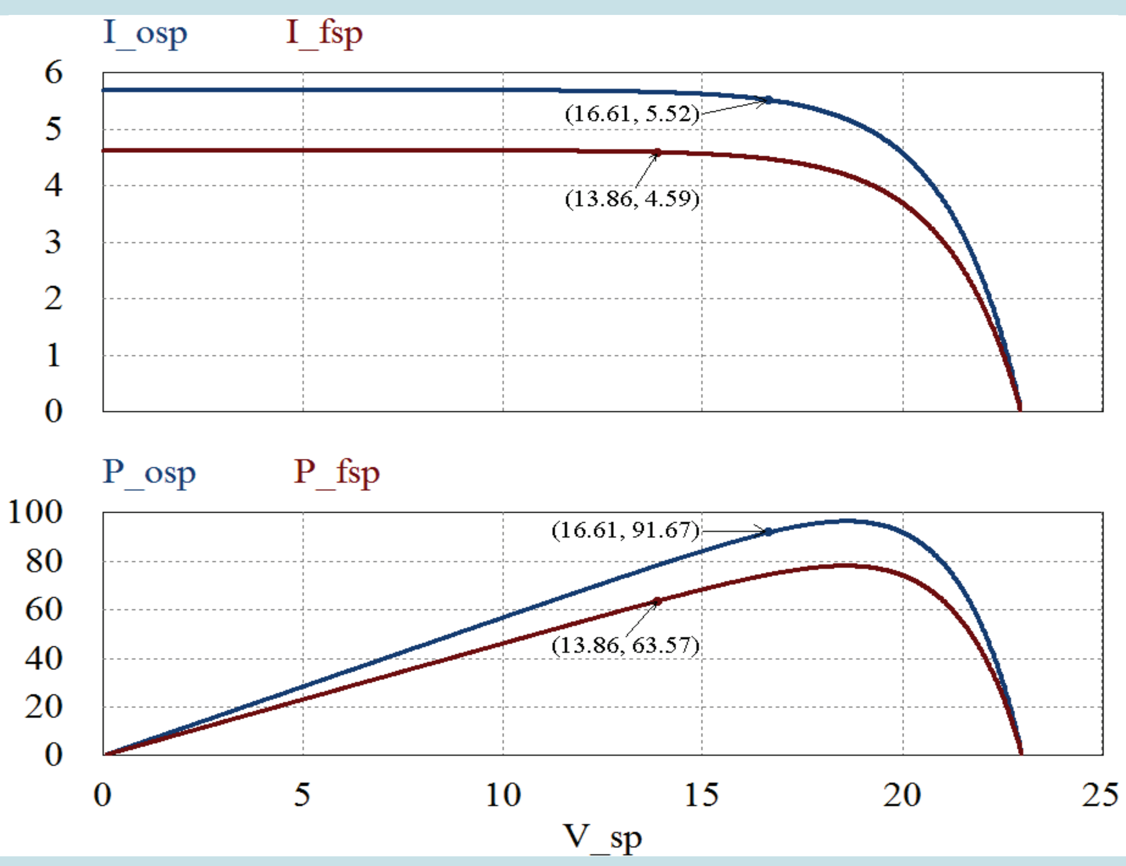


Figure 3. Comparison between the results obtained with the OSP and FSP at 11:10 o'clock, when FSP is tilted at 30°. (irradiations: SO ≈ 965W/m^2, SO' ≈ 784W/m^2, experimental PV outputs: I_fsp = 4.63A,V_fsp = 13.86V; P_fsp = 63.57W

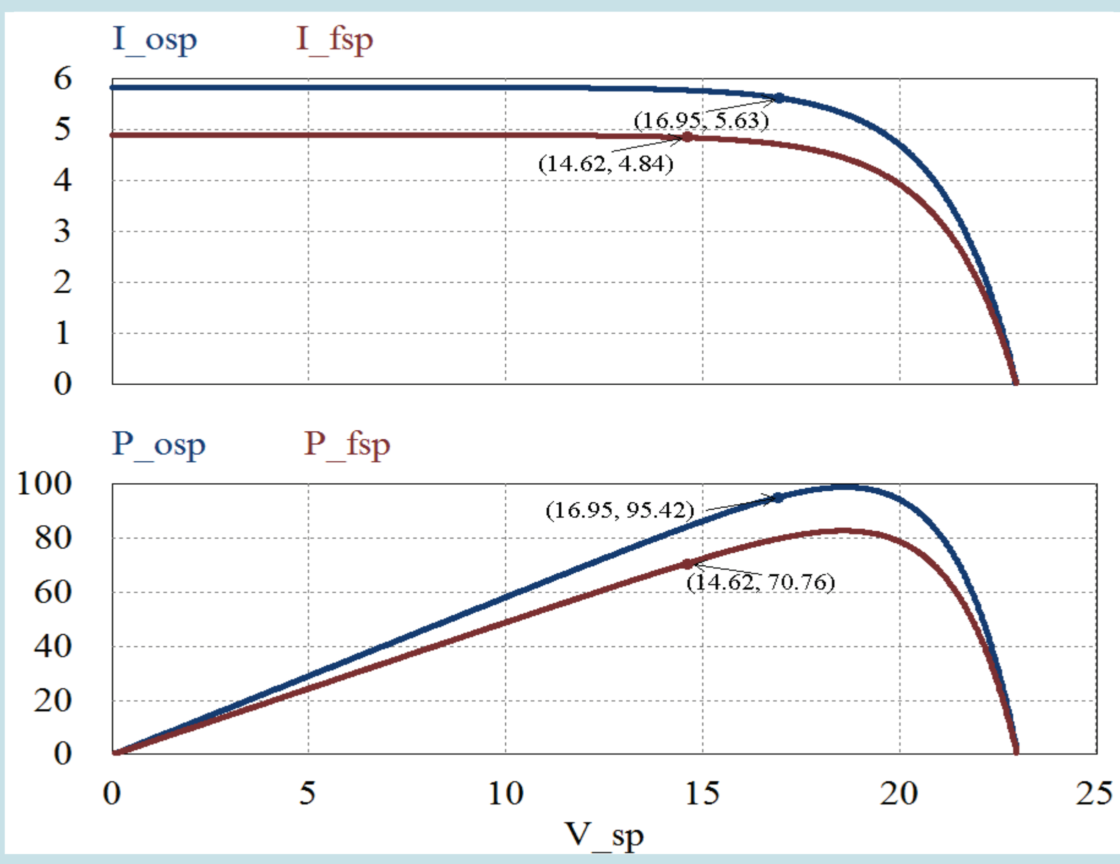


Figure 4. Comparison between the results obtained with the OSP and FSP at 15:00 o'clock, when FSP is tilted at 45°. (irradiations: SO ≈ 990W/m^2, SO' ≈ 831.6W/m^2, experimental PV outputs: I_fsp = 4.85A,V_fsp = 14.62V; P_fsp = 70.90W

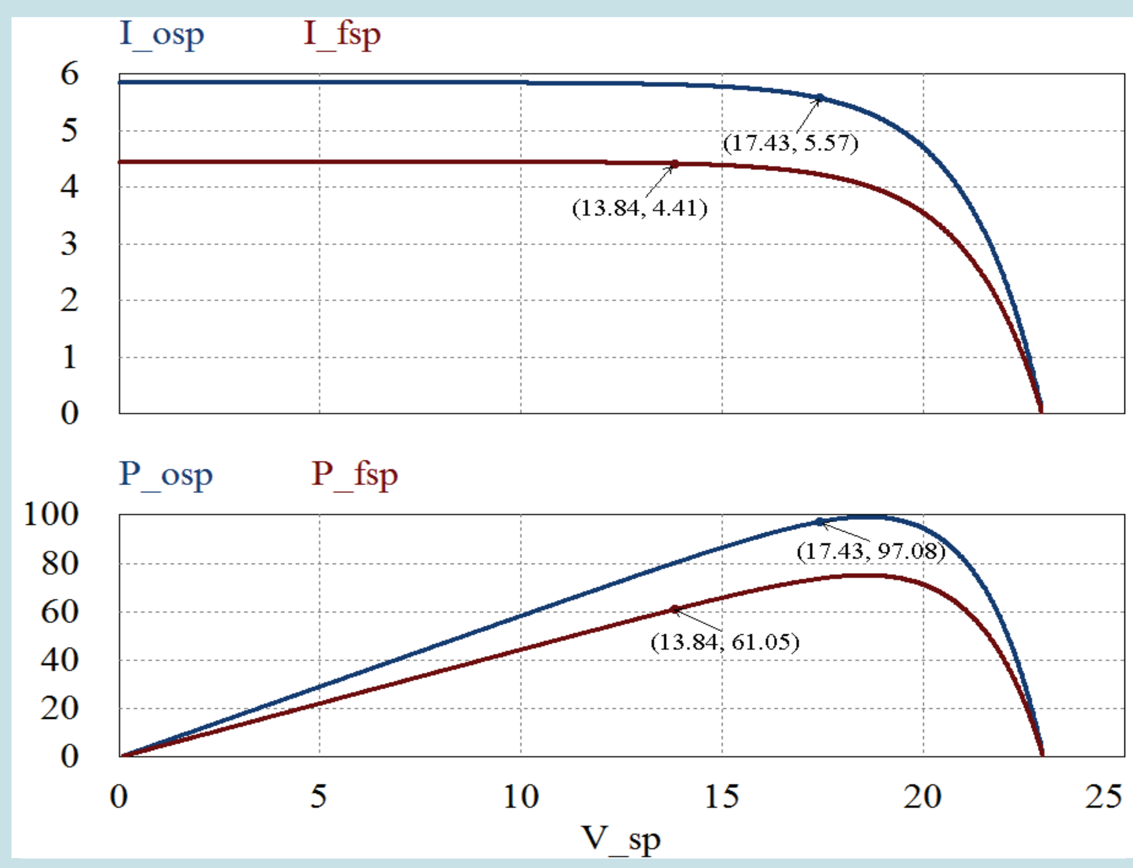


Figure 5. Comparison between the results obtained with the OSP and FSP at 12:20 o'clock, when FSP is tilted at 60°. (irradiations: SO ≈ 991W/m^2, SO' ≈ 754W/m^2, experimental PV outputs: I_fsp = 4.57A,V_fsp = 13.73V; P_fsp = 62.73W

Conclusions

This paper aims to bring improvements in PV conversion process by tracking the PV modules to the sun, according to the data provided by Stellarium software. In this way the energy production of solar panels can be enhanced, improving the use of solar energy available at a certain moment by using dual-axis sun oriented mechanisms. The PSIM model used to simulate the PV module characteristics has the advantage of simplicity and it can be adapted easily to any solar panel. The equation describing the ratio between the equivalent irradiations on the south oriented Fixed Solar Panel (FSP) and sun Oriented Solar Panel (OSP) is an estimative one, but it can be successfully used when the differences between FSP and OSP angles are small.

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