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Simulink model of a bifacial PV module based on the manufacturer datasheet

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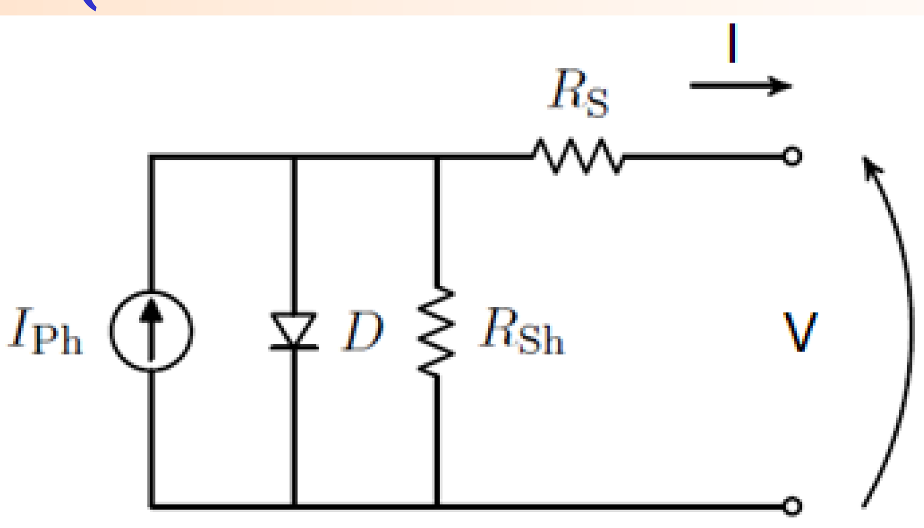
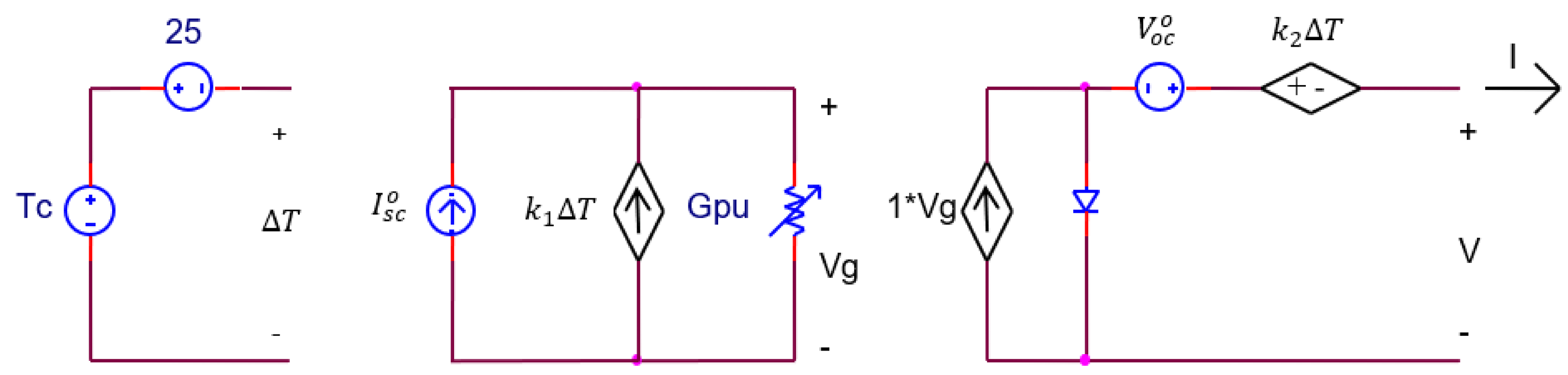
Five parameters model in STC (Standard Test Conditions)

Abstract. The paper proposes an update of a mathematical model of a Photo-Voltaic (PV) module, considering the possibility that also the rear face of the PV module produces energy. The proposed approach is based on the manufacturers' datasheet. No pre-processing of the datasheet's parameters is needed to use the proposed model, whichever are the solar irradiance and the cell/module temperature. The model considers the total solar radiation (front and back side). Simulink environment is used to calculate the total solar radiation.



$$I = I_{Ph} - I_o\left(e^{-\frac{q(V+I\cdot R_s)}{nkT_c}} - 1\right) - \frac{V + I\cdot R_s}{R_{sh}}$$

Model in any environment condition and rear solar radiation



$$I = G_{pu}\cdot(I_{sc}^o + k_1\cdot\Delta T) - \beta\cdot e^{\alpha\cdot\frac{T_c}{25}\cdot(V + k_2\cdot\Delta T - V_{oc}^o)}$$

$$I_{Rear} = \alpha DNI\cdot\frac{1+\cos\beta}{2} + \alpha(GHI - DNI)\cdot\left(\frac{1+\cos\beta}{2} - F_m\right)$$

with

$$DNI = 1367\cdot 23.45°\sin\left[\frac{360(d_n+284)}{365}\right]\cdot 0.7^{AM^{0.678}}\cdot\cos\theta_{ZS}$$

I_{Rear}: total rear irradiance;
DNI: Direct Normal Irradiance;
GHI: Global Horizontal Irradiance;
α: albedo coefficient;
β: installation inclination;
F_m: depending on the view factor;
d_n: day from the starting year;
AM: Air Mass;
θ_{zs}: angle between the direction perpendicular to the ground and the sun.

$$I_{total} = I + I_{Rear}$$

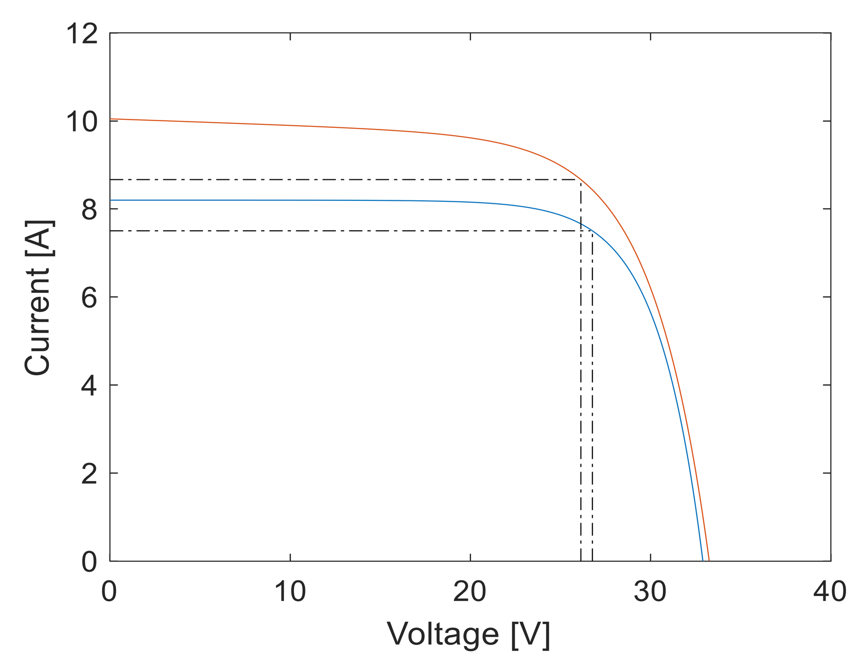
Results for I-V and P-V curves of mono-facial (blue) and bi-facial (red) PV module

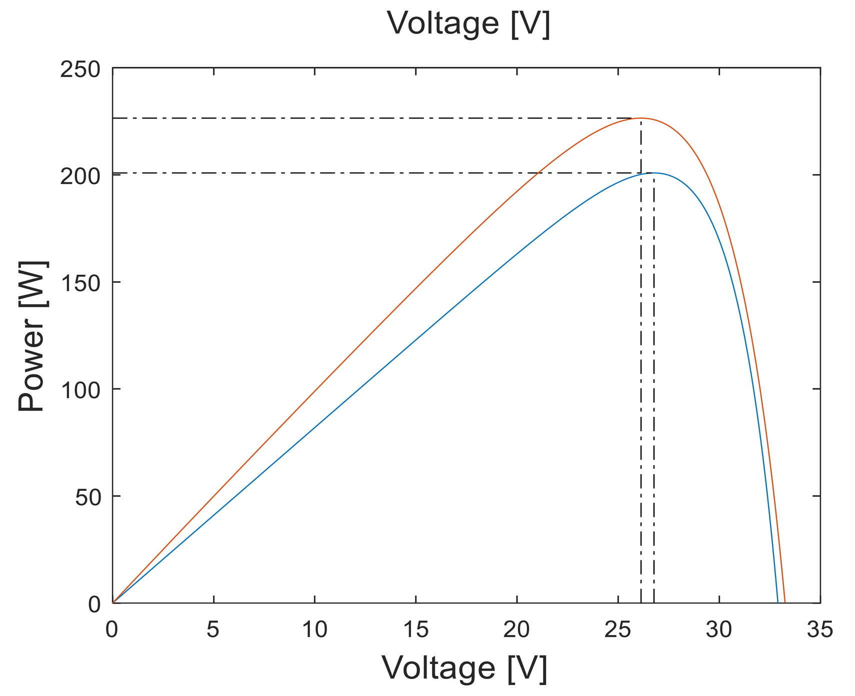
PV module	
Parameter	**Value**
Voc	32.9V
Vmpp	26.3V
Isc	8.2A
Impp	7.6A
Pn	200W
k1	0.0032 A/K
k2	-0.123 V/K

By comparing the curves in the Figs, results that:

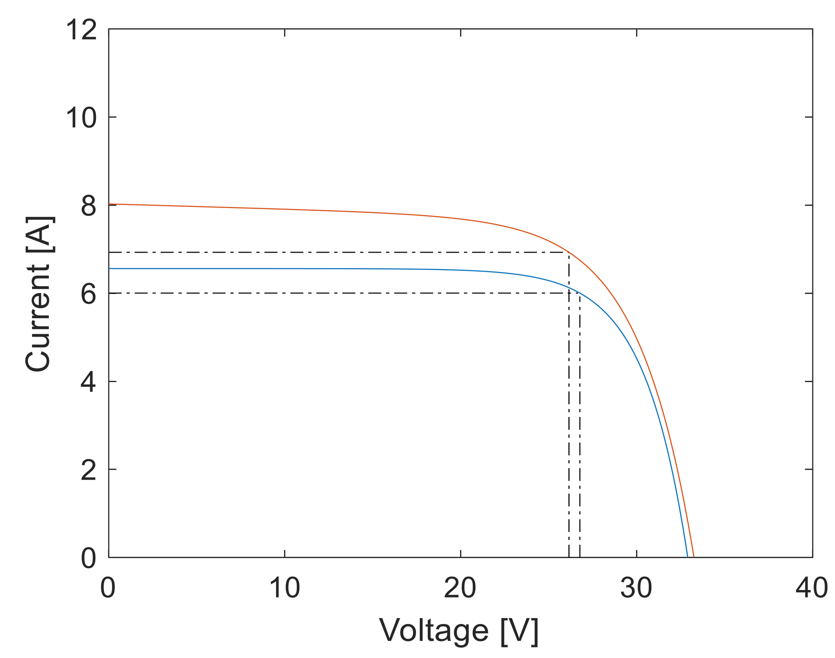
- I_{sc} increases;
- I_{mpp} increases, thanks to the I_{rear};
- V_{oc} has almost the same value;
- V_{mpp} has a similar value;
- P_n increases from 200W to 226W, i.e. of about 13%.

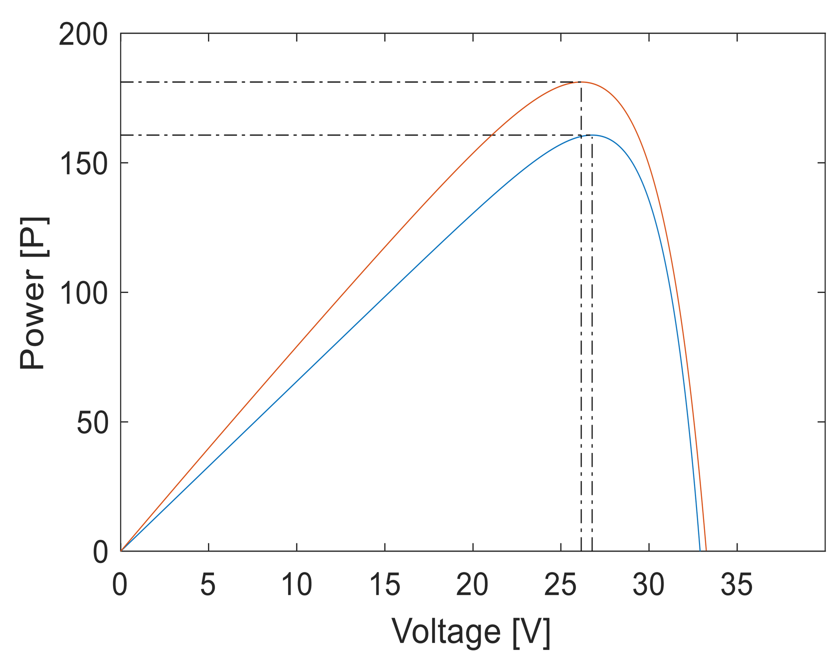
in STC: G=1000W/m² and Tc=25°C;





in other conditions: G=800W/m² and Ta=20°C;





Conclusions

1. The proposed model of a bifacial PV module is based on the model of a mono-facial PV cell and the model of the rear radiation.
2. The proposed bifacial model is constituted by two sub-circuits, one for the front side and the other one for the back side.
3. The simulation results highlight that the bifacial module produces 13% energy more than the mono-facial one.
4. This technology is promising, because it increases the power density of the PV plants.
5. The effect of the shading on the rear side is not solved, differently from the same issue on the front side.
6. The electronic equipment to separately acquire the electrical variables of both front and rear side is not available.
7. The typical defects of the rear side are not known.