Case Study 2: Classical MPPT *vs.* MPPT with Wind Turbulence as Searching Signal

This case study contains 2 applications corresponding to the two types of MPPT algorithm: the classical one, using the hill-climbing method, and another one, which uses extremum seeking control methods. These applications are described below.

1. Uses the mdl-file named `mppt1.mdl`

   Scope: Evaluation by numerical simulation of the *hill-climbing* (gradient) searching method used to maximize the captured power of a low-power SCIG-based wind turbine.

   Application analysis: The file `data_mppt1.m` contains the system data. The mdl-file is organized as follows. At the right is placed the plant (also containing the inner torque control loop), whereas at the left one can see, from up to down: the system data loading button, the scopes and some computation/display blocks (containing, for example, the active power calculation), the outer control loop implementing the MPPT algorithm and the speed control loop (employing some conditioning operations). The SCIG model is coded in the `asmcn.m` s-function; a pre-computed wind speed sequence can be found in `vntu.mat` file.
   One can use multiple wind velocity sequences/profiles for testing the controlled system behaviour, selectable from the wind speed generator. The interaction between the WECS and the electrical grid cannot be changed. The WECS implementation comprises the turbine, the drive train, the induction machine and the generator-side inverter. The electrical grid has been taken as ideal, because the grid interface is not of interest in this application. The MPPT control parameter, `k`, and the sampling time are the adjusting elements of the control law efficiency. Some additional improvements can be achieved by adjusting the parameters of the PI speed controller or by choosing a more accurate method of estimating active power and rotational speed gradients.

   Running the application:
   Step 1: Load system parameters.
   Step 2: Select the wind velocity sequence according to your test needs.
   Step 3: Select from the menu “Simulation → Parameters” a convenient time horizon and proceed with the simulation.
   Step 4: Dynamical system behaviour can be overviewed by opening the scopes (left-upper part of the application file). Operating point position and/or its variation around the ORC can be plotted using the LSS mechanical power and rotational speed data (vectors `pwrl` and `omgl`) saved in the workspace from the corresponding scopes.

   Remarks: During its start-up the system works at constant speed; after few moments the control automatically switches to the MPPT algorithm. This strategy was chosen because the MPPT control law starts working after the system has reached a “normal” operating point; the integrator used by this algorithm has the corresponding value of the rotational speed as initial state. But this strategy can be changed by the user, if desired.

2. Uses the mdl-file named `mppt2.mdl`

Scope: Evaluation by numerical simulation of the *extremum seeking control* method used to maximize the captured power of a low-power SCIG-based wind turbine.

Application analysis: The file `data_mppt2.m` contains the system data. The mdl-file is organized as follows. At the right is placed the plant (containing the inner torque control loop), whereas at the left one can see, from up to down: the system data loading button, the scopes and some computation/display blocks (containing, for example, the active power calculation), the outer control loop implementing the MPPT algorithm and the speed control loop (employing some conditioning operations). The SCIG model is coded in the `asmcn.m` s-function; a pre-computed wind speed sequence can be found in `vntu.mat` file.

One can use multiple wind velocity sequences/profiles for testing the controlled system behaviour, selectable from the wind speed generator. The interaction regime between the WECS and the electrical grid cannot be changed. The WECS implementation comprises the turbine, the drive train, the induction machine and the generator-side inverter. The electrical grid has been taken as ideal, because the grid interface is not of interest in this application. The adjusting elements of the control law efficiency are:

- the MPPT control (integrator) parameter, `k`;
- the sampling time, `tes`;
- the number of `tes` intervals for computing the FFT (computation time);
- linear approximation coefficients (denoted as `aa` and `bb` in the application), used to obtain the operating point position from the average phase lag signal.

Some insignificant improvements can be achieved by adjusting the parameters of the PI speed controller.

Running the application:

Step 1: Load system parameters.

Step 2: Select the wind velocity sequence according to your test needs.

Step 3: Select from the menu “Simulation → Parameters” a convenient time horizon and proceed with the simulation.

Step 4: Dynamical system behaviour can be overviewed by opening the scopes (left-upper part of the application file). Operating point position and/or its dispersion around the ORC can be plotted using the LSS mechanical power and rotational speed data (vectors `pwrl` and `omgl`) saved in the workspace from the associated scopes.

Remarks: During its start-up the system works at constant speed; after few moments the control automatically switches to the MPPT algorithm. This strategy was chosen because the MPPT control law starts working after the system has reached a “normal” operating point; the integrator used by this algorithm has the corresponding value of the rotational speed as initial state. But this strategy can be changed if the user needs so.