Case Study 3: 2 MW WECS Optimal Control by PI Speed Control

This case study contains an application which implements the WECS optimal control using a PI-based rotational speed control loop. This application uses the mdl-file named `PI_speed_ctrl.mdl` and is described below.

Scope: Evaluation by numerical simulation of the control method aiming at preserving the optimal tip speed ratio in order to maximize the captured power of a high-power fixed-pitch SCIG-based wind turbine. The outer control is a rotational speed loop, whose reference is computed based on the wind velocity measurement and on the optimal tip speed ratio. The error is zeroed by means of a PI controller.

Application analysis: The file `data_PIspeed.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 speed control algorithm and also 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 rigid 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 PI control parameters, T_i and K_p (which can be found in the block labeled `Rotational Speed Control`), are the adjusting elements of the control law. The wind velocity has to be filtered in order to limit the speed reference variations to reasonable values.

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 corresponding scopes. The histograms of the tip speed ratio and of the speed error can be plotted using the following procedure:

```
lam1=lam(1000:length(lam),2);     % uses the tip speed sequence data stored by
                                  % the associated scope
[hst,ics]=hist(lam1,100);         % histogram with 100 bins
plot(ics,hst/length(lam1),'k');   % normalisation
```

Step 5: Change the PI controller parameters (in the outer control block) and restart the simulation.

Remarks: During its start-up the system works at zero electromagnetic torque; after few moments, when the rotational speed reaches a normal operating value, the reference automatically switches to the one issued by the PI speed control algorithm. The start-up strategy can be changed by the user, if needed.