Next edition of IEC 61400-27

Electrical simulation models for wind power plants

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***Abstract*—The purpose of the IEC 61400-27 standards series is to provide dynamic wind power plant models to be used in power system stability studies. This paper provides a brief overview of the state-of-the-art for the development of a new edition of the IEC 61400-27 series which includes generic wind power plant models in addition to the wind turbine models published in the first edition of IEC 61400-27-1.**

Electrical simulation model; IEC standard; grid protection system; aerodynamics; reactive power capability; generator reference frame rotation; frequency measurement; Common Information Model.

I. INTRODUCTION

The purpose of the IEC 61400-27 standards series is to provide an international standard for dynamic wind power plant models to be used in power system stability studies. The dynamic models are intended for short term voltage stability and short term frequency stability studies.

The North American Electric Reliability Corporation (NERC) and the Western Electricity Coordinating Council (WECC) in USA have published similar models [1], [2]. Although the IEC working group has collaborated closely with the WECC working group, there are small differences between the approaches [3].

The 1st edition of Part 27-1 was published in February 2015 [4], providing specification and validation procedures for wind turbine models.

Originally, the plan was to supplement the published Part 27-1 with a Part 27-2 for wind power plant models. However, in order to avoid excessive duplication from Part 27-1 to Part 27-2, a new structure of the IEC 61400-27 series was proposed and accepted [5].

According to the new structure, the next edition of the IEC 61400-27 series shall consist of a Part 27-1 with specifications of generic models for wind turbines and wind power plants, and a Part 27-2 providing validation procedures for wind turbine and wind power plant models.

Those parts will be published simultaneously replacing the existing Part 27-1. Committee drafts of those publications were circulated to national standardization committees in October 2016, and committee drafts for voting (CDV's) will be circulated later in 2017. Thus, publication of the new standards can be expected in early 2019.

This overview paper is organized as follows:

Chapter II describes the generic wind turbine models.

Chapter III describes the generic wind power plant models.

Chapter IV describes the validation procedures.

Chapter V describes the dissemination of the generic models and validation procedures.

Chapter VI concludes the paper.

II. WIND TURBINE MODELS

A. Wind turbine types

IEC 61400-27 specifies generic models for the four grid connection types for wind turbines installed today. Those four types were originally classified as A,B,C,D in the literature [6], but today they are commonly denoted as 1,2,3,4. The different types are characterized by:

- Type 1. Directly connected induction generator (with fixed rotor resistance).
- Type 2. Directly connected induction generator with variable rotor resistance.
- Type 3. Doubly fed asynchronous generator with converter on rotor circuit
- Type 4. Generator connected through full scale converter

B. First edition

The general modular structure of the wind turbine models published in the 1st edition is shown in Figure 1 [7]. The horizontal sequence of blocks in the middle reflects the physical power flow, while protection and control is shown above and below respectively.

Depending on the type of wind turbine, some of the modules are omitted, but all wind turbine model types include submodels for generator system, electrical equipment and grid protection.

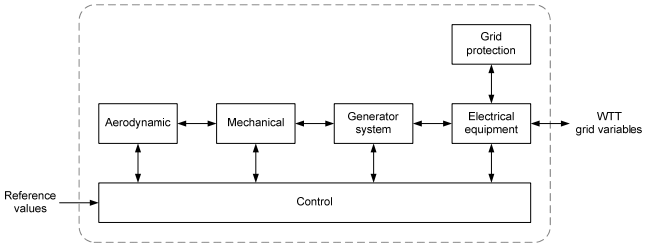

Figure 1. General modular structure of 1st edition wind turbine models [7].

C. Second edition wind turbine models

Focusing on development of wind power plant models for the 2nd edition models, the 2nd edition wind turbine models are very similar to the 1st edition wind turbine models. However, the modular structure of the wind turbine models will be expanded in the 2nd edition as shown in Figure 2

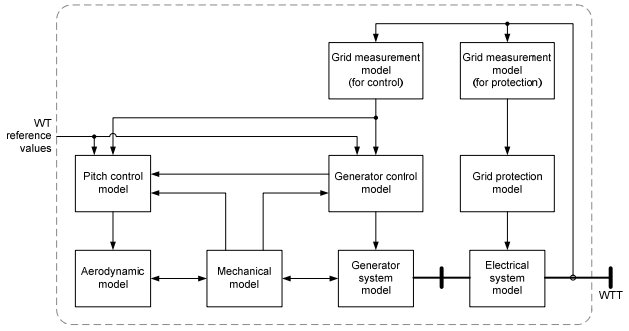

Figure 2. General modular structure of 2nd edition wind turbine models.

The first change compared to the 1st edition structure in Figure 1 is the separation of the original control model into a pitch control model and a generator control model.

The second change in the new structure Figure 2 is the extraction of the grid measurement model from the control models and grid protection models respectively. This change is done to avoid duplicate specification of grid measurement models, not only in the wind turbine model shown here, but also in the wind power plant model shown in next chapter.

Other minor changes have been made inside sub-model diagrams keeping same structure. Those changes enhance the capability of the models to include different performances from manufacturers but also allow reproduce same performance as previous edition . The main sub-models affected are:

1. P control type 3, in which rotor speed can be optionally used instead of generator speed to consider a drive train damping oscillation filter without the need of a second order or higher filter or generator speed can be optionally used to calculate maximum torque instead of reference speed.
2. Pitch control type 3, in which in version 1 ramp rates and hard limiters shared same parameters but in edition 2 dedicated parameters are included to allow improvements in control performance.
3. Q control model, in which reactive current absorption has been included to model HVRT function.

III. WIND POWER PLANT MODEL

A. Structure

The 2nd edition will define wind power plant models within the general modular structure shown in Figure 3. Here, WP is used as abbreviation for wind power plants, WT for wind turbine, AUX for auxiliary equipment such as STATCOM and PD for either WT or AUX.

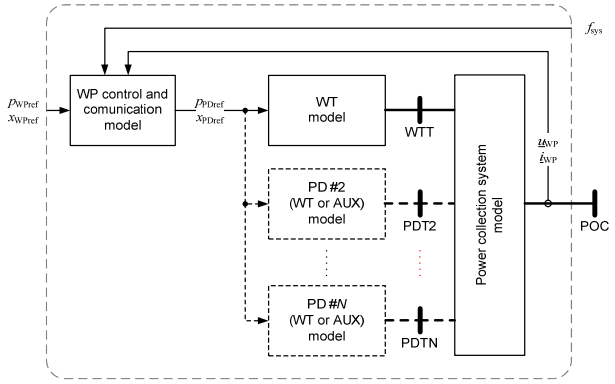

Figure 3. General modular structure of the wind power plant model.

The idea with this structure is that it can be used for different granularities of models. Thus, the structure applies to a simple and often sufficient wind power plant model consisting of models for a plant controller, a single aggregated wind turbine model and a simple aggregated model for the power collection system. On the other hand, for instance to represent a wind power plant using auxiliary reactive power compensation equipment and / or consisting of different wind turbine types.

B. Control and communication

A 1st version of the WP control and communication model was published as models for "voltage and reactive power controller" and a "frequency and active power controller" respectively in an informative annex of the 1st edition of IEC 61400-27-1.

The WP control and communication block for the 2nd edition WP models is further detailed in Figure 4. The grid measurement block is the same as the one already used twice in the wind turbine model, and likewise duplicate specifications of communication models are avoided using the same model but allowing for different model parameters.

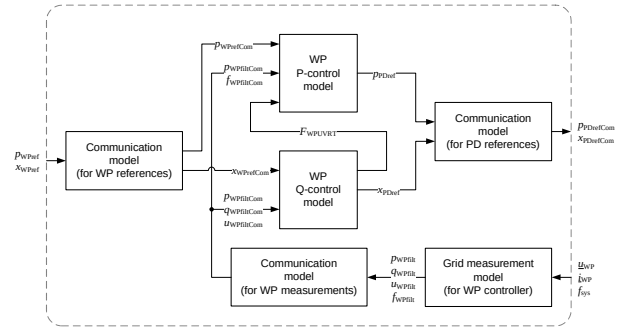

Figure 4. General modular structure of the wind power plant control and communication block.

C. Power collection system

The power collection system model in Figure 3 is conveniently described by a single line diagram specifying

the connection of wind turbines, transformers, lines and auxiliary equipment.

Figure 5 shows the single line diagram for the basic wind power plant model, i.e. with a single aggregated model representing all the wind turbines in the plant, a wind turbine transformer model (TRWT), an aggregated model for the lines (ACL) and a wind power plant transformer model (TRWP).

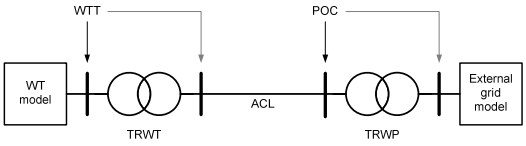

Figure 5. Single line diagram for the basic wind power plant model

More comprehensive single line diagrams can be used, for instance to represent a wind power plant using auxiliary reactive power compensation equipment and / or consisting of different wind turbine types.

IV. Model validation

The second version of validation procedures will be published in the 1st edition of IEC 61400-27-2. The main change in the second version is to include validation of wind power plant models.

The procedure for model validation of the wind turbine models is based on tests specified in IEC 61400-21 [8]. A corresponding standard for tests of wind power plants is initiated as part of the IEC 61400-21 series, but those test procedures are not yet described.

Therefore, IEC 61400-27-2 will recommend using other tests for validation. One option is to use commissioning tests, which usually include at least active and reactive power control. Another option is to test a wind power plant controlling a single wind turbine subjected to a voltage dip. Finally, if no tests are available, then model-to-model validation may be applied to validate the generic models specified in Part 27-1 against more detailed manufacturer models.

Results applying the wind turbine model validation procedure has already been published in [9], [10], [11]. Besides, the power factor mode of the voltage and reactive power controller of the wind power plant has been validated [12].

V. Dissemination

IEC Technical Committee TC57 deals with the scope power systems management and associated information exchange. As part of this scope, TC57 has issued a standard IEC 61970-301 [13], which defines the basics of the Common Information Model (CIM) for exchange of the static data of elements of the power systems.

Currently, a new standard IEC 61970-302 is under development for exchange of dynamic data [14]. This CIM dynamics standard is based on available standardized IEC or IEEE models which are already used models in dedicated power system simulation software packages. The CIM dynamics standard will use the models specified in IEC 61400-27-1 to represent the wind power plants and related control equipment of the wind turbines.

The ENTSO-E Common Grid Model Exchange Standard (CGMES) [15] which is a superset of IEC CIM standards (including the IEC 61970 series) is used as a baseline data exchange standard among European transmission system operators for continuous exchange of information about the data for their interconnected power systems.

VI. Conclusions

The 2nd edition of IEC 61400-27-1 will include specification of *generic models* of wind turbines as well as wind power plants.

The 1st edition of IEC 61400-27-2 will include specification of *validation procedures* for models of wind turbines as well as wind power plants.

The IEC 61400-27 models have been partially validated in published literature.

The IEC 61400-27 models are disseminated representing wind power models in future IEC Common Information Model (CIM) for Dynamics Specification and in European TSO network (ENTSO-E) Common Grid Model Exchange Standard (CGMES).

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