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WECC Specifications for Modeling Distributed Generation in Power Flow and Dynamics

February 27, 2015

The specifications for modeling distributed generation, as recommended by the joint meeting of the WECC Renewable Energy Modeling TF and the WECC Load Modeling TF on November 19, 2014, are described in this document. Distributed generation (DG) is generation in small units connected at various locations in the distribution and subtransmission systems at voltage levels below that typically represented in detail in system planning studies. Therefore, DG is to be included in the "load modeling" rather than as separate generator models in the system data.

Power Flow Modeling of DG

The preferred way of modeling known (or estimated) amounts of DG is to specify the P and Q values of the DG as separate entries in the power flow "load" data, including the following values:

Pdg - MW output of distributed generation

Qdg - MVAr of distributed generation (sign convention same as generators)

stdg - DG status (0 – off-line; 1 – on-line)

For executing the power flow solution, if stdg = 1, the Pdg and Qdg values will be subtracted from the constant MVA portion of the load. If stdg = 0, Pdg and Qdg will be ignored in the solution.

Load scaling – For the load scaling function, Pdg should be kept constant.

Dynamic Modeling of DG - CMPLDWG

A new version of the WECC Composite Load model, named CMPLDWG, will be used to represent both the load and DG for dynamic analysis. The load modeling will be identical to that in the present Phase 1 CMPLDW model as described in reference 1. The DG model will be added at the " load bus" as shown in Figure 1. The "system bus" is the bus where the load is represented in the power flow data.

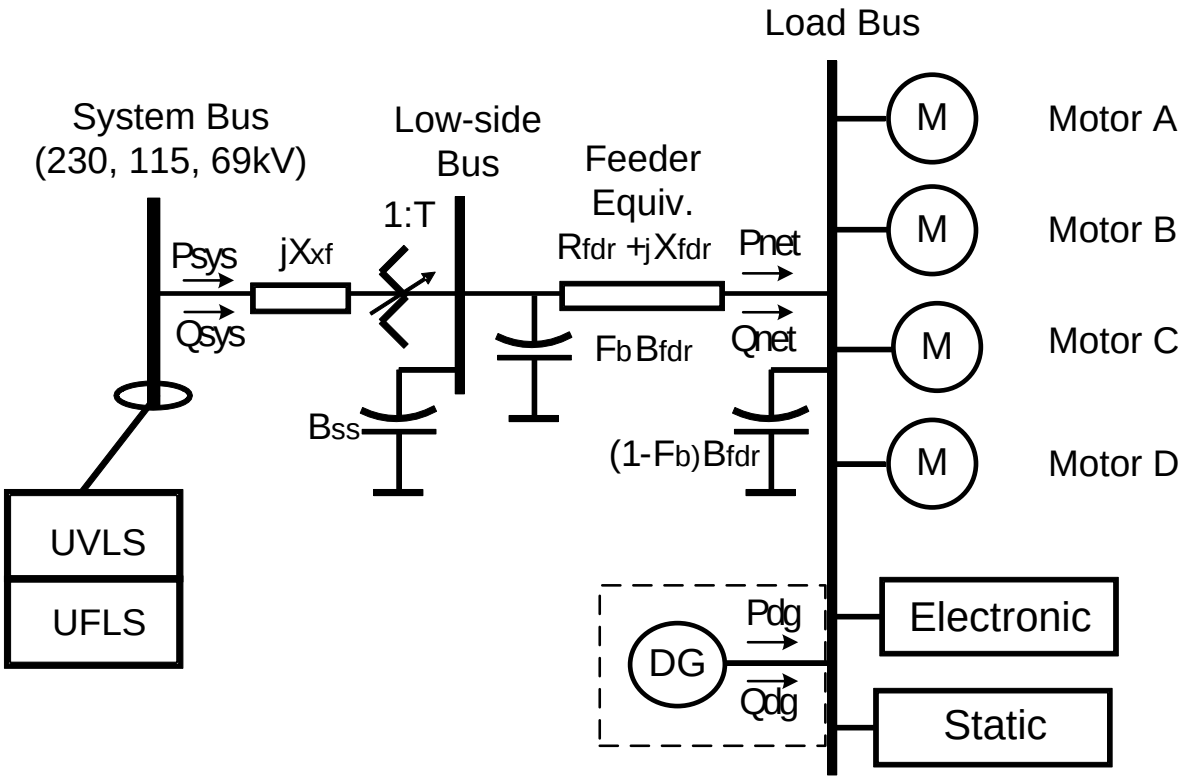

Figure 1 CMPLDWG Model Structure

Interface between dynamic model and power flow

Several options will be provided for specifying the amount of DG to be included in the CMPLDWG model. In all cases, the net values of P and Q at the system bus (Psys, Qsys) must match the values used in the power flow solution or an error condition will exist. Three input parameters (Pflgdg, Pgdg, and Pfdg) of the CMPLDWG model are used to determine the values of Pdg and Qdg, as follows:

Pflgdg = 0 - Pdg is spcified as a fraction of the **gross** load

= 1 – Pdg is specified in MW.

= 2 – Pdg and Qdg from the power flow load data are used directly

For Pflgdg = 0,

Pgdg is the **fraction** of the **gross** load to be represented as DG

Pfdg is the power factor of the DG and is used to determine Qdg.

Note: Gross load = Pnet + Pdg. Therefore, Pdg = Pgdg * Pnet / (1 - Pgdg).

Gross load is distributed among the load components.

For Pflgdg = 1,

Pgdg is the MW value of Pdg

Pfdg is the power factor of the DG and is used to determine Qdg.

Note: Gross load (= Pnet + Pdg) is then distributed among the load components

For Pflgdg = 2,

Pdg and Qdg from the power flow load data are used directly as Pdg and Qdg in the dynamic model (if stdg = 1). If stdg = 0, no DG is modeled.

Pgdg and Pfdg are ignored.

Note: Gross load (= Pnet + Pdg) is then distributed among the load components

In all cases, Pnet and Qnet will be calculated from Psys, Qsys and the voltage at the power flow system bus using the specified parameters of the substation transformer, shunt capacitor, and equivalent feeder.

Note: If the load flow values of both Pdg and stdg are non-zero, these values should be used and the values of Pflgdg, Pgdg, and Pfdg ignored.

Model for PV (and other inverter-based) Distributed Generation

The simplified model for inverter-based generation (e.g. photovoltaic) shown in Figure 2 will be used in the CMPLDWG model. An option should be provided for additional DG models of other types to be added in the future.

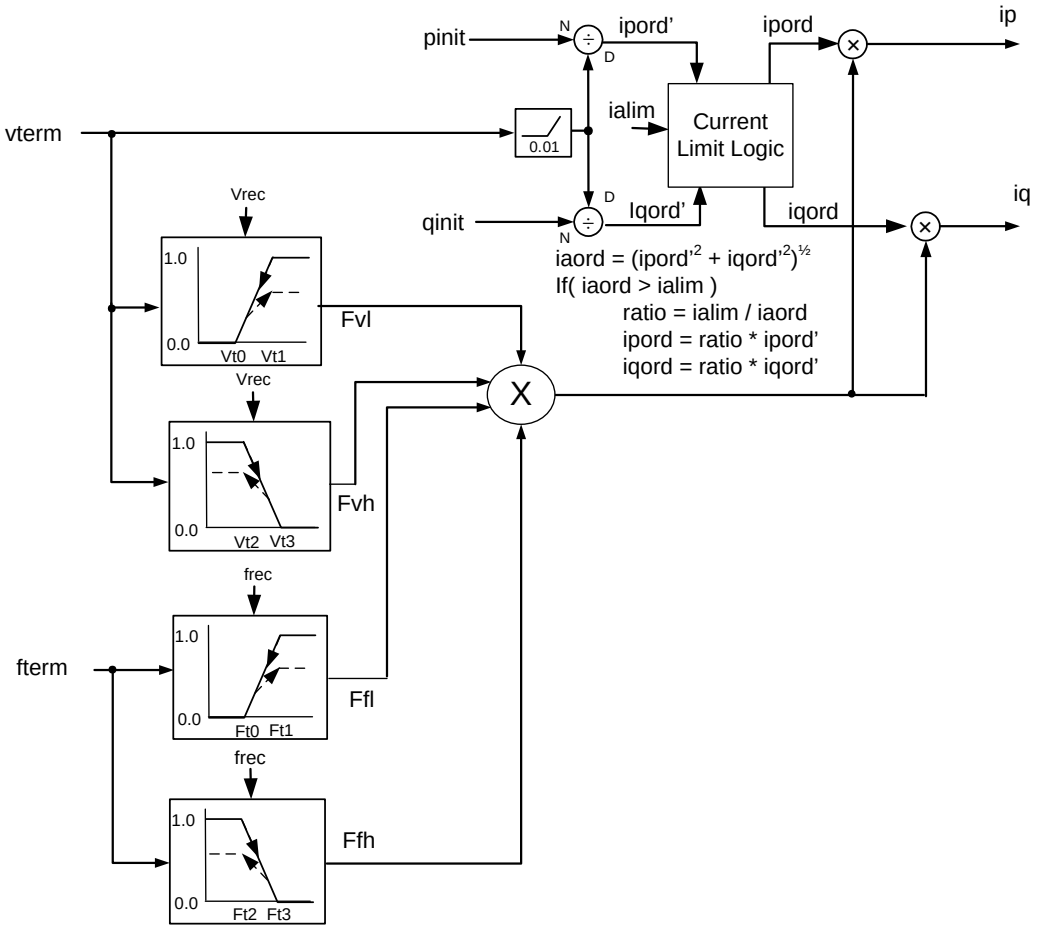

Figure 2 Inverter-based (e.g. PV) DG Model

CMPLDWG input parameters for DG model

The following input parameters must be provided in order to include the inverter-based DG model in CMPLDW:

- DGtype - (0 – none, 1 – inverter-based, e.g. PV)
- pflgdg – Pdg input method (0 - fraction of gross Pload,
  1 – MW value, 2 - Use Pdg, Qdg from power flow load data)
- Pgdg – Pdg fraction (for pflgdg = 0); Pdg in MW (for pflgdg = 1); ignored for pflgdg = 2.
- Pfdg – Power factor (for pflgdg = 0 or 1); ignored for pflgdg = 2
- Imax – Maximum current (pu)
- Vt0 – Voltage below which all generation is tripped (pu)
- Vt1 – Voltage below which generation starts to trip (pu)
- Vt2 – Voltage above which generation starts to trip (pu)
- Vt3 – Voltage above which all generation is tripped (pu)
- Vrec – Fraction of generation that can reconnect after low or high voltage tripping
- ft0 – Frequency below which all generation is tripped (Hz)
- ft1 – Frequency below which generation starts to trip (Hz)
- ft2 – Frequency above which generation starts to trip (Hz)
- ft3 – Frequency above which all generation is tripped (Hz)
- frec – Fraction of generation that can reconnect after low or high frequency tripping

CMPLDWG Output Variables for DG model

The following output variables should be provided for the DG model in CMPLDW:

- **Level 1**
  - Pdg – DG P, MW
  - Qdg – DG Q, MVAr
- **Level 2**
  - xdgn – nominal value of MW tripped by model protective functions
  - xdgi – instantaneous value of MW tripped by model prot. functions
- **Level 4**
  - Fvl – Fraction of DG not tripped by low voltage
  - Fvh – Fraction of DG not tripped by high voltage
  - Ffl – Fraction of DG not tripped by low frequency
  - Ffh – Fraction of DG not tripped by high frequency

References

1. WECC Composite Load Model (CMPLDW) Specifications, December 4, 2014: