Distributed Generation Simulation Example - 1

Distributed Generation System Set-up

Motivation

This case is used to illustrate the correct method to set-up a base simulation model which represents a distributed generation system.

In the past, power has been generated solely at large central generating stations where it was sent through transmission and distribution networks in order to reach customers. However, now the emerging trend is toward distributed generation. Distributed generation is when a group of small generators are connected at the distribution level, close to the customer. However, this presents new challenges to the engineer that need to be studied. Some of these challenges include things such as protection and control, self excitation and islanding. In order to properly study these issues, the engineer must set-up the base simulation model to accurately represent the distributed generation system.

System Overview

A distributed generation system rated at 0.6 kV is shown in Figure 1. The distribution network is connected to a HV network rated at 115 kV via a 0.6/115 kV step up transformer.

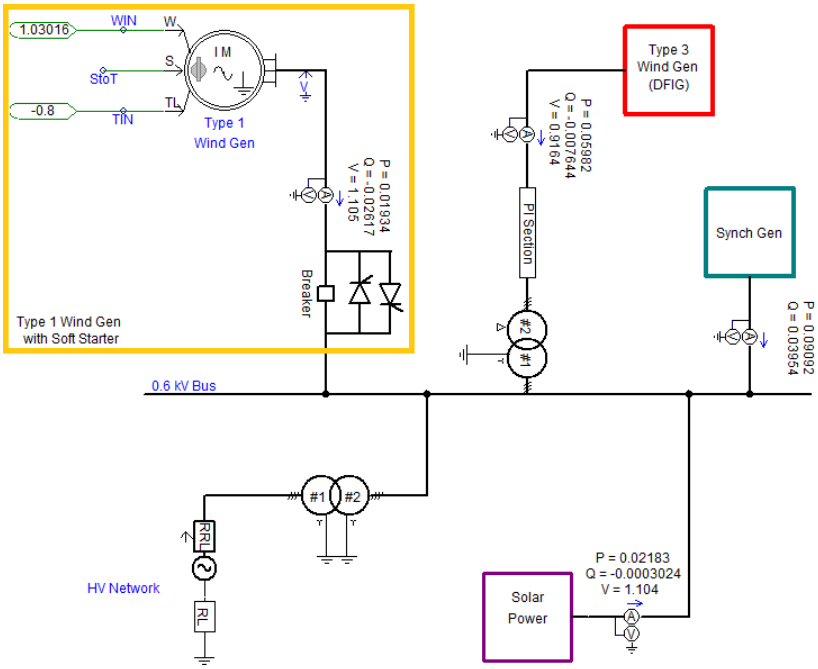

Figure 1: Distributed Generation System

The following generator types are included in the simplified model shown above:

1) Type 1 Wind Turbine with soft starter capability
2) Type 3 DFIG based Wind Turbine
3) Solar Power (Photovoltaic Array)
4) Synchronous Generator (Small Hydro)

The models are initialized to have the following active (P) and reactive (Q) power as shown in Table 1.

Table 1: Active and Reactive Power Initialization

	P [kW]	Q [kVAR]
Type 1 WT	19.34	26.17
Type 3 WT (DFIG)	59.82	7.644
Solar Power	21.83	0.302
Synchronous Gen	90.92	39.54

Therefore, from the data above, it can be determined that the distributed generation system is able to supply approximately 206 kVA of power.

Type 1 Wind Generator with soft start capability

This is a fixed-speed wind turbine with a squirrel-cage induction generator. The generator is rated at 25 kVA and operates at a line voltage of 0.6 kV with a frequency of 60 Hz. The wind turbine is represented by the input torque (T=-0.8 PU) to the generator. This type of induction machine cannot excite itself. Therefore, in order to reduce the amount of reactive power drawn into the machine during startup (hence, limit inrush currents), it uses a thyristor based soft starter.

Type 3 DFIG based Wind Turbine

This is a variable speed wind turbine with a doubly-fed wound-rotor induction generator. The generator is rated at 100 kVA and operates at a line voltage of 0.6 kV with a frequency of 60 Hz. The wind turbine is represented by the input torque (T=-0.25 PU) to the generator. Through the use of power electronics, reactive power can be supplied to the machine via the rotor. Hence, no reactive power needs to be drawn from the system during start up.

This wind turbine is located 2 km away from the system bus and is connected through a 25 kV transmission line (represented by a pi-section). Note that the voltage is stepped up to 25 kV along the transmission line and stepped back down to 0.6 kV at the wind generator.

Solar Power (Photovoltaic Array)

The solar panels are represented by the 'PVMod2' component. The photovoltaic array and cell parameters are shown in Figure 2. Solar radiation and cell temperature are inputs to the component. A positive and negative DC voltage is outputted from the PV array and sent to a DC/DC converter for the purpose of maximum power point tracking. The DC voltage is then sent through a power electronic inverter, which converts it to an AC voltage with a magnitude of approximately 0.23 kV and a frequency of 60 Hz. The voltage is then stepped up using a 0.23/0.6 kV step up transformer and sent to the system.

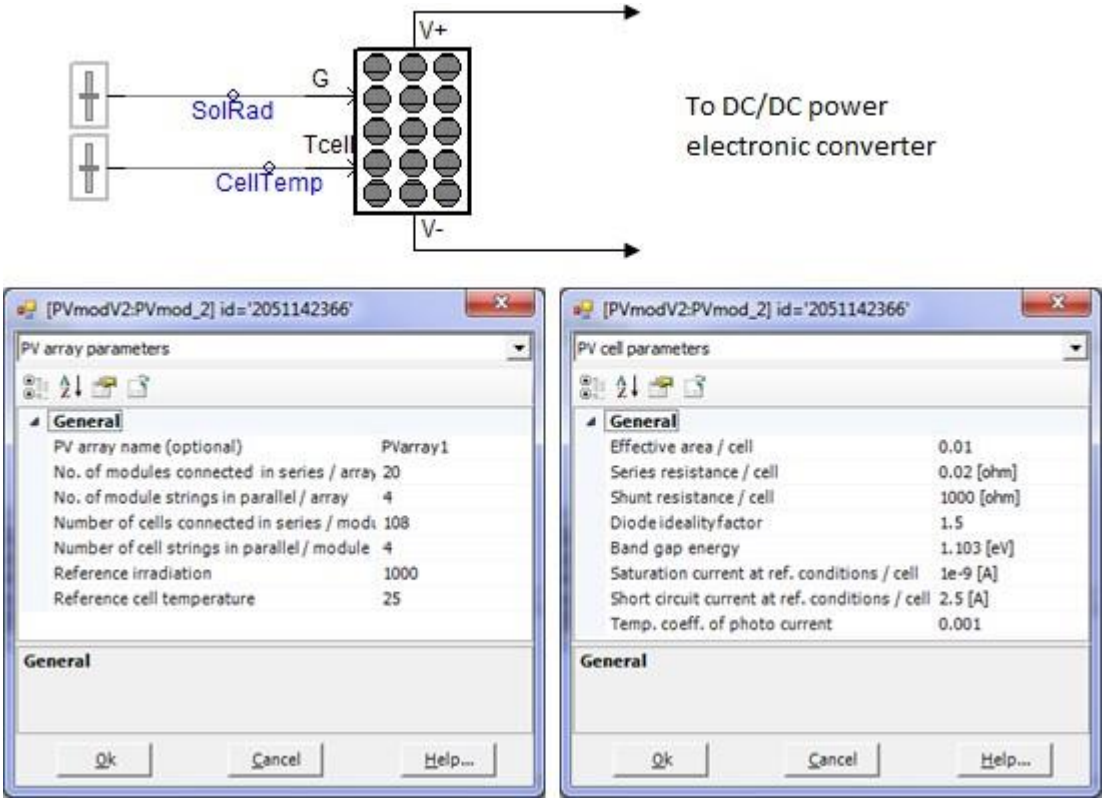

Figure 2: PVMod2 Component Configuration

Synchronous Generator (Small Hydro)

A synchronous generator is driven by a small hydro turbine which is initialized to operate at its rated conditions. The amount of power generated by the turbine is controlled by the governor. The synchronous generator is rated at 0.12 MVA, with a line voltage of 0.6 kV and a frequency of 60 Hz. Its field windings are connected to an exciter, which is used to magnetize the machine. Hence, no reactive power will be drawn from the system.

The objective of a distributed generation system set-up study is

- To ensure the engineer is able to represent the distributed generation system accurately using a simplified simulation model.

PSCAD

Refer to PSCAD case: Distributive_Gen.pscx, Distributive_Gen_LibraryA.pslx and Distributive_Gen_LibraryB.pslx