SIMple® PowerSystems to solve distribution systems

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Introduction

SIMple® PowerSystems Library can simulate generation, transmission and distribution and perform Power Flow and Transient Stability analysis. This article will focus on how SIMple® can simulate the daily behavior of a distribution system considering the quasi steady state approach.

9-bus Distribution System

SIMple® PowerSystems Library is divided in four subfolders: Equipment, AVR, PSS and Relays. The Equipment subfolder has eleven blocks to build a customized power system topology. A 9-bus example, shown in Figure 1, was created to illustrate the library capabilities

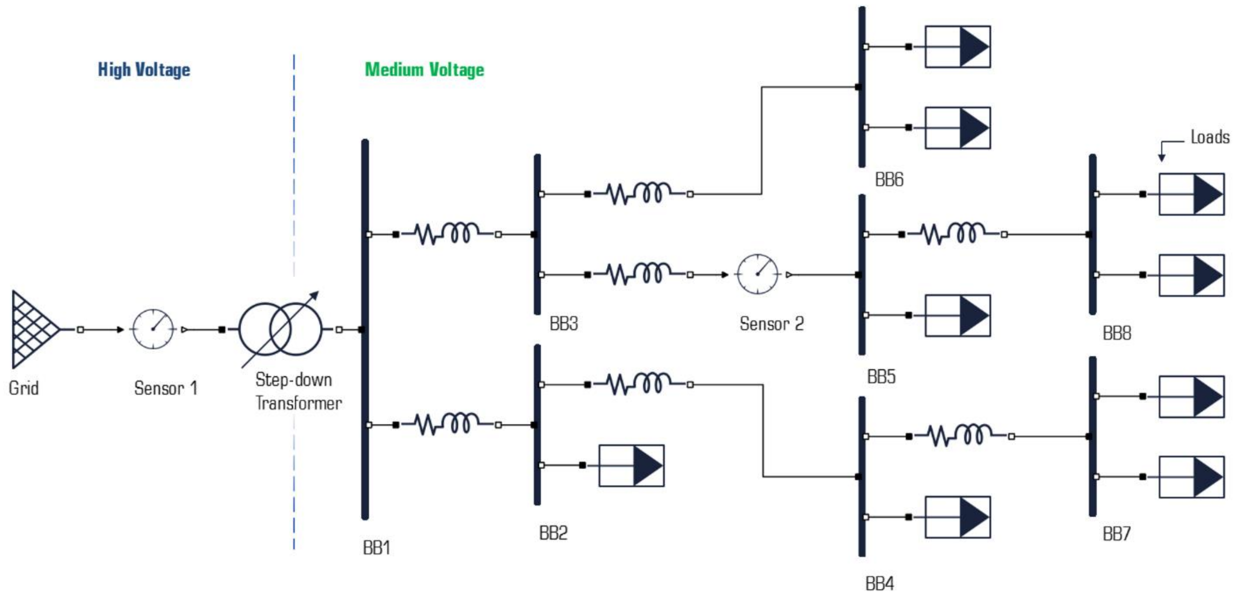
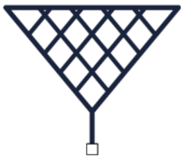
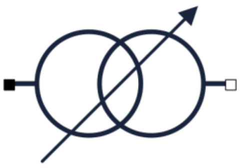


Figure 1 – 9-bus distribution system.

The circuit consists of an Infinite bus block to represent the High Voltage National Grid, a step-down transformer in the interface between the High and Medium Voltage regions, loads that can represent medium voltage consumers like hospitals, shopping malls or even entire neighborhoods. Table 1 explains briefly what each block can do.

Table 1 – SIMple PowerSystems blocks used in the 9-bus example.

Block	Features
InfiniteBus 	This block is a voltage and angular reference for any given power system and provides or absorbs the necessary amount of active and reactive power to guarantee the null power balance of the simulated circuit. It serves as an approximation for a large utility or grid network with fixed frequency.
 Load	This block is useful to represent loads whose dynamics are neglectable. Active and reactive power consumption values can be varied as a function of time.
 Transformer	The main function of the transformer is to transfer power between different points of the circuit creating regions with different voltage and current levels. The simplified transformer model for power systems, referred to as Pi model, is comprised of a resistance followed by a positive reactance, whose values are given in % by the user.
 VariableImpedance	The variable impedance, comprised by a real part (resistance r) and an imaginary part (reactance x), is useful to represent a power loss in a part of the circuit. It can be a constant value specified in % or vary over time according to an external signal, representing the influence of heating, for example.

The user can set the parameters Active and Reactive of the Load block to be a function of time which is a useful feature to simulate how energy consumption can vary during an entire day, for example. This is the kind of simulation Electrical Distribution Companies perform to analyze and predict grid conditions based on demand history data and forecasts.

Figure 2 shows three different normalized household demand curves that were randomly distributed across the Load blocks in the 9-bus system. Load demand has slow dynamics and does not change abruptly within an hour, so discretizing one-day demand in 24 points, one for each hour of the day, is enough for this type of study.

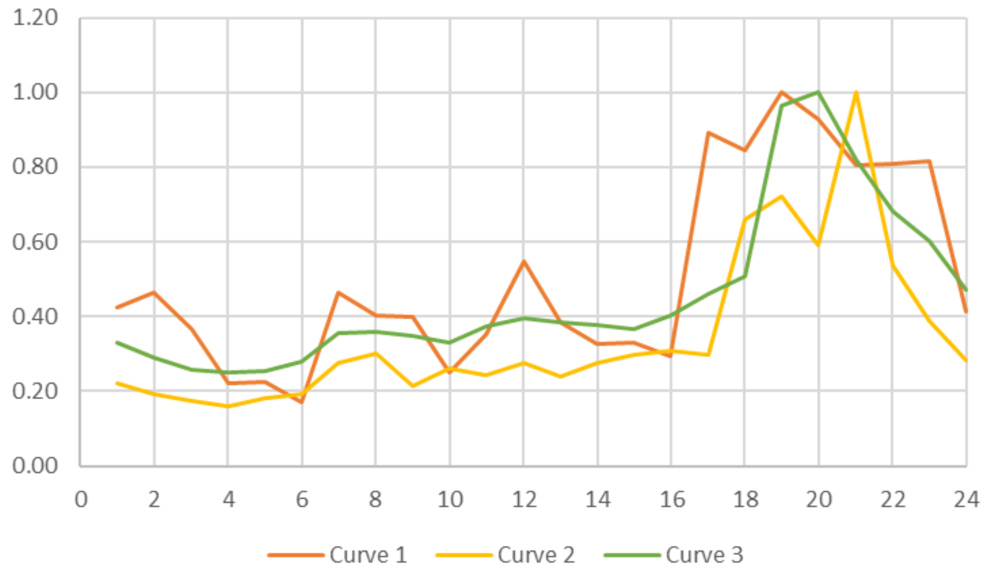


Figure 2 – Different demand curves.

Figure 3 shows how to input a demand curve in a Load block using Activate™ native blocks to get the data from a comma-separated values (CSV) file and then to multiply it by an arbitrary gain so it can be received by the Load block as a variant power in kilowatts. By choosing Variable Active Power in Load block mask, a new port shows up to receive the result of the multiplication. This same process is repeated for all those loads seen in Figure 1.

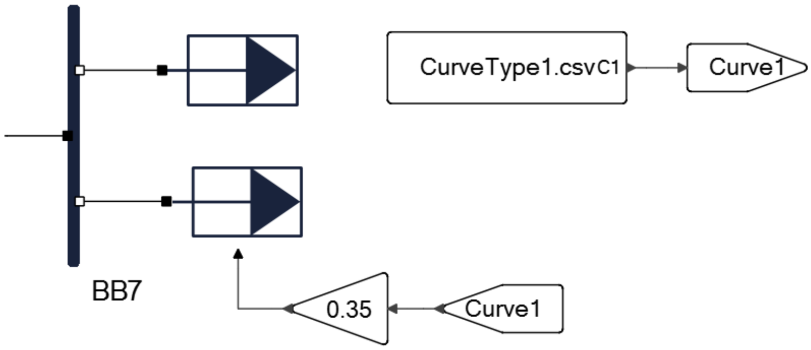


Figure 3 – Adding demand curve to the Load block.

Simulation Results

Two Sensor blocks were placed in different parts of the system to measure power flow and voltage variation. Results for Sensor 1, which measures the sum of all demand in the circuit throughout the day, are in Figure 4 and Figure 5. The active power curve in Figure 4 has the same behavior of the demand curves, showing that the sum of the demands follows the same tendency of the three load demand curves separately. Figure 5 shows that the Infinite Bus block holds the voltage constant as expected and that is why the reactive power varies slightly during the day even though the load curves were used to vary only active power demand.

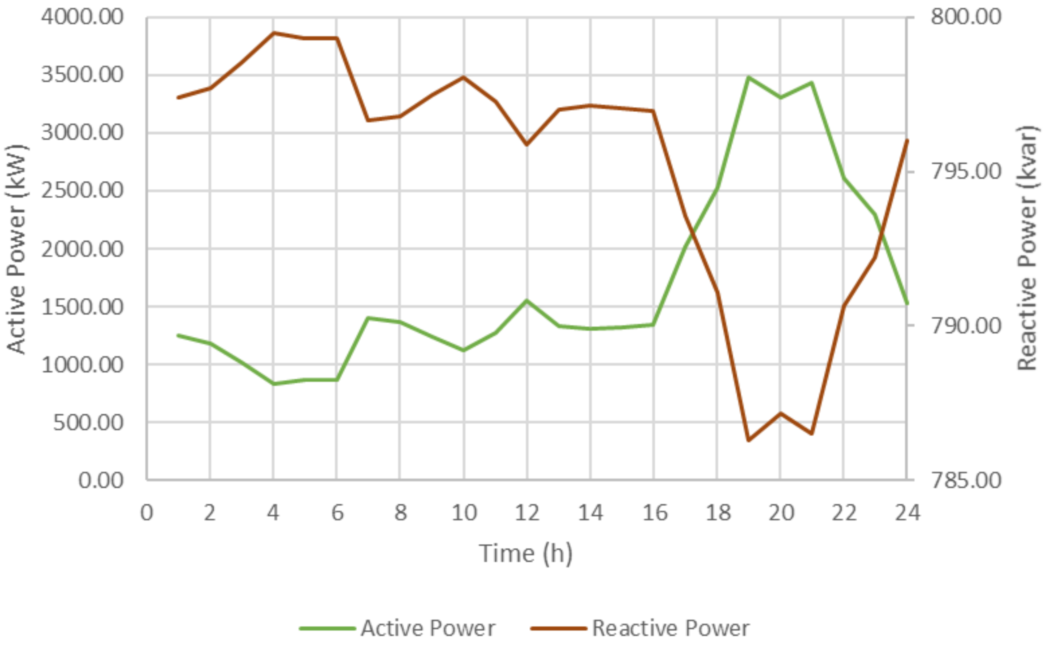


Figure 4 - Active and reactive power measured in Sensor 1.

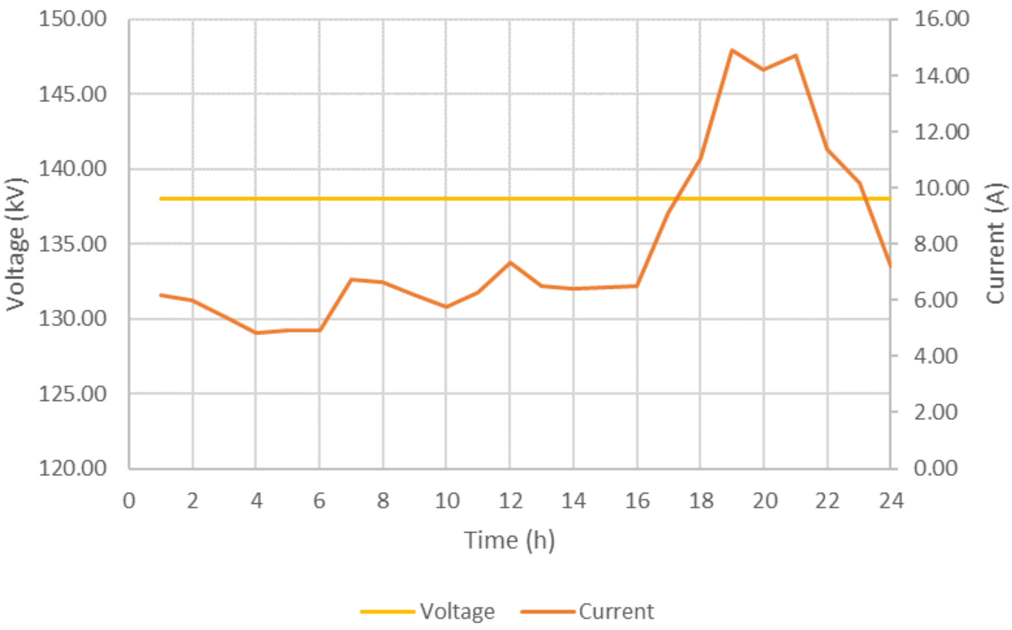


Figure 5 - Voltage and current measured in Sensor 1.

When analyzing Sensor 2, Figure 6 and Figure 7, changes in reactive power are almost neglectable during the day. Voltage in busbar 5 (BB5) is normally below nominal and decreases when load peaks around 9 a.m.

Figure 6 - Active and reactive power measured in Sensor 2.

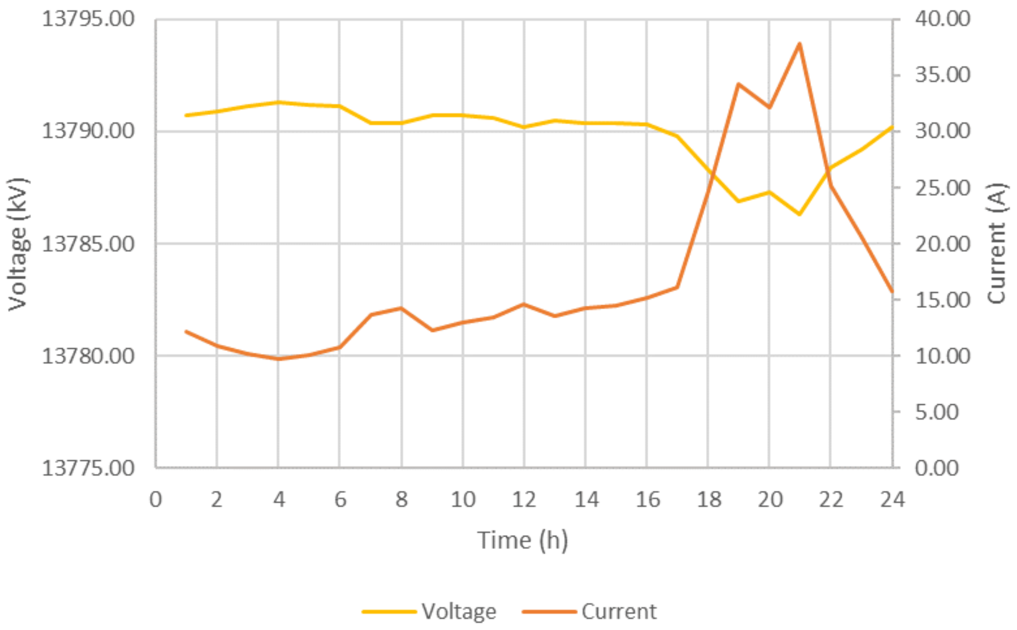


Figure 7 - Voltage and current measured in Sensor 2.

Conclusions

SIMple® PowerSystems library is a useful tool for Electrical Distribution Companies to study and predict grid conditions throughout multiple time span horizon. It helps the Distribution System Operators (DSO) to know their grids better so they can plan the maintenance routine and grid improvements more efficiently.