Beskrivelse av simuleringsmodell ==> Description of simulation model

General

The modelled system consists of one rotary converter (synchronous-synchronous converter) rated at 6.2/5.8 MVA. The converter consists of a three-phase synchronous motor, which is mechanically connected (via the shaft) to a single-phase synchronous generator. Grid frequency is 50 Hz, and the traction power system frequency is 16 ? Hz. The model includes a transformer between the grid (66 kV) and the three-phase side of the converter (6.3 kV), and a transformer between the single-phase side of the converter (4 kV) and the overhead catenary system (16 kV).

The grid model (66 kV, 50 Hz) is assumed to represent a typical grid in this context.

In the modeling only power frequency components of voltages and currents in the AC network are considered. Harmonics are neglected. Hence, the validity of this model is limited to the fundamental frequency components of voltages and currents. The electrical state in the AC system is then assumed to be sinusoidal. As a consequence, the AC voltages and currents are described by phasors, defined by their magnitude and phase angle. The phasors of the ac quantities will vary in time for transient conditions.

The data used in the modeling and simulations of the synchronous machines (of the rotary converter), are partly based on information received from The Norwegian National Rail Administration, Oslo, Norway, and partly based on measurements made by SINTEF Energy Research, Trondheim, Norway, and experiences from previous similar work.

For the voltage regulator for the (1-phase) synchronous generator and the three-phase synchronous motor, respectively, no detailed data have been available for the present study. For these components standard models (in SIMPOW®) and typical data have been chosen.

Data for transformers and lines are received from The Norwegian National Rail Administration.

Simulator

The power system simulation and analysis software SIMPOW®, originally developed by ABB Power Systems, Sweden, has been used for the simulations. (Release 10.2 revision 061 for Windows NT).

For further details see http://www.stri.se/simpow

Single-line diagram

Figure 1 shows a single-line diagram of the model used in the simulations.

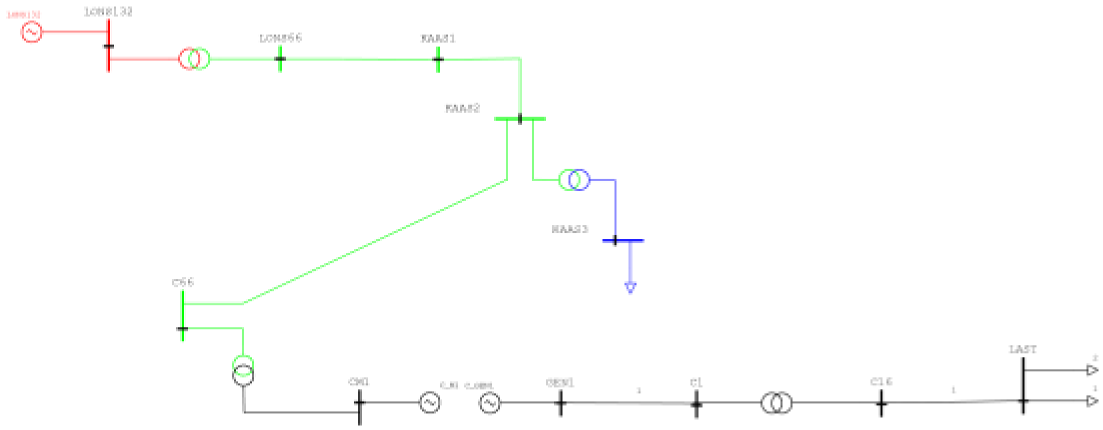

Figure 1. Single-line diagram of model.

For further details about the model, see text.

Synchronous generator model and data

The synchronous generator is modelled with one field winding, one damper winding in d-axis and one damper winding in the q-axis. Magnetic saturation is included in the model (SIMPOW Type 2A).

Input data for the synchronous generator model are given in Table 1.

Table 1 Data for the synchronous generator used in the modelling

Ratings and parameters			**Symbol**	**Value**
Rated power	(MVA)		S_n	5,8
Rated voltage	(kV)		U_n	4,0
Synchronous reactance	(pu)	d-axis	X_d	1,4
		q-axis	X_q	0,68
Transient reactance	(pu)	d-axis	X_d'	0,25
		q-axis	X_q'	
Transient time constant (”open circuit”)	(s)	d-axis	T_{d0}'	5,0
		q-axis	T_{q0}'	
Stator leakage reactance	(pu)		X_l	0,11
Stator resistance	(pu)		R_a	0,0091
Normalised inertia constant	(Ws/VA)		H	1,3754
Damping coefficient	(pu)		D	1,9

For further details regarding input data for this machine model, please contact the Norwegian National Rail Administration, Oslo.

Synchronous motor model and data

The synchronous motor is modelled with one field winding, one damper winding in d-axis and one damper winding in the q-axis. Magnetic saturation is included in the model (SIMPOW Type 2A).

Input data for the synchronous motor model are given in Table 1.

Table 2 Data for the synchronous motor used in the modelling

Ratings and parameters			**Symbol**	**Value**
Rated power	(MVA)		S_n	6,2
Rated voltage	(kV)		U_n	6,3
Synchronous reactance	(pu)	d-axis	X_d	1,26
		q-axis	X_q	0,56
Transient reactance	(pu)	d-axis	X_d'	0,29
		q-axis	X_q'	
Transient time constant (”open circuit”)	(s)	d-axis	T_{d0}'	8,0
		q-axis	T_{q0}'	
Stator leakage reactance	(pu)		X_l	0,11
Stator resistance	(pu)		R_a	0,0011
Normalised inertia constant	(Ws/VA)		H	1,224
Damping coefficient	(pu)		D	1,9

For further details regarding input data for this machine model, please contact the Norwegian National Rail Administration, Oslo.

Synchronous generator exciter model

The exciter model used for the synchronous generator is made by SINTEF Energy Research. The model is named TYPE = DSL/IEEN/.

For further details regarding this model, please contact the Norwegian National Rail Administration, Oslo.

Synchronous motor exciter model

The exciter model used for the synchronous motor is a standard model in SIMPOW®. The model is named TYPE = 1.

For further details regarding input data for this model, please see SIMPOW manual, or contact the Norwegian National Rail Administration, Oslo.

Three-phase transformer (50 Hz) for synchronous motor

Table 3 Transformer data (50 Hz) for synchronous motor

Primary node	C66				
Secondary node	CM1				
Nominal power [MVA]	4.4				
Primary voltage [kV]	66				
Secondary voltage [kV]	6.3				
Short-circuit resistance [pu]	0,0054				
Short-circuit reactance [pu]	0,079				

Single-phase transformer (16 ? Hz)

Table 4 Transformer data (16 ? Hz) for generator

Primary node	C1				
Secondary node	C16				
Nominal power [MVA]	4				
Primary voltage [kV]	4				
Secondary voltage [kV]	16,6				
Short-circuit resistance [pu]	0,0129				
Short-circuit reactance [pu]	0,031				

Line data (50 Hz)

Table 5 Line data (50 Hz)

From node	LONS66	KAAS1	KAAS2
To node	KAAS1	KAAS2	C66
Nominal voltage [kV]	66	66	66
Length [km]	20,9	0,055	0,219
Resistance [Ω/km]	0,151	0,078	0,123
Reactance [[Ω/km]	0,386	0,170	0,178

Line data (16 ? Hz)

Table 6 Line data (16 ? Hz)

From node	C16		
To node	LAST		
Nominal voltage [kV]	16,5		
Length [km]	60		
Resistance [Ω/km]	0,18		
Reactance [[Ω/km]	0,19		