Power System Model for Resonance Studies

List of revisions

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1 Background

This document lists revisions to the research report "Power System Model for Resonance Studies", available from http://urn.kb.se/resolve?urn=urn:nbn:se:ltu:diva-70914 (ISBN 978-91-7790-213-3). The latest version of this document is available at https://i2group.se/phd/.

Revisions are listed by date.

2 Revision 2018-10-05

2.1 HVDC transformer data

Chapter 7 has been updated (changes in red):

An HVDC link is located at bus G3. The layout of the converter, including filters, is shown in Figure 15 and Figure 16, and the data for the filters is listed in Table 15. The data is based on a typical configuration for a 1000 MW HVDC Classic [1]. The converter impedance (at different operating points) is considered an open circuit and has not been included in the model. The converter transformers are single-phase transformers with data according to Table 16.

Table 16 - HVDC transformer data

Un (kV)	Sn (MVA) 1-2/2-3/3-1	Uk (%) 1-2/1-3/2-3	P0 (kW)	Pk (kW) 1-2/1-3/2-3
410/210/210	340/170/170	18/18/36	140	400/400/800

2.2 Transmission transformer data

Table 11, 12 and 13 in Chapter 5 has been updated (changes in red):

Table 11 - List of transmission transformers

Bus	No. of transformers	Type	Grounding (Primary/Secondary)
1	2	C	Solid/Solid
2	2	A	T1: Solid/Isolated, T2: Solid/Solid
3	2	A	T1: Solid/Isolated, T2: Solid/Solid
4	2	B	Solid
5	1	C	Solid/Solid
6	1	C	Solid/Solid
8	2	C	Solid/Solid
9	2	A	T1: Solid/Isolated, T2: Solid/Solid
10	2	A	T1: Solid/Isolated, T2: Solid/Solid
11	2	C	Solid/Solid

Table 12 - Main data for the transmission transformer types.

	A (1-2/1-3/2-3)	B	C
Rating [MVA]	500/500/100	750	350
Rated voltages [kV]	410/225/20	410/225	410/145
u_k [%]*	16/3.5/1.2	12	15
P_0 [kW]	150	200	100
P_k [kW]	1000/50/50	1400	500
Type	3-winding, 3-limb	2-winding 3-limb	2-winding, 3-limb
Vector group	YNyn0d11	YNauto0	YNyn0

**Referred to the lowest MVA of the two windings*

Table 13 - Core saturation characteristics for different transformer types

	A	B	C
Voltage at knee point [p.u.]	1.14	1.14	1.14
Magnetizing current [%]	0.04	0.04	0.04
Air core reactance [p.u.]	0.2	0.2	0.2
Nominal flux density [T]	1.72	1.72	1.72

3 Revision 2019-04-25

Table 1 - Cables included in the model

ID	Voltage [kV]	Length [km]	Parallel cables	Cable type	Laying	Cross-bonding
CA 1	400	6.4	3	2500 mm^2 Cu	A	CB
CA 2	400	13.5	3	1200 mm^2 Al	D	BB
CA 3A	400	3.6	3	1200 mm^2 Al	D	BB
CA 3B	400	5	3	2500 mm^2 Cu	A	CB
CA 4	400	16.4	3	2500 mm^2 Cu	A	CB
CA 5A	400	4.4	3	2500 mm^2 Cu	A	CB
CA 5B	400	5.6	3	U-1200 mm^2 Al	F	BB
CA 5C	400	2.3	3	2500 mm^2 Cu	A	CB
CA 6A	220	2.1	3	2000 mm^2 Al	A	BB
CA 6B	220	1.2	3	U-2000 mm^2 Al	G	BB
CA 6C	220	4.2	3	1200 mm^2 Al	D	BB
CA 7A	220	5.3	3	2000 mm^2 Al	A	BB
CA 7B	220	1.2	3	U-2000 mm^2 Al	G	BB
CA 7C	220	3.7	3	1200 mm^2 Al	D	BB
CA 8	220	11	2	1200 mm^2 Al	E	BB
CA 9A	220	3.7	2	1200 mm^2 Al	E	BB
CA 9B	220	3.2	2	2000 mm^2 Al	B	CB
CA 9C	220	1.2	2	1200 mm^2 Al	E	BB
CA 10	220	4.4	2	1200 mm^2 Al	E	BB
CA 11	220	7	2	2000 mm^2 Al	B	BB
CA 12A	220	3.6	2	2000 mm^2 Al	B	BB
CA 12B	220	1.7	2	1200 mm^2 Al	E	BB
CA 13	130	25	1	1200 mm^2 Al	C	BB
CA 14	130	20	1	1200 mm^2 Al	C	BB
CA 15	130	15	1	1200 mm^2 Al	C	BB

Table 2 - Overhead lines

ID	Voltage [kV]	Length [km]	Conductor*	Shield wires	Tower type	Transposed
OHL G1	400	52.8	B	2xB	A	Y
OHL G2	400	85.3	A A	A	C	Y
OHL G3	400	78.5	A B	A	C	Y
OHL G4	400	99.3	A	2xA	A	Y
OHL G5	400	76.5	B	2xA	A	Y
OHL 1	400	25.3	B	2xA	A	N
OHL 2	400	41.6	A	2xA	A	N
OHL 3	400	47.7	A	2xA	A	Y
OHL 4	400	67.2	A	2xA	A	Y
OHL 5	400	20	C	2xA	A	N
OHL 6	400	8.5	A	2xA	A	N
OHL 7	400	27.1	B	2xA	A	N
OHL 8	400	9.7	A	2xA	A	N
OHL 9	220	23	D	2xA	B	N
OHL 10	130	28	D	-	D	N
OHL 11	130	25	D	-	D	N
OHL 12	130	25	D	-	D	N
OHL 13	130	20	D	-	D	N
OHL 14	130	18	D	-	D	N

**If two conductors are named, it means that there are two parallel lines in the corridor.*

4 Revision 2020-03-04

4.1 Cross-bonding details

Table 3 – Cross-bonding details

ID	Major/minor sections	Minor section avg. length	Avg. earthing resistance [Ω]
CA 1	3/9	710 m	10
CA 3B	2/6	833 m	10
CA 4	5/15	1093 m	10
CA 5A	2/6	733 m	10
CA 5C	1/3	767 m	10
CA 9B	1/3	1067 m	10

4.2 Tower models

Section 3.2 has been updated (changes in red):

This section presents the tower types used in the model, including all primary dimensions.

For tower types A and C, presented in Figure 2 and Figure 4 below, a maximum sag of 12 m for conductors and 10.2 m for shield wires have been used. For tower type B, presented in Figure 3 below, a maximum sag of 8 m for conductors and 6.8 m for shield wires have been used. For tower type D, presented in Figure 5 below, a sag of 6 m was used for the conductors.

4.3 40 kV OHL parameters

Section 10.2.1 has been updated (changes in red):

Table 23 and Table 24 list the parameters of the 40 kV overhead lines and Figure 19 shows the 40 kV tower. A sag of 4 m has been used for the conductors.