Pscad Modeling of 154 kV İkitelli-Yenibosna 1-2 Double Circuit Overhead Transmission Line in İstanbul District

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Abstract

154 kV İkitelli-Yenibosna 1-2 double circuit overhead transmission line which is operated by Turkish Electricity Transmission Incorporated Company (TEİAŞ) 1. Region Management in İstanbul district is modeled by using conductor constants subroutine of Power System Computer Aided Design/Electromagnetic Transients including DC (PSCAD/EMTDC) with operator data. It is used Frequency Dependent (Phase) Model of PSCAD/EMTDC for modeling.

1. Introduction

In Turkey, if electrical energy's voltage level is over the 36 kV, it is named transmission line. There are 66 kV, 154 kV and 380 kV voltage level transmission lines in Turkey.

PSCAD/EMTDC includes accurate transmission line models which allow to take into account the characteristic phenomena occurring in the transmission lines. These phenomena include line losses, time travel, reflections, inductive and capacitive mutual coupling between conductors (resistivity, radius and bundle information) and the geometrical layout of conductors on the tower (distances between conductors sag).

Generally in electromagnetic transient simulations, there are two main ways to represent transmission lines. The first method is to use PI-sections. The second and more acknowledged method is to use a distributed transmission line, which is most suited for transient line response modeling using a digital computer.

PI section model is a lumped parameter model derived by series RL elements and parallel CG elements. This model is adapted for short lines to study the 50/60 Hz load flow, and transient behavior. This model is also used when tower geometry is unknown.

The distributed transmission line models operate on the principle of traveling waves. There are types of distributed transmission models that may be selected in PSCAD to represent the transmission cable: the Bergeron Model, the Frequency-Dependent (Mode Model), and the Frequency-Dependent (Phase) Model [1].

The rest of the paper is organized as follows. Section 2 informs about National Power Quality Monitoring Network and Assessment Center for the Turkish Electricity Transmission System. PSCAD/EMTDC modeling of 154 kV İkitelli-Yenibosna 1-2 double circuit overhead transmission line is presented in Section 3. Conclusions are given in Section 4.

2. National Power Quality Monitoring Network and Assessment Center for the Turkish Electricity Transmission System

The National Power Quality Monitoring System is developed for monitoring the power quality (PQ) of the Turkish Electricity Transmission System. The National PQ Monitoring System consists of three main parts:

- PQ monitors, which are installed all over the country,
- A monitoring center, which collects the data sent by the power quality monitors in a database and provides assessment facilities,
- Client software for remote connection to the center and analysis of the collected PQ data.

PQ monitors compute the PQ parameters according to the IEC-Standard 61000- 4-30. The PQ monitoring center is located in the TEİAŞ Ankara Bahçelievler campus and it has a huge digital light processing (DLP) display to observe the PQ events on the map of Turkey as soon as the event occurs. The client software provides remote connection from universities, research institutes and TEİAŞ offices to the monitoring center to analyze the collected PQ data [2].

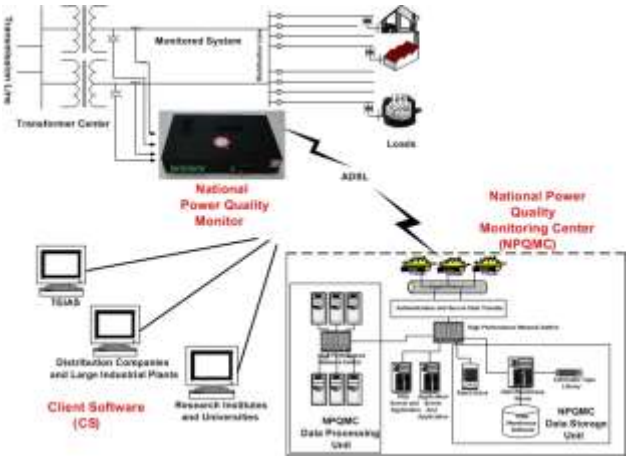

Fig. 1. National Power Quality Monitoring Project and Operation Department

Within the scope of the this study, from 23.01.2015 / 19:18:34 to 26.01.2015 / 19:18:14 the frequency, voltage, current, powers (active, reactive, apparent powers) and power factor components' real time measurement results of 154 kV İkitelli-Yenibosna-1 (Fig. 2) and İkitelli-Yenibosna-2 (Fig. 3)

double circuit overhead transmission line, which is operated by TEİAŞ 1. Region Management in İstanbul district are obtained from National Power Quality Monitor.

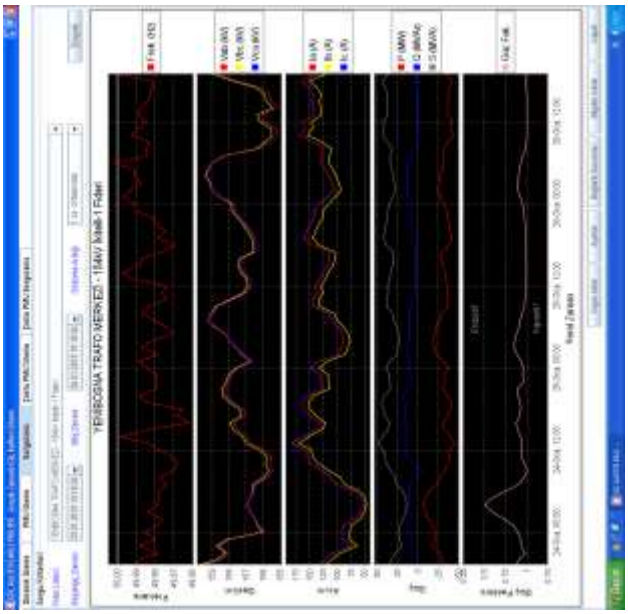

Fig. 2. 154 kV İkitelli-Yenibosna-1 overhead transmission line

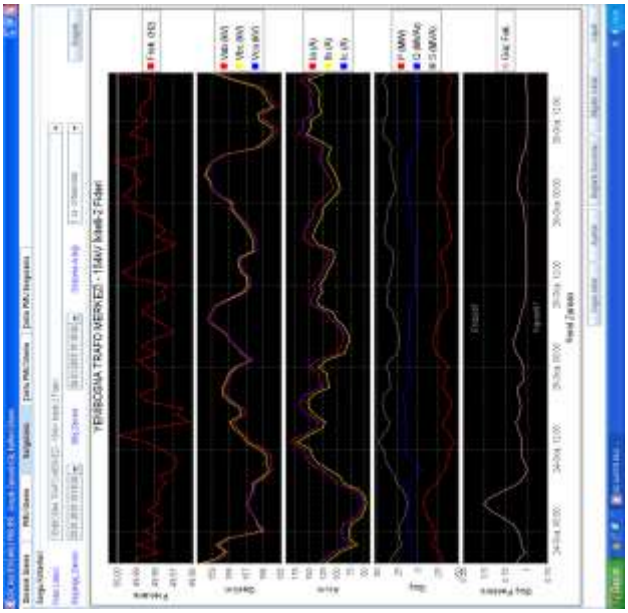

Fig. 3. 154 kV İkitelli-Yenibosna-2 overhead transmission line

3. 154 kV İkitelli-Yenibosna-1 and İkitelli-Yenibosna-2 Double Circuit Overhead Transmission Line Modeling in PSCAD/EMTDC

The data of 154 kV İkitelli-Yenibosna-1 and İkitelli-Yenibosna-2 double circuit overhead transmission line which has been operated by TEİAŞ 1. Region Management in İstanbul district is used for design of the conductor and the tower model that are being created in PSCAD/EMTDC and its model library.

In the first step, for the modeling the 154 kV İkitelli-Yenibosna-1 and İkitelli-Yenibosna-2 double circuit overhead transmission line in the PSCAD/EMTDC, line constants are needed. The constants of 154 kV İkitelli-Yenibosna-1 and İkitelli-Yenibosna-2 double circuit overhead transmission line are given in Table 1, which is obtained from Ankara National Load Dispatch Center.

Table 1. İkitelli-Yenibosna 1-2 double circuit overhead transmission line conductor constants

Voltage Base Value (U_B)	154 kV
Appearent Power Base Value (S_B)	100 MVA
Resistance (r')	0,003068 pu
Inductive Reactance (x')	0,014399 pu
Admittance (y')	0,006167 pu

In the second step, for the modeling of the overhead line and tower of 154 kV İkitelli-Yenibosna-1 and İkitelli-Yenibosna-2 double circuit overhead transmission line in the PSCAD/EMTDC, the project of line is needed. The line profile project of the 154 kV İkitelli-Yenibosna-1 and İkitelli-Yenibosna-2 double circuit overhead transmission line is obtained from TEİAŞ 1. Region Management. 28 towers have been used at the line. RA1+15 type tower which is the majoerities type of towers in the line is modeled at PSCAD/EMTDC. RA1+15 type tower that is used in 154 kV double circuits overhead transmission line is the bearing type of towers. Photograph of the RA1+15 type tower that has used in the line is given Fig. 4 and the main part dimensions of RA1+15 type tower are given in Fig. 5 and Table 2. In Fig. 5, H=±0 body and ±0 footed of tower's total length above ground. The length of the line is 8,852 km, the voltage is 154 kV, the frequency is 50 Hz and the conductor type is 795 MCM Drake. For the line is double circuit system, there are 6 conductors. Additionally there has been used also 24xG652 type OPGW (Optical Ground Wire) for line protection and communication for between the substations.

Fig. 4. 154 kV İkitelli-Yenibosna 1-2 Double Circuit Overhead Transmission Line RA1+15 Tower Photography

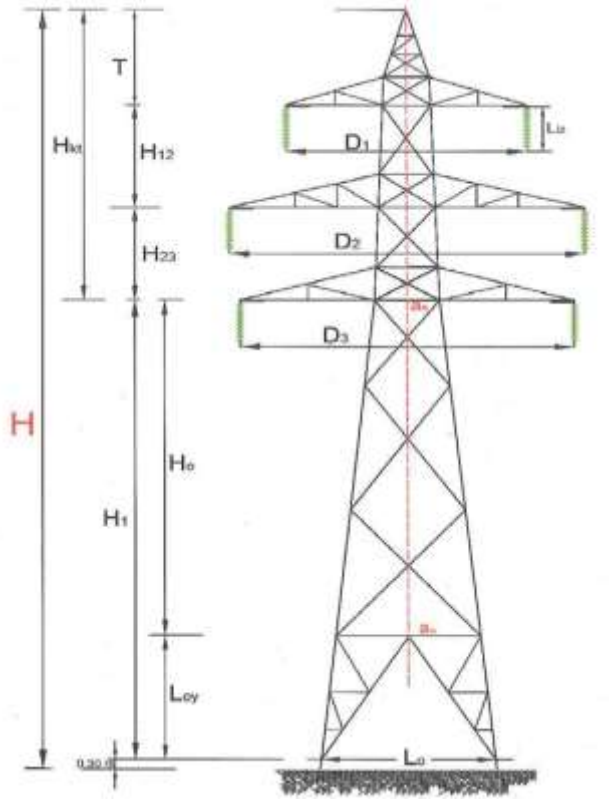

Fig. 5. 154 kV Double Circuit Overhead Transmission Line Tower

Table 2. 154 kV Double Circuit Overhead Transmission Line Towers' Main Part Dimensions

Kesit	Direk Tipi	D_1 (mm)	D_2 (mm)	D_3 (mm)	T (mm)	H_{12} (mm)	H_{23} (mm)	L_{ay} (mm)	L_t (mm)	H_o (mm)	H_1 (mm)	H_{TB} (mm)	H_{kt} (mm)	H (mm)
MCM	2FA	7.000	10.000	7.800	3.900	4.300	4.300	2.600	5.536	17.600	20.200	18.250	12.500	33.000
2x1272	2FB	7.600	10.600	8.200	4.400	4.300	4.300	2.650	6.040	17.550	20.200	18.250	13.000	33.500
2FD	6.800	10.000	7.800	6.000	4.200	4.200	2.350	7.454	15.700	18.050	18.250	14.400	32.750
MCM	2FN	7.800	11.600	9.400	6.900	4.300	4.300	3.050	9.337	15.000	18.050	18.250	15.500	33.850
MCM	CP1	6.700	9.000	6.900	3.900	4.200	4.200	2.000	2.796	19.200	21.200	19.250	12.300	33.800
2x1272	CP2	5.800	8.200	6.100	4.900	4.100	4.100	2.760	3.263	16.060	18.850	19.050	13.100	32.250
MCM	CP3	6.200	8.700	6.600	5.450	4.200	4.200	2.535	4.200	16.315	18.850	19.050	13.850	33.000
Kompakt	CP4	7.000	9.400	8.100	7.550	4.200	4.200	2.500	5.565	17.350	19.850	20.050	15.850	36.100
	TA1	7.000	9.400	7.400	3.150	4.150	4.150	2.750	4.395	15.419	18.169	18.219	11.450	29.919
2x795	RA1	7.400	10.000	8.000	4.100	4.200	4.200	3.250	4.843	14.882	18.132	18.182	12.500	30.932
2x954	VA1	6.400	9.000	7.000	5.300	4.150	4.150	2.850	5.863	12.457	15.307	15.507	13.600	29.207
MCM	ZA1	7.800	10.400	8.400	5.300	4.150	4.150	3.527	7.378	11.657	15.384	15.584	13.600	29.284
	N1	6.800	9.200	7.200	3.300	4.100	4.100	2.600	3.367	17.201	19.801	17.851	11.500	31.601
2x477	P1	7.200	9.800	7.800	3.900	4.100	4.100	2.600	4.476	17.000	19.800	17.850	12.100	31.950
MCM	F1	6.800	9.200	7.200	5.450	4.100	4.100	2.250	4.941	14.601	16.851	17.051	13.650	30.801
	E1	7.800	10.200	8.200	5.450	4.100	4.100	3.000	6.126	13.850	16.850	17.050	13.650	30.800

In Fig. 6, it is seen of the basic scheme that formed by PSCAD/EMTDC of the double circuit transmission line between İkitelli Substation and Yenibosna Substation.

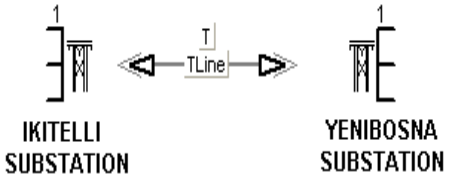

Fig. 6. İkitelli Substation and Yenibosna Substation basic scheme in PSCAD/EMTDC

The main part dimensions of RA1+15 type tower are given in Table 3, the data of the 795 MCM Drake is given in Table 4, and the data of the 24xG652 type OPGW (Optical Ground Wire) is given in Table 5.

Table 3. RA1+15 tower main part dimensions

Height of Lowest Conductors	31,182 m
Vertical Offset of Conductors	4,2 m
Horiz. Spacing Between Lower Cond's	8 m
Horizontal Dist. Of Outside Cond's from Inner Cond's	1,3 m

The data which is been in Table 3 is added the sub-section of " Tower Data" chapter which is been in "Frequency Dependent (Phase) Model Options" of PSCAD/EMTDC model library as shown in Fig. 7.

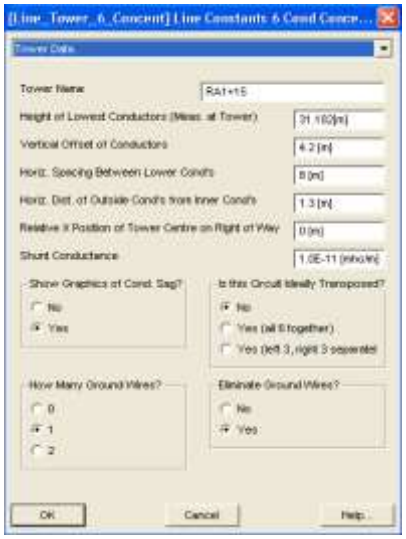

Fig. 7. RA1+15 tower main part dimensions

Table 4. 795 MCM Drake conductor data

Conductor Geometric Mean Radius	0,014055 m
Conductor DC Resistance	0,0715 ohm/km
SAG for all Conductors	9 m
Number of Sub-Conductors in a Bundle	1

The data which is been in Table 4 is added the sub-section of "Conductor Data" chapter which is been in "Frequency Dependent (Phase) Model Options" of PSCAD/EMTDC model library as shown in Fig. 8.

Fig. 8. 795 MCM Drake conductor data

Table 5. 24xG652 OPGW conductor data

Ground Wire Radius	0,0076 m
Ground Wire DC Resistance	0,43 ohm/km
SAG for all Ground Wires	6 m
Height of Ground Wires Above Lowest Con.	14,45 m

The data which is been in Table 5 is added the sub-section of "Ground Wire Data" chapter which is been in "Frequency Dependent (Phase) Model Options" of PSCAD/EMTDC model library as shown in Fig. 9.

Fig. 9. 24xG652 OPGW conductor data

In this study, the modeling of overhead transmission line and tower is made by using the PSCAD/EMTDC and graphical based model which located in PSCAD/EMTDC' s model library with data that obtained from Table 1, Table 2, Table 3, Table 4 and Table 5. The Frequency Dependent (Phase) Model that located in PSCAD/EMTDC of İkitelli-Yenibosna 1-2 double circuit overhead transmission line is formed by using sub-section data of Fig. 7, Fig. 8 and Fig. 9 as shown in Fig. 10.

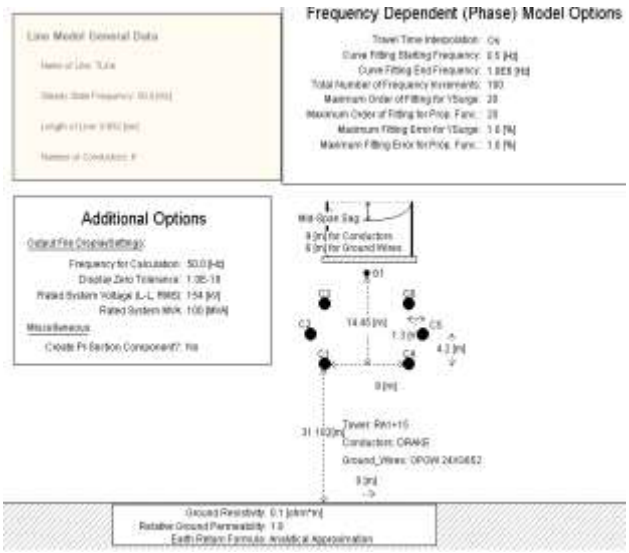

Fig. 10. 154 kV İkitelli-Yenibosna 1-2 double circuit overhead transmission line Frequncy Dependent (Phase) Model

According to base values given by TEİAŞ Ankara National Load Dispatch Center regarding İkitelli-Yenibosna 1-2 double circuit overhead transmission line: S_B = 100 MVA, U_B = 154 kV and positive component constants of the all transmission line are r' = 0.003068 pu, x'=0.014399 pu ve y' = 0.006167 pu. These pu values are converted to unit long belonging to line constants with the aid of Eq.1 – Eq.3. Obtained results are shown in Table 6. These values are obtained in 50 Hz frequency of the line.

$$R = \frac{r' U_B^2}{S_B} \quad (1)$$

$$X = \frac{x' U_B^2}{S_B} \quad (2)$$

$$Y = \frac{y' S_B}{U_B^2} \quad (3)$$

The data obtained through the result of the inverting process are used for comparing with the line constants that provided after modeling of conductor and tower which shown in Fig. 10. The parameters of that conductor's model are calculated by using the settings of "Frequncy Dependent (Phase) Model Options" and "Additional Options" of the PSCAD/EMTDC Transmission Line program. Obtained results are shown in Table 6 along with the data of TEİAŞ.

Table 6. Conductor constants which calculated by PSCAD/EMTDC and obtained from TEİAŞ data

	TEİAŞ (ohm/m)	**PSCAD (**ohm/m)
Resistance (R)	0,08219689E-03	0,096296953E-03
Induc. React. (X_L)	0,38577347E-03	0,541153422E-03
Admittance (Y)	0,29375800E-08	0,251065040E-08

4. Conclusions

As it can be seen at the Table 6, the line constants of TEİAŞ and PSCAD/EMTDC are very close to each other. The differences seen between the line constants of operator's (TEİAŞ) data and PSCAD/EMTDC's data, because of:

- The conductor geometry and material properties of the 795 MCM and 24xG652 conductor system which are obtained from the manufacturer firms are used for calculating the line parameters with sub-program of conductor constants in PSCAD/EMTDC. But 795 MCM and 24xG652 conductors' material properties which are imputed by manufacturer firms are not one-to-one 795 MCM and 24xG652 conductors' material properties which are in operating time.
- In the sub-program of the PSCAD/EMTDC conductor constants, the all towers' main part dimensions of the 154 kV İkitelli-Yenibosna 1-2 double circuit overhead transmission line are not been used and just only RA1+15 type tower's main part dimensions are considered.
- RA1+15 tower' s main part dimensions are calculated based on single hanger team chain insulator height (1,950 m) in PSCAD/EMTDC program. However couple hanger team chain insulators (2,077 m) are used at RA1+15 towers of 154 kV İkitelli-Yenibosna 1-2 double circuit overhead transmission line at the same time. And couple hanger team chain insulators' heights are different from single hanger team chain insulators' heights.
- Each manufacturer firm insulators' chain heights are different from each others.
- The ground resistivity value of the line is accepted 0,1 ohm*m. However the length of the 154 kV İkitelli-Yenibosna 1-2 double circuit overhead transmission line is 8,852 km. Ground resistivity isn't stability during the along distance.

In this paper, 154 kV İkitelli-Yenibosna 1-2 double circuit overhead transmission line which is operated by TEİAŞ 1. Region Management in İstanbul district is modeled by used "Frequency Dependent (Phase) Model" sub-program of PSCAD/EMTDC with operator data.

Turkish Electricity Transmission Incorporated Company (TEİAŞ) would like to thank them for their support.

5. References

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[2] T. Demirci, A. Kalaycıoğlu, Ö. Salor, S. Pakhuylu, T. İnan, D. Küçük, M. Gülder, T. Can, Y. Akkaya, S. Bilgen, I. Çadırcı, M. Ermiş, "National power quality monitoring network and assessment center for the Turkish electricity transmission system", IEEE. 2008