A Case Study Of Turkish Transmission System For VoltageDips

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A Case Study Of Turkish Transmission System For Voltage Dips

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***Abstract-* Power quality problems usually appear in the form of voltage sags, transients and harmonics. From these three broad categories of power quality problems, voltage dips account the most disturbances experienced by industrial customers. Voltage dips generally refer to instantaneous short-duration voltage variations. The aim of this paper is to have an idea about voltage dip performance of Turkey Transmission System. Turkey's transmission system has 21 regions. For simulations, 2nd region, which includes Istanbul city's area is heavy loaded, is selected. For purposes of early warning and later analysis of voltage dip performance of the whole transmission system, is used to compare with results constructed fault statics from SIMPOW DIPS analysis program real data. SIMPOW DIPS software enables to calculate dip frequency for all busses and lines.**

Keywords-* V*oltage dip performance, monitoring, fault position method exposed area, fault index

I. INTRODUCTION

Voltage dip phenomena one of the important issues of power quality problems. Voltage dips are short duration reductions in rms voltage. In general sag magnitude between 0.1-0.9 pu. and durations from 0.5 cycles to 1 min. Momentary voltage dips due to remote faults in the utility system result in failures of sensitive equipment which can effect entire end user process[1].

The only voltage-dip characteristics defined in an international standard are residual voltage and duration. According to IEC 61000-4-30 the residual voltage is the lowest one-cycle rms voltage measured in any of the voltage channels during the event. The duration is the time during which the one-cycle rms voltage for at least one voltage channel is below a voltage dip threshold. The standard document does not describe a value for threshold but a value equal to %90 of nominal voltage is commonly used. Number of dips with a remaining voltage less than a given value, called voltage dip frequency, is usually used to describe the site performance index[2].

This paper includes a study case for Turkish transmission system. The aim of the study is have idea about voltage dip performance of Turkish transmission system. The paper is organized as follows. Section II briefly recalls stocahastic prediction methods: critical distance and fault position, also includes some information about used software SIMPOW DIP. In Section III Turkish grid is described. IV and V Sections describe voltage dip calculation and exposed area. Exposed area method is applied in Levent and Atışalan_A busses when all system is full loaded. This gives information about how the system reacts to faults in a certain bus. the same method is applied to the Levent Bus, when the system in half loaded and a comparison is made between full loaded and half loaded exposed area.

II. THEORETICAL DESCRIPTION

Voltage dip performance can be obtained by monitoring or stochastic predictions. Monitoring gives ideas about the average power quality of the network and ideally all buses are monitored over a long period of time to have more accuracy results. Stochastic prediction gives the results immediately and its even possible to assess the power quality of a system that does not exist yet. Along with the stochastic approach, the methods of fault positions and critical distance are generally used to assess and understand the system voltage dip performance.

Concept of critical distance calculates the fault position for a given voltage by using some simple expressions, it is possible to find out where in the network a fault would lead to a voltage dip down to a given magnitude value. Generally this method is used for radial systems.

In the fault positions method, a number of fault positions are defined. Different fault types are applied at the fault positions one at the time and remaining voltages at the customer locations in the network are calculated. By increasing the number of fault positions, the accuracy of the results can be increased. The faulted buses that lead to the voltage dips with similar characteristics are grouped into one area that called exposed area in which faults lead to a dip below a certain voltage. The term exposed area was originally linked to equipment behaviour. Suppose that the equipment trips when the voltage drops below 70%. In that case the equipment is exposed to all faults within the 70% contour [3].

For simulation of the system SIMPOW DIPS software, which is belong to STRI group, is used. The current version of SIMPOW DIPS produces a result file in text format containing information about the dips expected at the selected locations. SIMPOW DIPS uses three files for calculation of voltage dip frequency. They are: otres file that is output file of power flow analysis, dynpow file, dynamic analysis module, and fault file, contains number of faults per year of all fault types for all busses and lines. In SIMPOW DIPS Software fault position method for calculations of dip frequency is used[4]. Figure 1 gives flow chart of the software. SDips results file contains voltage dip characteristics for all nodes in the network due to the different fault types at each fault position.

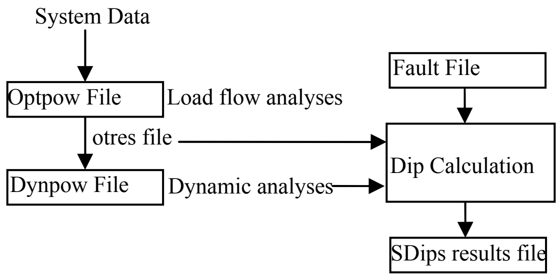


Fig. 1. Flow chart of SIMPOW DIPS Software.

III. DESCRIPTION OF TURKISH SYSTEM

Turkey transmission system has 21 transmission regions and connects to the European grid in Hamitabad Bus at the 1st region. Figure 2 shows Turkey Transmission system for 380kV voltage level. 2nd region of Turkey transmission system is the most heavy area. This area includes lots of companies and production units, also consumes 25% of the electrical energy of used in Turkey. Even tough this area is only 2% of Turkey, it includes 35% of total population. Therefore the 2nd region is chosen to evaluate and have some ideas about the voltage dip performance of the system. There are 55 buses in this region. The voltage levels are 380 kV and 154 kV. Also there are 7th large power steam turbine generators. These are connected to the Ambarli A1-A2, B1-B2, Hadimkoy and Esenyurt Buses. nd region is marked on Figure 3. Transmission components and length of lines in Turkish 2nd region are given Table 1 and Table 2 [5].

Table 1. Transmission components of Turkish Transmission System in year 2007.

Transmission System Parameters	Number
380 kV Busses	5
154 kV Busses	43
Generator Busses	7
Lines	76
Transformers	36
Switched Shunt Impedances	24
Generation Units	38

Table 2. Length of Lines in Turkish Transmission System in year 2007.

Voltage Level (kV)	Length (km)
400	112
154	664.8
TOTAL	776,8

IV. VOLTAGE DIP PERFORMANCE

The first step to evaluate voltage dip performance of the system, is to calculate the voltage dip levels of all buses for all fault positions. Second step is to determine the exposed area what helps to investigate the drop of voltage magnitude due to faults other buses and determine a voltage threshold for all nodes. Lastly annual voltage dip frequency is calculated.

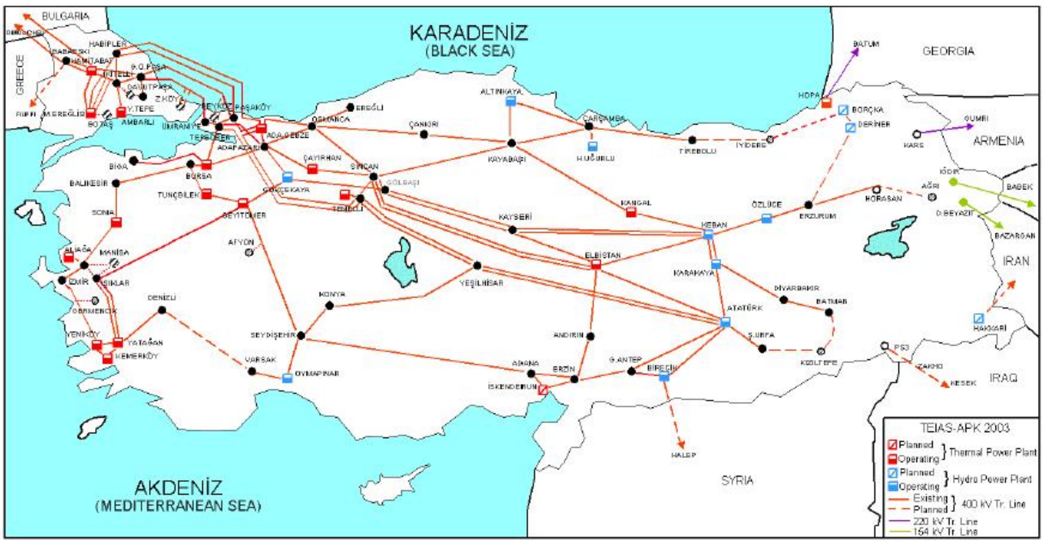
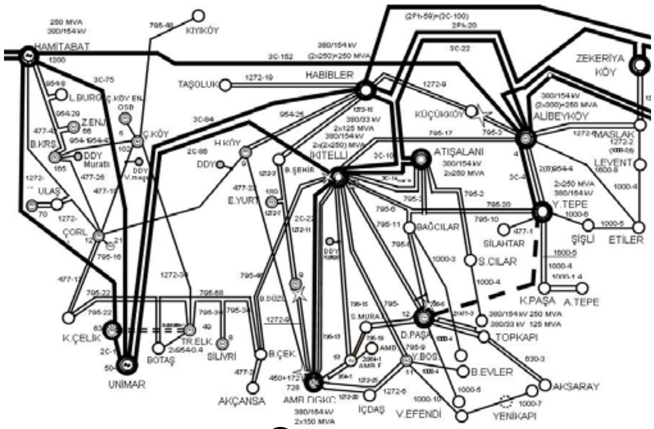


Fig. 2. Turkey 380 kV transmission system[5].



◯154 kV Substations **◯**380 kV Substations
——154 kV Transmission Lines ▬▬380 kV Transmission Lines

Fig. 3. 2nd region of Turkey Transmission system.

A. *Exposed Area for Bus Levent*

When a three phase fault is occurred on the Levent Bus, voltage level is 154kV, the most affected busses from the fault are Maslak, Etiler and Şişli. Because these buses are the nearest buses to the faulted bus and the voltage level is the same. Also there is no distributed generation or generation unit which corroborate the voltage connected these buses. Figure 4 shows an exposed area due to three phase fault of Levent Bus while the system is full loaded. 10%, 50% and 70% show the remaining voltage during the fault for the other buses. The area helps to understand how the system's behaviour during a three phase fault on a certain bus.

B. *Exposed Area for Bus Levent When the System is Half Loaded*

For the half loaded system the obtained exposed area due to three phase fault at Levent Bus is shown in Figure 5. During the three phase fault the exposed area with remaining voltage 10% is the same for full loaded (see in Figure 4). However voltage drop of the buses in the area of 50% decayed to 30% when the system is half loaded.

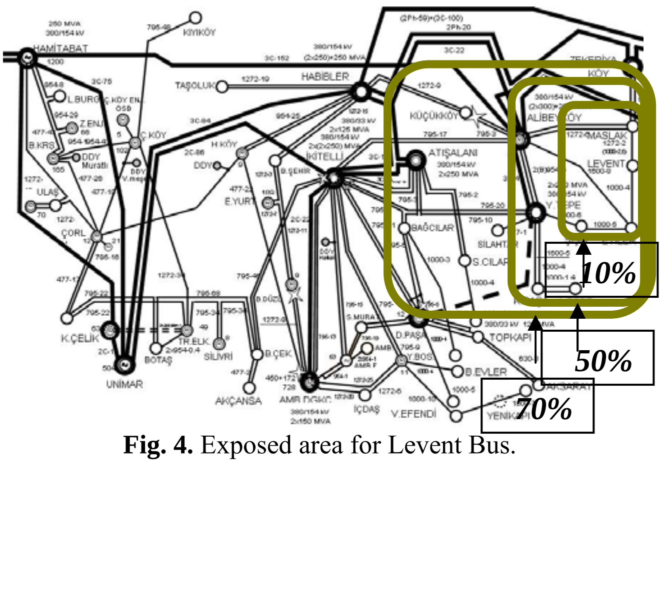


Fig. 4. Exposed area for Levent Bus.

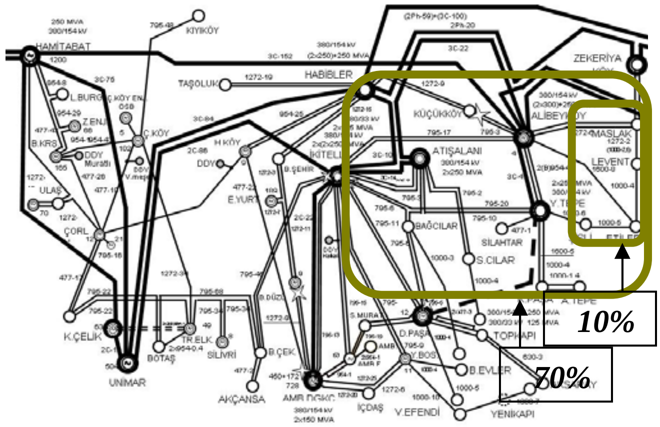


Fig. 5. Exposed area Levent Bus in half loaded condition.

C. *Exposed Area for Bus Atışalan_A*

Figure 6 shows the exposed area when a three phase fault occurs at the Atışalan_A Bus, voltage level of the bus is 380 kV. During the fault, the voltage dip magnitude is between %0-%30 at the buses of Bağcılar and Davutpaşa. The remaining voltage is around 50% at the buses Küçükköy, İkitelli, Etiler, Şişli, İçdaş. When Figure 4 and Figure 6 are compared, the exposed area is wider in Figure 6. Especially the buses in which voltage level is 154kV are more affected. Atışalan_ A Bus has more influence on the system than Levent Bus.

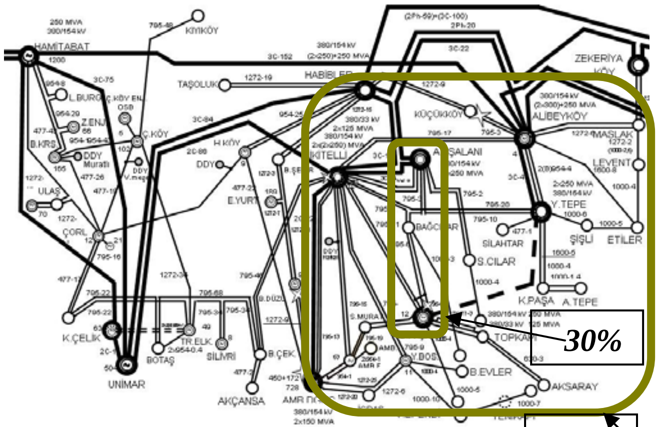


Fig. 6. Exposed area for Bus Atışalan_A.

V. VOLTAGE DIP CALCULATION

The current version of Simpow Dips produces a result file in text format containing information about the dips expected at the selected locations. A fault is simulated at each one of the nodes in the system. For every fault the following information about the resulting dips at all nodes in the system is given;

1. Number of faults per year divided into three phase, two phase to ground, phase to phase and single phase to ground faults.
2. For each fault type, indicates which phases that are involved in the dip; characteristic voltage,

PN-factor and zero sequence voltage, all in complex format[4].

Characteristic voltage indicates the severity of the dips. For balanced dips, it equals to phase voltages. For unbalanced dips, it is defined as the subtraction of positive and negative sequence voltages. PN-factor, relating to the dynamic loads contribution to the source impedance for unbalanced dips. Details about the characteristic voltage and PN-factor are found in [6].

Calculations of SIMPOW DIP is based on method of fault positions. Fault positions method is one of the stochastic methods that give an idea about the system dip performance. In this method, a number of fault positions are defined. Different fault types are applied at the fault positions one at the time and remaining voltages at the customer locations in the network are calculated[7].

Fault index defines fault frequency data for all buses and lines. For buses, the fault frequency should designate the number of faults per year and for lines, it should designate the number of faults per year and kilometers. It is assumed the fault is distributed uniformly. Fault index used is from year 2006, on the Turkish Transmission System, and it is shown in Table 3 and Table 4 for voltage levels of 380 kV and 154 kV, respectively. Fault index mostly depends on weather and geographic conditions because of overhead lines. The other lines connected to the line also affect the fault index.

Voltage dip frequency according to the characteristic voltage for some buses are given in Figure 7 and Figure 8, respectively. The voltage level of buses in Figure 7 is 154 kV and in Figure 8 is 380 kV. From Figure 7, it can be seen that there is no big changes number of disturbance in Hadımköy, Taşoluk and Aksaray_B buses for voltage larger 0.8 pu. For Levent and Zekeriyaköy Buses, number of disturbance is higher than the other buses up to 0.7 pu.

In Figure 8, the number of voltage dips at the Alibeykoy Bus is higher than the Habibler Bus eventough their voltage levels are the same. It shows that the strength of Habibler Bus to the dips that have characteristic voltage between 0.9-0.6 pu. is higher than the Alibeyköy Bus. For Habibler bus there are not big changes after the magnitude of characteristic voltage reaches 0.7 pu, but for Alibeykoy Bus it is near zero after 0.55 pu. Ambarlı and Alibeyköy buses have almost same characteristic.

Table 3. Fault index for lines at the voltage level of 380 Kv

BUS	BUS		FT	2F	2FT	3FT	Length (km)	Number of fault	Fault Index (faults per 100 km)
ALIBEYKOY	PASAKOY		5	4	0	0	45.574	9	19.69
ALIBEYKOY	UMRAN		0	2	1	5	38.662	8	20.64
AMBAR.D.G	IKITELLI		6	1	0	0	21.960	7	31.79
HABIPLER	IKITELLI		2	0	1	0	9.550	3	31.33
TEMELLI	YESILHIS	GUNEY	46	0	0	0	296.800	46	15.46
TEMELLI	YESILHIS	KUZEY	35	0	0	0	296.291	35	11.78

FT: Phase to earth fault, 2F: Two phase fault, 2FT: Two phase to earth fault, 3FT: Three phase to earth fault.

Table 4. Fault index for lines at the voltage level of 154 kV

BUS	BUS		FT	2F	2FT	3FT	Length (km)	Number of fault	Fault Index (faults per 100 km)
AKSARAY	TOPKAPI	2	0	0	0	0	2.797	3	106.96
ALIBEYKOY	Y.TEPE	2	1	0	2	0	3.822	3	78.28
BAGCILAR	D.PASA		4	0	1	0	4.440	5	112.30
ETILER	SISLI		0	0	0	0	4.100	14	340.53
IKIZLER	YUMURTALI		21	0	0	0	23.960	21	87.41
KARTAL	KURTKOY	1	1	3	1	0	6.092	5	81.85
KPASA GIS	Y.TEPE	1	5	0	0	0	3.972	5	125.54
KPASA GIS	Y.TEPE	2	3	0	0	0	3.972	5	125.54

FT: Phase to earth fault, 2F: Two phase fault, 2FT: Two phase to earth fault, 3FT: Three phase to earth fault.

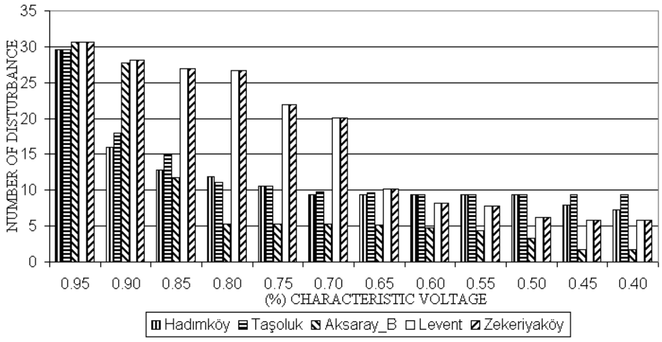


Fig. 7. Simulation results for some 154 kV buses.

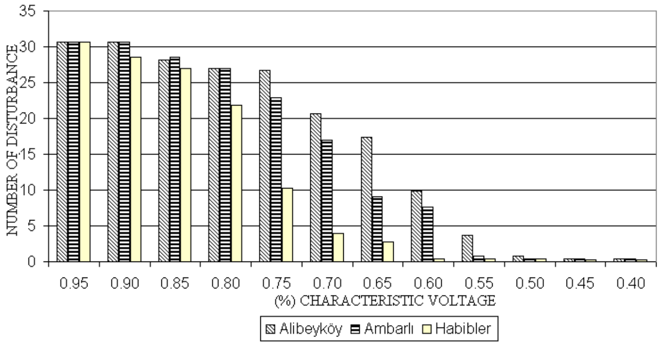


Fig. 8. Simulation results for some 380 kV buses.

VI. FUTURE WORK

Turkey Electric Transmission Incorporated Company (TEIAS) plans to structure for power quality monitoring. When this is implemented, the simulation results will be compared with monitoring results. Consistence between simulation and monitoring results provide to apply this study to all Turkey system.

VII. CONCLUSION

In this paper, the most heavy area of the Turkish Transmission system was chosen to evaluate the dip performance of Turkey system. Real data was obtained from the TEIAS. For this region power flow, dynamic and dip analyzes of the system were made. To assess the power quality of a system that does not exist yet, is possible by using software. Improve the existing electrical system is possible by real time monitoring or use of software. In this study for an existing system, using real system data, simulations by SIMPOW DIPS software were realized. Do not have any monitoring result of the region is a big difficulty to assess the simulation results but these problem will be solved in the future.

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