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PLANNING AND MANAGEMENT OF THE POWER SYSTEM USING DSATOOLS' SOFTWARE

BOBRIC Elena Crenguta, IRIMIA Daniela, RATA Gabriela, RATA Mihai
"Ştefan cel Mare" University
Str. Universităţii nr. 13, 720 225 Suceava, Romania
crengutab@eed.usv.ro

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Abstract: The planning and control activity of electrical networks has a significant importance on power systems ensemble, being now, an important opportunity in the world over, and the research of power systems management is in full development. The DSATools' software provides a complete toolset for power system planning and operational studies. In this paper is presented a study case which used DSATools' software for electrical networks analysis.

1. INTRODUCTION

Planning, supervision and control of electric networks impose to use the complex methods and techniques, based on classical proceedings from respectively area, improved with that of computational intelligence, artificial intelligence methods, modelling and simulation methods, etc.

Now, the various implications of power system generated increased needs, according with that it's improved routine calculus, but mostly data sorting, realization of some complex processing (selective analysis, multi-objective optimisation, online optimal power flow control, s.o.).

Planning and management of energy systems is based on power flow calculation. The power flow defines the state of a power system at certain of time and corresponds to a given generation and consumption pattern. The results obtained after the load flow calculation, can be the starting point for any analysis of power system, as [5]:

- information for planning strategies of electric networks development for determination of the optimal configuration as well as in the exploitation activity for establishing the operating regime;
- input data for:
  - contingency analyses, for testing the unavailability of an electric line, transformer or synchronous generator;
  - transmission capacity analysis, for testing the limits of transfer power (thermal limit);
  - reactive power - voltage analysis, for assessment of necessity of VAr – voltage equipment and its regulation manner;
  - on-line control of power system operation, using state estimators and process computers;
- starting point in the study and the selection of the protection relay and automations, also for static, transient and voltage stability analysis, the optimisation of operating regimes, etc.

Small and large utilities, industrial organizations, engineering companies and universities, use several programming languages, such as Matlab, Mathcad, Mathematica, NEPLAN, ETAP or DSATools for solving a real problem of exploitation, research or educational purposes.

Using this programming language for modelling and simulations of power system, the electricity companies can further develop superior marketing strategies, improving the efficiency, s.o.

2. DSATOOLS SUITE

Consumers of electric power demand reliable, high-quality electricity supply from utilities at low cost. This requires the ability to properly design power systems and the associated controls, and assess system performance under a wide variety of conditions — a formidable task considering the complexity of modern power systems and the continually changing environment in which they operate.
DSATools offers the computer simulation techniques to fully assess and enhance power system performance. This software provides a complete toolset for power system planning and operational studies.
This software has four module: VSAT-Voltage Security Assessment Tool, TSAT - Transient Security Assessment Tool, Small-Signal Analysis Tool SSAT, PSAT, Power flow & Short circuit Analysis Tool, each dedicated to a particular study.
PSAT – Power flow & Short circuit Analysis Tool is a fully graphical tool which offers: power flow analysis, steady-state voltage decline, line and transformer thermal loading, active/reactive power supply problems, s.o. PSAT is also designed to be used as a case preparation tool for the other components of the DSATools suite.
VSAT-Voltage Security Assessment Tool offer: automatically determines voltage security limits, limiting contingencies and problem areas.
SSAT - Small-Signal Analysis Tool performs comprehensive small signal stability analysis of large systems and includes a number of special features for automatic analysis of contingencies and power transfers, as: comprehensive model library and model customization capability, small signal stability index computation, frequency/step response computation, contingency and sensitivity analysis, automatic power transfer analysis determination, s.o.
TSAT -Transient Security Assessment Tool automatically determines transient security limits, critical contingencies, unstable groups of machines, and transient voltage violations. Features include: comprehensive criteria definition (transient stability, damping, transient voltage, and transient frequency), full time-domain simulation engine, multiple contingency and multiple scenario processing capability, comprehensive model library and model customization capability, automatic power transfer limit determination and s.o.
With PSAT is possible to create a new power flow case. So, is can create a Single Line Diagrams (SLD) of the analysed systems by drawing busses, lines, transformers and generators. For these, data can be viewed and modified through Properties dialogs or data tables. After drawing schemes of networks and introduction input data can solve the power flow and view the solution on the interactive diagram or solution tables.

3. POWER FLOW ANALYSIS

The load-flow problem models the nonlinear relationships among bus power injections, power demands, and bus voltages and angles, with the network constants providing the circuit parameters. It is the heart of most system-planning studies and also the starting point for transient and dynamic stability studies. In the following will be summarized a formulation of the load-flow problem and its associated solution strategies.
To define the power flow problem, the essential aspects are:

- knowing: voltage magnitude and phase – angle at the slack node, active and reactive powers, demanded at the PQ – nodes, voltage magnitudes and active powers, generated at the PU – nodes and technical limits of the reactive powers, generated at the PU – nodes;

- the following quantities are to be calculated: voltage magnitudes and phase – angle at the PQ – nodes, reactive nodal powers and phase – angle at the PU – nodes, active and reactive powers, injected at the slack node, active and reactive powers flows and losses, reactive power generated by the line capacitances.

There are two popular numerical methods for solving the power-flow equations. These are the Gauss-Seidel and the Newton-Raphson Methods. The Newton-Raphson methods have a faster convergence characteristic compared with Gauss-Seidel Methods. But the N-R method suffers from the disadvantage that a "flat start" is not always possible since the solution at the beginning can oscillate without converging toward the solution. In order to avoid this problem, the load-flow solution is often started with a G-S algorithm followed by the N-R algorithm after a few iterations.
Voltage and power in network nodes are, generally, variables the power flow problem and the relationship matrix of connection between them is:

$$[\underline{S}] = \lfloor \underline{U} \cdot \underline{I}^* \rfloor \tag{1}$$

The mathematical model for steady state analysis is based on nodal voltage method using either nodal admittance matrix:

$$\underline{I}_i = \frac{\underline{S}_i^*}{\underline{U}_i^*} = \sum_{k=1}^{n} \underline{Y}_{ik} \cdot \underline{U}_k \tag{2}$$

where:

- U_k - phase-to-phase nodal voltage;
- I_i - phase-to-phase currents multiplied by $\sqrt{3}$
- S_i - three-phase powers injected in node *i.*

The nodal power is the difference between the generated (noted by g) and consumed (noted by c) powers into a node. The expression of the nodal complex power in node i, is:

$$\begin{aligned} P_{gi} - P_{ci} &= P_i(U_m, \theta_m) \\ Q_{gi} - Q_{ci} &= Q_i(U_m, \theta_m) \end{aligned} \tag{3}$$

where U_m, θ_m are vectors of state variables.

4. CASE STUDY

In this section is presented a study case which used DSATools' software for electrical networks analysis. With PSAT is modelled a complex electrical network loops. This network has 39 nodes (three voltage levels), 35 transmission lines, 11 generators, 13 transformers and 19 customers connected to network nodes. Test SLD diagram is shown in Figure 1.
The load flow analysis calculates the steady state buses voltage (magnitude and angle), branch currents, real and reactive power flows and losses. Also, the network diagram in Figure 1 is illustrated in graphical form animated movements active and reactive power. With this you can easily see directions of power flow, it can highlight the types of generators, power consumption, etc.
For test network, convergence solution is obtained by applying Newton-Raphson fast decoupled method, and the results are presented in Table 1.

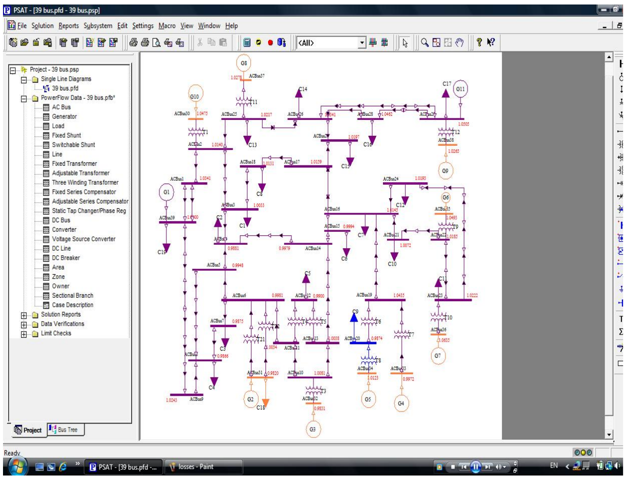

Fig. 1: Test network

Table 1: Power flow

	From Bus	To Bus	From Bus			To Bus		
	Number	Number	MW Flow	MVAr Flo	Current	MW Flow	MVAr Flo	Current
1	1	39	57.69	-13.04	95.71	-57.63	-25.32	102.27
2	1	39	57.69	-13.04	95.71	-57.63	-25.32	102.27
3	2	1	115.95	-92.70	245.01	-115.38	26.09	191.43
4	2	3	367.87	36.27	610.09	-366.13	-42.20	614.71
5	3	4	51.20	57.85	128.85	-51.10	-78.24	158.27
6	4	14	-280.41	-59.44	485.48	281.08	56.57	480.83
7	4	5	-168.49	-46.32	295.96	168.73	37.06	290.61
8	5	6	-487.46	-85.47	832.51	487.95	87.58	831.25
9	5	8	318.73	48.41	542.31	-317.88	-51.05	546.09
10	6	7	428.23	89.45	733.53	-427.07	-82.81	737.24
11	6	11	-350.44	-37.27	590.91	351.31	33.54	588.57
12	7	8	193.27	-1.19	327.55	-193.12	-4.65	327.66
13	8	9	-11.00	-120.30	204.90	11.25	85.74	141.27
14	11	10	-352.86	-78.03	602.70	353.37	76.21	600.08
15	13	10	-296.26	-74.21	509.15	296.63	70.79	506.23
16	14	13	-288.48	-37.66	487.90	289.24	28.93	484.59
17	15	14	-7.40	-17.47	31.77	7.40	-18.91	34.05
18	16	15	313.62	128.90	559.33	-312.60	-135.53	570.54
19	16	21	-327.80	68.55	552.41	328.69	-79.62	561.91
20	16	19	-450.92	-111.25	766.12	454.23	119.31	753.17
21	17	16	-179.57	24.76	298.59	179.79	-35.72	302.37
22	17	27	14.31	-39.84	69.73	-14.30	6.65	25.88
23	18	17	-165.07	-26.45	276.15	165.26	15.08	273.35
24	18	3	7.07	-3.55	13.07	-7.07	-18.05	32.33
25	21	22	-602.69	-35.38	1003.09	605.56	59.26	999.69
26	22	23	44.44	-51.45	111.71	-44.42	32.58	90.18
27	24	16	44.12	76.21	144.59	-44.09	-82.77	154.70
28	24	23	-352.72	15.99	579.71	355.38	-11.28	582.07
29	25	2	238.26	-105.43	426.76	-233.81	95.77	417.01
30	25	26	75.98	-72.54	172.05	-75.73	20.77	127.08
31	26	28	-141.14	-50.94	242.84	141.95	-24.60	230.45
32	26	29	-189.85	-54.45	319.61	191.77	-36.28	310.91
33	27	26	-266.70	-82.15	457.99	267.73	67.62	446.87
34	28	29	-347.95	-3.00	556.61	349.50	-7.65	556.90
35	39	9	11.25	-40.72	68.64	-11.25	-85.74	141.27

5. CONCLUSIONS

Given the changes in production and domestic consumption of electricity must have made an analysis and planning of the entire system of electricity transmission and distribution. By simulating the entire system, or independent parts of the system, we can obtain the system analyses in very short time. Based on those results can take a correct decision on certain changes to be made in real network.

In this paper is presented DSATools software used for simulations and some applications in power systems analysis. These tools come with a variety of procedures for static and dynamic analysis that can be used with easiness in educational and research activities.

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