ALTERNATIVE TRANSIENT PROGRAM – THE POWERFUL TOOL FOR POWER ENGINEERING SIMULATIONS

Marián MEŠTER
Department of Electric Power Engineering, Faculty of Electrical Engineering and Informatics,
Technical University of Košice, Letná 9, 042 00 Košice, Slovak Republic, tel. 055/602 4145, E-mail: marian.mester@tuke.sk

SUMMARY

In this article is presented the capabilities and practical experience with Alternative Transient Program (ATP). ATP is an universal program system for simulation of transient phenomena of electromagnetic as well as electromechanical nature.

In the article presented we simulation of 220 kV transmission network of Eastern Slovakia. The practical outputs of ATP simulation are compared with the other simulation tool - Matlab.

Keywords: *Alternative Transient Program, transient phenomena, fault currents, Matlab*

1. INTRODUCTION

Modelling of transient phenomena is the important part of design and analysis of power systems. It is very important for education, too. In the world exist a few software tools, suitable for simulations of transient phenomena. The mostly world-wide used program is Alternative Transient Program (ATP).

2. ALTERNATIVE TRANSIENT PROGRAM

ATP has extensive modelling capabilities and additional important features besides the computation of transients. It has been continuously developed through international contributions over the past 20 years. Besides actual simulation module there exist several non-simulation supporting routines, which can be used to generate model data. A schematic overview of available simulation modules and supporting routines and their interaction is shown on Fig. 1.

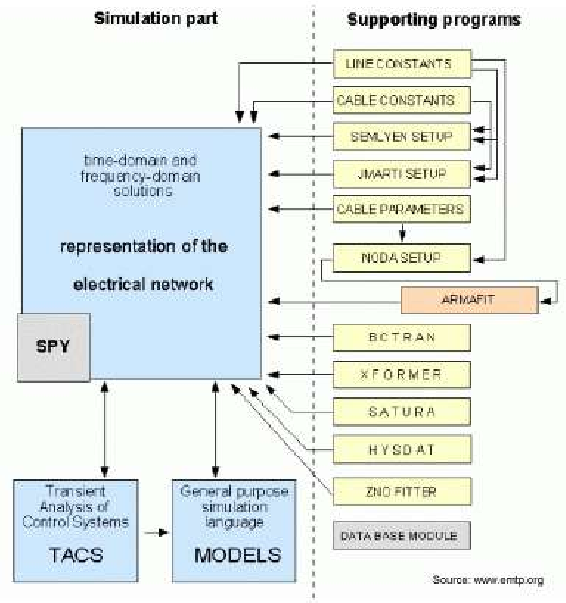

Fig. 1 Modules of ATP [1]

2.1 Historical Background

ATP has been continuously developed from EMTP (Electromagnetic Transient Program) through international contributions by Drs. W. Scott Meyer and Tsu-huei Liu, the co-Chairmen of the Canadian/American EMTP User Group. The birth of ATP dates to early in 1984, when Drs. Meyer and Liu did not approve of proposed commercialization of BPA (Bonneville Power Administration) EMTP by DCG (the EMTP Development Coordination Group) and EPRI (the Electric Power Research Institute). Dr. Liu resigned as DCG Chairman, and Dr. Meyer, using his own personal time, started a new program from a copy of BPA's public-domain EMTP. Requirements of ATP development include honesty in all dealings and non-participation in EMTP commerce. ATP is not in the public domain, and licensing is required before ATP materials are received [1].

2.2 Operating Principles and Capabilities of ATP

The ATP program predicts variables of interest within electric power networks as functions of time, typically initiated by some disturbances. Basically, trapezoidal rule of integration is used to solve the differential equations of system components in the time domain. Non-zero initial conditions can be determined either automatically by a steady-state phasor solution or they can be entered by the user for simpler components. ATP has many models including rotating machines, transformers, surge arresters, transmission lines and cables. Interfacing capability to the program modules TACS (Transient Analysis of Control Systems) and MODELS (a simulation language) enables modeling of control systems and components with nonlinear characteristics such as arcs and corona. Dynamic systems without any electrical network can also be simulated using TACS and MODELS control system modeling.

Symmetrical or unsymmetrical disturbances are allowed, such as faults, lightning surges and several kind of switching operations including commutation of valves. Frequency-domain harmonic analysis using harmonic current injection method (HARMONIC FREQUENCY SCAN) and calculation of the frequency response of phasor networks using FREQUENCY SCAN feature is also supported. The model-library of ATP at present consists of the following components:

- Uncoupled and coupled linear, lumped R,L,C elements.
- Transmission lines and cables with distributed and frequency-dependent parameters.
- Nonlinear resistances and inductances, hysteretic inductor, time-varying resistance, TACS/MODELS controlled resistance.
- Components with nonlinearities: transformers including saturation and hysteresis, surge arresters (gapless and with gap), arcs.
- Ordinary switches, time-dependent and voltage-dependent switches, statistical switching (Monte-Carlo studies).
- Valves (diodes, thyristors, triacs), TACS/MODELS controlled switches.
- Analytical sources: step, ramp, sinusoidal, exponential surge functions, TACS/MODELS defined sources.
- Rotating machines: 3-phase synchronous machine, universal machine model.
- User-defined electrical components that include MODELS interaction.

2.3 Output and Maximum Capabilities

Output:

Time-varying output in printed lists, character plots, or vector plots using separate interactive graphic programs TPPlot, PCPlot, PlotXY. HP-GL and PostScript also can be produced. Postprocessing of monitored variables using MODELS and/or TACS, Fourier analysis.

Maximum capabilities:

ATP tables are dimensioned dynamically at the start of execution to satisfy the needs of users and their hardware (e.g., RAM). No absolute limits have ever been observed.

Busses	3000
Branches	3000
Switches	1200
Sources	340
Nonlinear elements	460
Synchronous machines	45

Tab. 1 Default table sizes [1]

2.4 Additional Tools

ATPDraw for Windows is a graphical, mouse-driven preprocessor for ATP on the MS-Windows 3.x and Windows 95/98/2000/NT platforms. Using ATPDraw for Windows, one builds a graphical picture of an electric circuit by picking objects from menus, connecting and editing objects, and keying data interactively. ATPDRAW then creates the corresponding ATP input data file. The user can create his own circuit objects by using the Data Base Module feature of ATP.

ATP Control Center (ATPCC) is a user-shell for the ATP versions, supporting programs ATPDraw, PCPlot, PlotXY and any other ATP related programs running under Microsoft Windows 95/98/NT/2000. ATPCC can working with two different ATP versions at the same time possible.

PlotXY is a WIN32 plotting program originally designed for use with ATP, but now able to work satisfactorily also with ASCII data files. It is able to perform some post-processing on the plotted curves: algebraic operations, computation of the Fourier series coefficients.

2.5 Typical Applications

Typical ATP studies are [2]:

- Lightning overvoltage studies,
- Switching transients and faults ,
- Statistical and systematic overvoltage studies,
- Very fast transients in GIS and groundings,
- Machine modeling,
- Transient stability, motor startup,
- Shaft torsional oscillations,
- Transformer and shunt reactor/capacitor switching,
- Ferroresonance,
- Power electronic applications,
- Circuit breaker duty (electric arc), current chopping,
- FACTS devices: STATCOM, SVC, UPFC, TCSC modeling,
- Harmonic analysis, network resonances,
- Protective device testing.

3. SIMULATION OF 220 KV TRANSMISSION NETWORK OF EASTERN SLOVAKIA

The transmission network, which are simulated, shown Fig. 2. Three-phase faults were simulated on buses 1 to 6 in succesive steps.

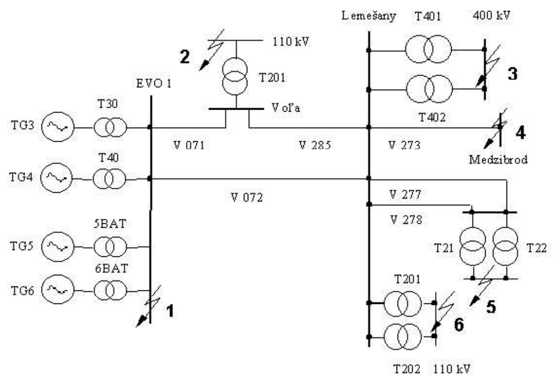

Fig. 2 220 kV transmission network of Eastern Slovakia

Tab. 2 presented the parameters of generators and transformers and Tab. 3 presented the electrical parameters of transmission lines. Fig. 3 shows ATP Draw model of these network.

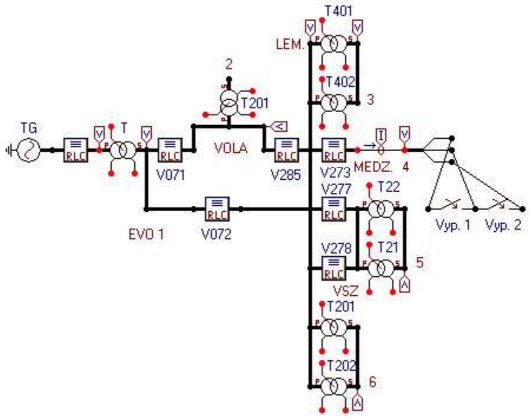

Fig. 3 ATP Draw model (fault on bus 4)

Generators	S_a [MVA]	U_n [kV]	x''_d [%]	x_d [%]	cosφ [-]
TG3, TG4	137,5	13,8	13	218	0,8
TG5, TG6	137,5	13,8	11,8	190	0,8

Transformers	S_a [MVA]	U_{n1} [kV]	U_{n2} [kV]	u_k [%]
T30, T40	125	242	13,8	15,13
5BAT, 6BAT	125	242	13,8	12,04
T401, T402	167/60	400	213	13,50
T201, T202	200/100	231	121	8,31
T201(Voľa)	200/100	231	121	8,31
T21	200	213	121	12,30

Tab. 2 Parameters of generators and transformers

Branch	Begin-Bus	End-Bus	R [Ω]	X [Ω]
071	EVO 1	VOĽA	2,360	16,070
072	EVO 1	LEMEŠANY	4,840	32,880
273	LEMEŠANY	MEDZIBROD	16,630	82,140
277	LEMEŠANY	VSŽ	2,630	12,160
278	LEMEŠANY	VSŽ	2,600	12,040
285	VOĽA	LEMEŠANY	2,880	9,530

Tab. 3 Electrical parameters of lines

Fault	Transmission Line					
	071	285	072	273	277	278
	I_{k3}'' [kA]					
2	1,566	0,589	0,589	0	0	0
3	1,703	1,703	1,341	0	0	0
4	0,616	0,616	0,484	1,100	0	0
5	1,159	1,159	0,911	0	1,03	1,04
6	1,409	1,409	1,107	0	0	0

Tab. 4 Branch faults currents from ATP simulation

Using this model (Fig. 3) we have obtained branch fault currents (Tab. 4) and bus faults currents (Tab. 5).

For comparison we are modelled these network using Matlab, too. Tab. 5 shows comparison of bus faults currents between ATP and Matlab.

Fault	ATP I_{k3}'' [kA]	Matlab I_{k3}'' [kA]	Relative error [%]
1	4,904	4,833	1,47
2	4,115	4,056	1,46
3	1,243	1,242	0,08
4	1,100	1,100	0,00
5	3,953	3,861	2,38
6	4,803	4,670	2,85

Tab. 5 Comparison of bus faults currents computing by ATP simulation and by Matlab

3.1 Graphical Outputs

On Fig. 4 to 9 are a few graphical outputs from faults simulations, using PlotXY [3].

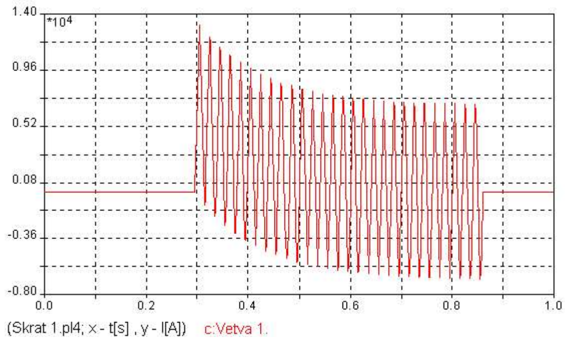

Fig. 4 Short current waveform on bus 1 (phase L1) during three-phase fault on bus 1

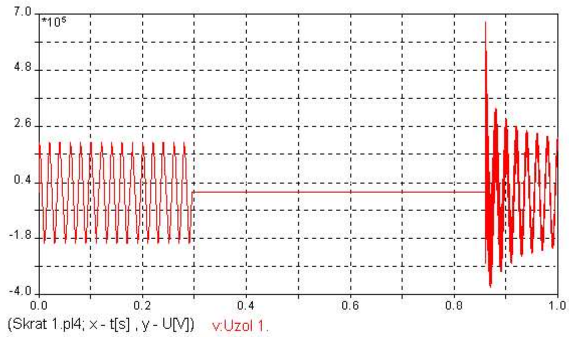

Fig. 5 Voltage drop on bus 1 (phase L1) during three-phase fault on bus 1

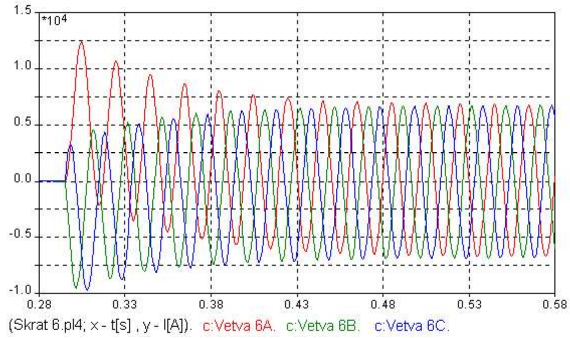

Fig. 6 Short current waveforms on bus 6 (phases L1, L2, L3) during three-phase fault on bus 6

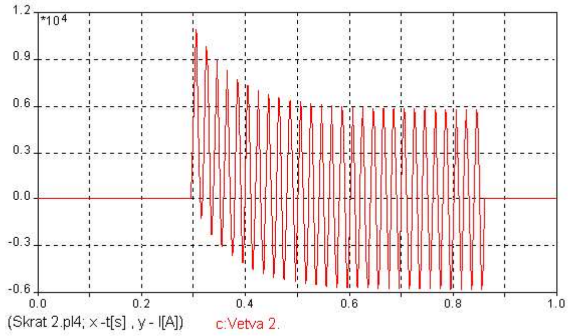

Fig. 7 Short current waveform on bus 2 (phase L2) during three-phase fault on bus 2

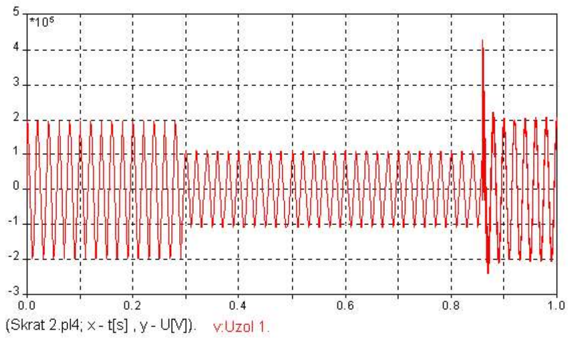

Fig. 8 Voltage drop on bus 1 (phase L2) during three-phase fault on bus 2

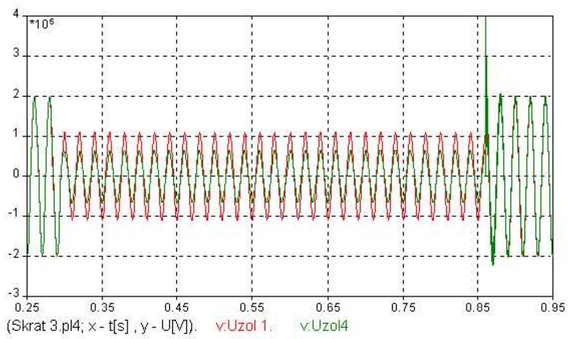

Fig. 9 Voltage drop on bus 1 (phase L1) and on bus 4 (phase L1) during three-phase fault on bus 3

CONCLUSION

The numerical outputs from ATP (Tab.4, Tab.5) shows, that the calculation of fault currents corresponds with Matlab solution. In Matlab were simulated the calculation of fault currents for a consideration of STN IEC 60909 [4].

ATP is used world-wide for switching and lightning surge analysis, insulation coordination and shaft torsional oscillation studies, protective relay modelling, harmonic and power quality studies, HVDC and FACTS modelling.

It is possible to use it to design power systems and to analyse existing networks. Especially suitable is ATP to faults analysis, if faults recordings are available.

Solutions of possible simulation problems are very simply, through internet. Every user has free access to the discussion group [1].

REFERENCES

[1] www.eeug.org

[2] EEUG Course: *Efficient use of ATP & modeling of transformers with saturation*, Gizzeria Lido, Italy, November 10, 1999.

[3] Patúš R.: *Transient phenomena of power systems analysis using EMTP – ATP*. Master Thesis, Košice, 2000. (in Slovak)

[4] STN IEC 60909: *Short–circuit current calculation in three-phase a.c. system. Výpočet skratových prúdov v trojfázových striedavých sústavách*, Úrad pre normalizáciu, metrológiu a skúšobníctvo SR, Slovenská technická norma, august 2000.

BIOGRAPHY

Marián Mešter was born in 1973. He is graduated (MSc.) at the Department of Electric Power Engineering of the Faculty of Electrical Engineering and Informatics at the Technical University in Košice in 1996. Since 1997 he has worked as an assistant professor on the Department of Electric Power Engineering. His research interest are power system stability and transient phenomena.