Configuration of Subroutine MODELS of ATPDraw in Transient Recovery Voltage (TRV) Studies for Circuit Breakers

D. G. Pimenta [1] and J. Amon Filho

FURNAS CENTRAIS ELÉTRICAS S.A.

Abstract - This article presents an application of MODELS in association with the interface ATPDraw in studies of calculation of the transient recovery voltage for circuit breakers (TRV). The developed auxiliary routine accomplishes the research of the values that characterize the severity of the TRV curve, generates reference curves (from standards) TRV, avoiding to the possibility of mistakes in the process of building up these graphs, increasing the user's productivity.

Keywords – ATPDraw/EMTP, circuit breakers, MODELS, Transient Recovery Voltage, TRV.

I. INTRODUTION

The association of ATP program (1) and the graphical tool ATPDraw (2) allow great flexibility and functionality on transient studies.

In a classic TRV study (3) (4) (5), the analysis of the results of each simulated case consists in evaluating the severity of the TRV obtained curve by determining its peaks (1st and maximum peaks), the corresponding peak times and the rise rate of recovery voltage (RRRV).

The application presented in this article has been motivated by the need of simulation of several cases for just a single TRV study. The routine MODELS associated with the interface ATPDraw (6), allows the observation of several possibilities for the network configuration close to the studied circuit-breaker.

The development of the routine was based on a three-phase module. As output of the data the developed application allow visualization by graphic form and a visualization by text form.

As the graphic visualization form the reference curves (7) (8) are also generated and printed on the same graphs of the obtained TRV curves and the parameters of evaluation of TRV severity. As the text visualization form is showed a table with values of parameters of TRV severity evaluation. The post-treatment process of the TRV results of is then automated, increasing the quality of the results and the user's productivity

II. MODELS LANGUAGE

MODELS language is a description language for general usage, associated to the interface ATPDraw, based on a group of simulation tools for representation and study of variant systems in the time. The language MODELS (similar to PASCAL) is focused on the description of the structure of a model and in the function of their elements.

The MODELS language contain many simple and power commands that allow several different constructions of routines. Its functionality can be more explored to develop others applications.

III. METHODOLOGY

The developed module consists of two parts. The descriptive file of the model, where the calculations and the processing of the read values are made, and the object file, linked to the descriptive file, which allows the flexibilities introduced by ATPDraw, of using a module in any point of the system where is the circuit breaker in which we want to analyze TRV, independently of the configuration around the circuit breaker.

It is necessary three parameters of the circuit breaker in the study. The first supplies an input variable that informs the status of the studied circuit breaker, if closed or open. The other ones supply the phase voltage before and after the circuit breaker, that allow us determine the behavior of the voltage on the poles of the circuit breaker during the occurrence of TRV.

A. Descriptive File Composition

The file MODELS, describing the operation of the model, should be written out of ATPDraw using a text editor ASCII or the internal editor Model Editor accessing main menu of tools by the options *Objects | Model / New* mod-file.

The standard descriptive file containing all the possible sections (input and output variables, data variables, functions, initialization of variables, body of the program, etc.) necessary to the construction of the routine. This descriptive file should be saved with the extension .mod and stored in the directory \ MOD in the tree of ATPDraw. This name will appear in the first line of the description file of the routine.

The routine develop the reading of each voltage point

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at each simulation step, witch goal is to determine the first and the maximum voltage crest of each pole after open operation of circuit breaker under fault occurrence. Between this points is determine its time instant of occurrence.

Also it is determine the maximum rise rate of recovery voltage (RRRV). In the determination of the RRRV four definitions exist for this rate according to the technology of construction of the circuit breaker. In this application the definition adopted was the maximum growth rate average, expressed as the tangent to the curve of TRV going by the origin.

The parameters analyzed in a study of TRV are described below and presented in Fig. 1:

- E1 – first TRV peak;
- T1 – time of E1 occurrence;
- E2 – maximum TRV peak;
- T2 – time of E2 occurrence;
- RRRV – rise rate of recovery voltage;
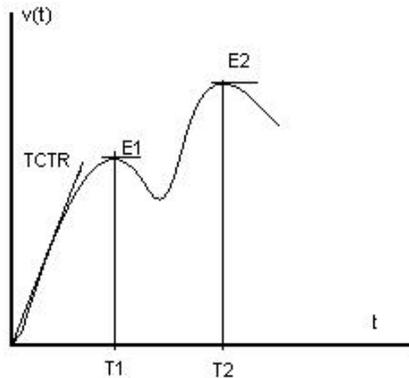- REF – reference curve of TRV.

Fig. 1. Analyzed parameters in a TRV study.

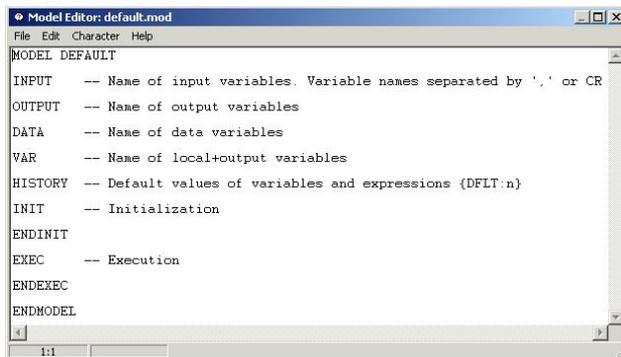Fig. 2 presents the window of edition of the descriptive file MODELS.

Fig. 2. Descriptive file MODELS standard.

B. MODELS Object Composition

An object MODELS consists of a file called support file, possessing the extension .sup. Each model should have a support file with objective of being used in ATPDraw. The support file pattern for all components contains the icon, information in the types and positions of us and parameters of data. There are two options for creation of the object of a model in ATPDraw:

- Manual Operation: selecting a file support manually by main menu Object | Model | New sup-file;

- Automatic Operation: selecting a file. mod directly in the option MODELS of the menu of selection of components and leaving ATPDraw to create the file support.

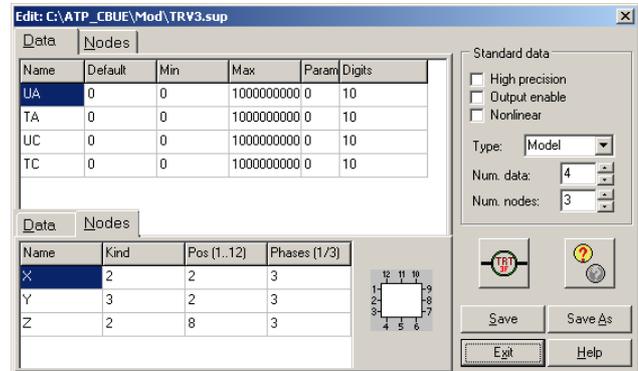Fig. 3 presents the window of edition of the support file MODELS.

Fig. 3. Support file edition.

C. Composition of Three-Phase Module

The most recent version of ATPDraw allows the operation of three-phase nodes on the MODELS routine. With that, the construction of the three-phase module is made directly in the descriptive file, being avoided the need of another procedure to obtaining of the three-phase module, as for instance, the use of the option COMPRESS of the main menu.

It is possible to edit a help file, Fig. 4, so that it can guide the users about data and variables of existent input/output object file, describing their functions and the unit of each greatness.

It is also possible, during the creation of support file, to edit the icon that will represent it, so that it is became easily identifiable.
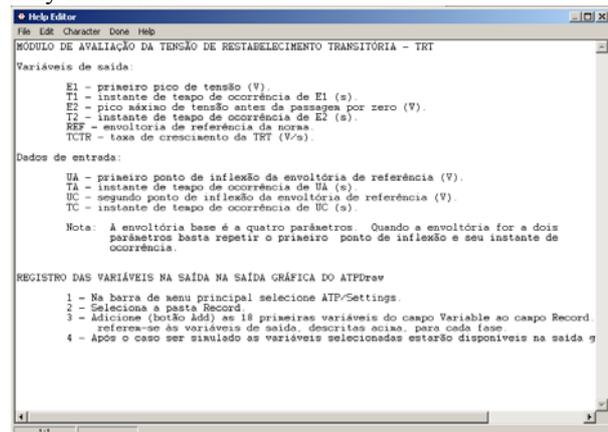

Fig. 4. Help file of developed interface.

D. Improvement of TRV studies

After the simulation of each case, with its respective net configuration, it can be obtained the behavior of the voltage on the poles in each phase of the circuit breaker during the opening operation. We can obtain the first peak and the maximum peak of this TRV with their respective occurrence time, the rise rate of recovery voltage and the reference curve. All values that are

obtained from this routine are showed in the output graphic of ATPDraw graphic interface.

In the reference (9) a methodology is described for the calculation of TRV of circuit breakers with the use of the program of calculation of electromagnetic transient EMTP.

The values needed to evaluate the TRV severity are also printed at the end of the .lis file in form of table.

This outputs, graphic and text form, allow the improvement of process of TRV analysis. Instead of read on the .lis file directly, the user will get all values in automatic manner avoid the possibility that mistakes can occur during the process of reading of an extensive text.

IV. STUDY OF CASE

The system adopted for a study of TRV is shown in Fig. 5. It was considered that the system already was in stead state and it was given the command so that the circuit breaker is opened in t = 0 s, being observed the interruption of the currents, in each phase, when of the passage for its natural zero.

The assembly of the system through the interface ATPDraw is simple, not having a rigid rule in the order of inclusion of the objects that can represent the sources, the transformers, the transmission lines (that can have the representation in concentrated or distributed parameters), the loads and the module of calculation of TRV, or any devices that compose the system to be analyzed.

The studied circuit breaker was the one of the line Itumbiara -Rio Verde (circuit I) on the side of bus of 230kV in the Itumbiara's Substation. The condition of applied fault was the three-phase fault not connected to ground, adopting as condition for maximization of the current fault the situation in that the circuit breaker in the opposite extremity of the line was open.
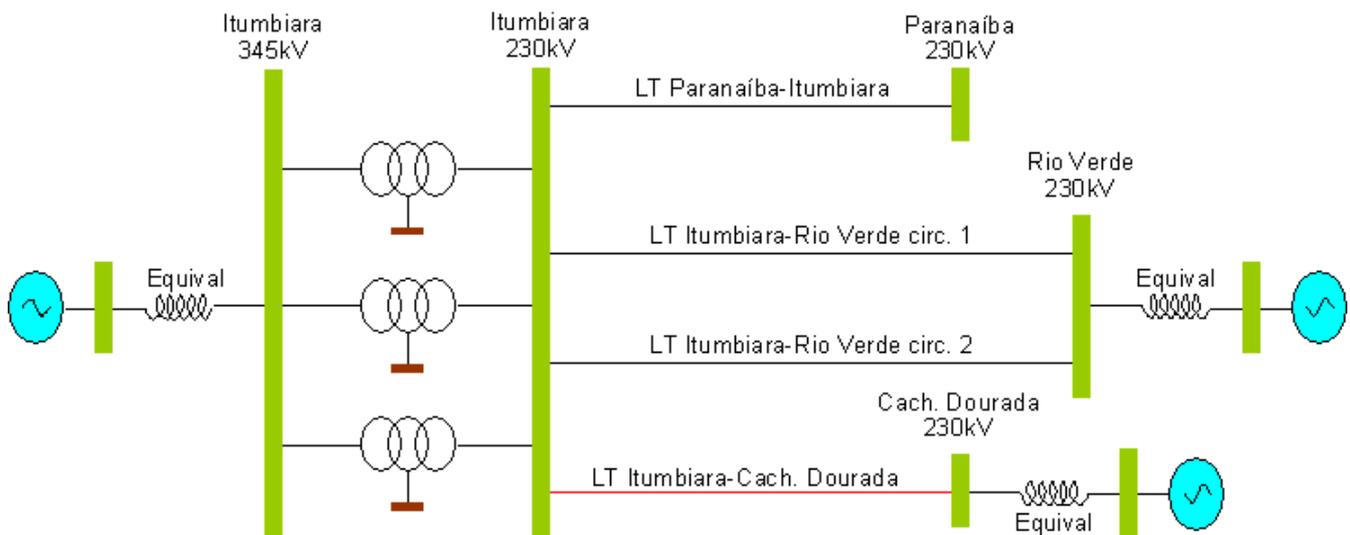

Fig. 5. System Studied.

If the study was made by the traditional procedure, the user might open the .lis file and read the output variables of this file at each simulation step to analyze the critical parameters of TRV curve. The routine developed make this analysis and offer the results in a graphic and text format

As a result of the study of TRV in the considered point we have the Fig. 6, that show in the same graph, the voltage on the pole of the phase C during the opening operation together with the normalized curve, the first peak and the maximum peak of TRV with their occurrence time.

Using the resource of the vertical bar to evaluate the points of the curve we can extract directly of the graph the parameters to evaluate the severity of TRV, as it can be seen in the window *Values* existent in Fig. 6.

In Fig. 7 we have the values of the rise rate of recovery voltage RRRV in the three poles of the circuit breaker.

The same procedure used in Fig. 6 was applied in this graph, being obtained the values of the rise rate of recovery voltage directly of the curves.

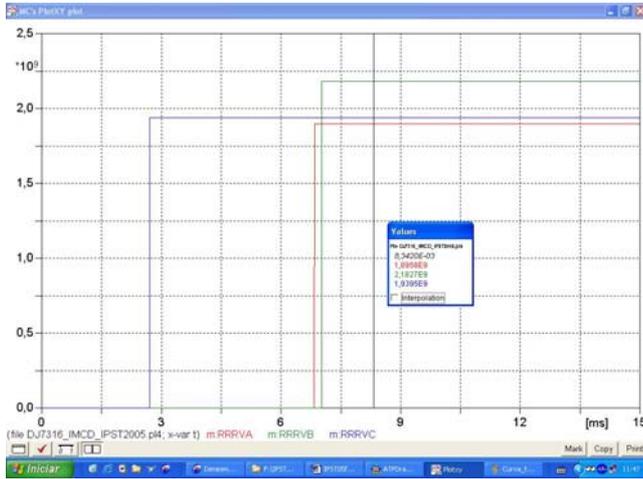Fig. 6. TRV curve of the pole of phase C.

Fig. 7. Rise rate of recovery voltage for three poles of circuit breaker.

In the two illustrations above the variables appear in the bottom bar of the graph indicated in their respective colors.

The parameters need to evaluate the TRV severity can also get on the table showed at the .lis file, as can be seem on fig. 8.
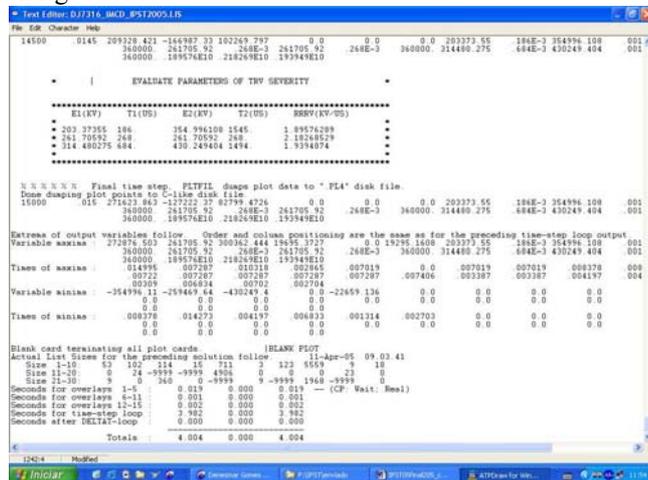

Fig. 8. Output data in text form of .lis file.

V. CONCLUSION

The objective of this work of automating a repetitive process, using the tools and facilities available in graphic interface ATPDraw and in MODELS language, was reached.

The module that was developed formed by the descriptive file and for the object file, can be connected in any existent circuit breaker in any point of the system.

The use of MODELS language to create a routine to read the voltage over circuit breakers poles and extract the parameters to evaluate the severity of TRV was done with success. This routine allow the automatic evaluation of any TRV study during the obtaining of parameters avoid mistakes that could be committed when reading text file containing a list of data from each variable.

VI. REFERENCES

Books:
[1] Alternative Transients Program (ATP) Rule Book – July 1987.
[2] László Prikler, Hans Kristian Høidalen, "ATPDraw version 3.5 for Windows 9x/NT/2000/XP – User's Manual," Preliminary Release 1.0, August 2002.
[3] A. D'ajuz, C. S. Fonseca, F. M. S. Carvalho, J. Amon Fº, L. E. N. Dias, M. P. Pereira, P. C. V. Esmeraldo, R. Vaisman, S. O. Frontin, "Transitórios Elétricos e Coordenação de Isolamento – aplicação em sistemas de potência de alta-tensão," Rio de Janeiro,RJ, Brazil, EDUFF, 1987.

Papers from Conference Proceedings (published):
[4] J. Amon Fº, D. G. Pimenta, "Aplicação da Rotina MODELS e da Interface ATPDraw do Programa ATP/EMTP para o Cálculo dos Valores de Pico, dos Instantes de Tempo Correspondentes e da Taxa de Crescimento da Tensão de Restabelecimento Transitória (TRT) em Disjuntores, bem como para a Impressão de Envoltórias de Referência Normalizadas," XVII Seminário Nacional de Produção e Transmissão de Energia Elétrica, Uberlândia,MG,Brasil, 19-24 October 2003.
[5] J. Amon Fº, "The Usage of Circuit Breackers: Direct Computation of Peak Values, Corresponding Times and Rate-of-Rise and generation of reference Envelopes", 21° EMTP Users Group Meeting, Greece 5-7 June 1992.
[6] J. Amon Fº, M. P. Pereira, "Novos Desenvolvimentos dos Programas ATP/EMTP e APTDraw", XVI SNTPEE, Campinas-SP, Brazil, 21-26 October 2001.

Standards:
[7] Disjuntores de Alta Tensão, Norma Técnica da ABNT - NBR 7118, Brazil, September, 1994.
[8] High-Voltage Alternating-Current Circuit-Breakers, International Standard IEC-62271-100, Brazil, May, 2001.

Dissertations:
[9] Amon Fº, Jorge – "Tensão de Restabelecimento Transitória de Disjuntores – Metodologia de Estudo" – Dissertação de Mestrado, PUC-RJ, January 1992.

VII. BIOGRAPHIES

Denesmar Gomes Pimenta was born in Vitoria,ES – Brazil on September 5, 1969. He received his B.Sc. (1996) in Electrical Engineering from UFES-Vitoria,ES - Brazil. He works at FURNAS Centrais Elétricas, since 2002, in the area of Power System Electrical Planning.

Jorge Amon Filho was born in Rio de Janeiro,RJ – Brazil on August 8, 1952. He received his B.Sc. (1975) and his M.Sc. (1986) degrees in Electrical Engineering from PUC-Rio de Janeiro, Brazil. He works at FURNAS Centrais Elétricas, since 1976, at the moment as the head of the Equipment Studies Division of the Transmission Planning Department. He is also the Brazilian member of CIGRÉ SC A3.