

FAST TRANSIENT SIMULATION OF FERNANDEZ SURGE ARRESTER MODEL ON A TRANSMISSION LINE USING ATP

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ABSTRACT

Lightning is a very impressive phenomenon that occurs in nature. The amount of energy contained in a lightning stroke is very high and it can be extremely destructive. Electric distribution networks are particularly vulnerable to lightning strokes. A single stroke to a distribution line can be sufficient to cause a blackout throughout a feeder. To prevent this, power systems are protected with lightning rods, ground wires and surge arresters. This project purpose is to study and analysis the effect of lightning and surge arrester in power distribution system. Lightning surge is modeled using equation and will be use to analyze its effect to system. When fast front transients, such as from lightning, are to be investigated, the MOV surge arrester behavior representation is significantly different. So, fast front surge arrester is designed because it has dynamic characteristics that are significant for overvoltage coordination studies involving fast front surges. In order to investigate the effects of lightning and surge arrester in power distribution system, in this project Fernandez Surge Arrester is modeled. System simulation, using Alternative Transient Program (ATP) simulation software has been carried out. Simulation results have illustrated the output waveform of lightning surge, the model of fast front surge arrester and the effects of lightning and surge arrester in test 132kV system.

ABSTRAK

Kilat adalah satu fenomena yang berlaku di alam semula jadi. Jumlah tenaga yang terkandung di dalam kilat adalah sangat tinggi dan mampu memusnahkan sesuatu sistem rangkaian. Rangkaian pembahagian kuasa mudah terdedah kepada kesan kilat. Satu panahan kilat pada talian pembahagian boleh menyebabkan bekalan terputus di pencawang. Untuk menangani kejadian ini, rangkaian pembahagian kuasa dapat dilindungi dengan penangkap kilat, wayar bumi dan rod kilat. Tujuan projek ini adalah untuk menganalisa dan mengkaji kesan penangkap kilat dalam sistem pengagihan kuasa. Penangkap kilat direka berdasarkan pengiraan yang dihasilkan daripada penganalisan terhadap sistem rangkaian. Ketika kelajuan kilat dikaji, sifat penangkap kilat MOV dapat dikenalpasti. Maka, penangkap kilat direka dengan ciri-ciri yang berspesifikasi dinamik yang penting untuk kajian yang melibatkan voltan tinggi. Oleh yang demikian, Penangkap Kilat Fernandez akan dijadikan rujukan semasa kajian kesan kilat dan penangkap kilat di rangkaian pengagihan kuasa. Sistem ini dikaji dengan menggunakan simulasi ATP. Keputusan simulasi ini akan menghasilkan gelombang yang menunjukkan kesan kilat terhadap penangkap kilat dalam sistem talian 132kV.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The lightning surges being considered the most dangerous events in power distribution systems, knowledge of the same allows to obtain a better selection and coordination of protection devices. Moreover, a better knowledge of lightning surges permits to optimize the location of device protection, to reduce the insulation costs of the installations, and to operate with risks of failure that are well known. The development of a computer application allowing determination of the optimal position of the surge arrester in power systems minimizes the risk of failure, thus permitting the selection of appropriate protection schemes for each network. As a consequence, protection costs are being reduced in accordance with the costs of the elements actually protected and the continuity of service to be achieved.

In order to improve the lightning performance of the high-voltage transmission networks and reduce the annual failure rate, overhead ground wires are installed intercepting the lightning strikes and protecting the phase conductors. Several power corporations install additionally surge arresters between phase conductors and ground diverting the overvoltage currents to earth. Some years ago, surge arresters with gaps

were used, but nowadays have been almost totally replaced by gapless metal-oxide surge arresters [6].

The purpose of this project was to study a Fernandez surge arrester model of surge arrester. The results show that Fernandez surge arrester has similar performance when subjected to fast front surges. The main of this dissertation is thus to model a 132kV overhead transmission-line by using ATP-EMTP software, for back flashover. Lastly, the surge arresters models were introduced in the study for analysis.

1.2 Objectives of Project

The objectives in this project are:

1. To study a Fernandez surge arrester model using ATP software.
2. To develop a modeling of 132kV overhead transmission-line by using ATP software.
3. To investigate back-flashover voltage when lightning 10kA current are injected into a top of transmission tower.

1.3 Problem of Statement

Over the last few decades, the electric utilities have seen a very significant increase in the application of metal oxide surge arresters on transmission lines in an effort to reduce lightning initiated flashovers, maintain high power quality and to avoid damages and disturbances especially in areas with high soil resistivity and lightning ground flash density. For economical insulation coordination in transmission and substation equipment, it is necessary to predict accurately the lightning surge overvoltage that occurs on an electric power system.

The main is to study and evaluate the medium transmission line protection with metal oxide surge arresters when a lightning strike hits the ground wire proposed Fernandez surge arrester model. In this work, the contribution of surge arresters in the

lightning protection of an operational 132kV circuit shielded overhead transmission line using the ATP program is studied. All the used models are extensively verified through a comparison of published simulated and experimental results.



Figure 1.1: Lightning Surge Arrester

1.4 Scope of Study

1. Study the behavior of Fernandez surge arrester in 132kV transmission line model. The model that will be used in this Surge arrester is ABB EXLIM model wave 8/20 μ s (Referred to IEEE (ANSI) C62.11)
2. Develop the surge arrester and 132kV transmission line model using ATP software.
3. Simulate the performance of surge arrester using Alternative Transient Program (ATP) version of Electromagnetic Transient Program (EMTP).

4. Simulate the surge arrester circuit to investigate back-flashover voltage pattern when lightning current magnitudes are injected into a top of transmission tower on difference conditions.

Nominal discharge current I_n 8/20 μ s	10 kA (pk)
Line discharge class (LD)	2
High current impulse I_{hc} 4/10 μ s	100 kA (pk)
Long duration current impulse	500 A / 2000 μ s
Short circuit rating I_s 50 Hz	50 kA (rms) for 0.2 s
Classification according to IEEE (ANSI) C62.11	intermediate

Figure 1.2: Surge arrester with metal oxide resistors without spark gaps (MO surge arrester) direct molded silicon housing, gray color, designed and tested according to IEC 60099-4.

1.5 Thesis Organization

Chapter 1 summarizes project background and elaborates on project objectives and scope. The dissertation is introduced in this chapter.

Chapter 2 reviews literatures, including Fernandez surge arrester model and description of lightning strike/flash phenomenon, problems of lightning in power system, back flashover, and detail specification.

Chapter 3 describes the methodology of the dissertation. ATP-EMTP software is introduced and described. Methodology flow chart is presented in this chapter as well. Elaborates on ATP-EMTP modeling guidelines for 132kV overhead transmission-line. Fernandez surge arrester model at transmission line and tower, tower surge impedance, lightning source, and AC voltage source are explained briefly in this chapter.

Chapter 4 presents results of simulations, together with necessary analysis and appropriate discussion of them.

Finally, Chapter 5 conclusions of the dissertation, and recommends possible future research.

CHAPTER 2

SURGE ARRESTER OF LIGHTNING PROTECTION: LITERATURE REVIEW

2.1 Introduction

The adequate circuit representation of metal oxide gapless surge arresters and the selection of their circuit parameters are significant issues for lightning and switching overvoltage performance studies. Metal oxide gapless surge arresters cannot be modeled only as non-linear resistances, since their response, i.e. their residual voltage for a given current, is a function of the magnitude and the slope of the injected pulse. Many researchers have presented appropriate circuit models, in order to predict the arrester residual voltage for a given injected current impulse. The accuracy of the results is strongly depended on the adjustment of the parameter values, for each model. For this reason, various iteration methods have been applied, in order to determine the parameter values that minimize the error between the computed and the manufacturer's residual voltage, adjusting the parameter values of each equivalent circuit model for one current level and waveform each time. In the current paper, a genetic algorithm is developed and is applied to each model, for each given injected impulse (lightning or switching) current separately, and then for all the current levels simultaneously.

2.2 Metal Oxide Surge arrester

Metal Oxide surge arresters are used to protect medium and high voltage systems and equipment against lightning and switching overvoltage. Measurements of the residual voltage of the metal oxide surge arrester indicate dynamic characteristics and specifically, the residual voltage increases as the current front time descends and the residual voltage reaches its maximum before the arrester current reaches its peak. For these reasons, the metal oxide surge arresters cannot be modeled by only a non-linear resistance, since its response depends on the magnitude and the rate of rise of the surge pulse. Several frequent dependent models have been proposed, in order to simulate this dynamic frequency-dependent behavior. In the current work three modes – IEEE, Pinceti-Gianettoni and Fernandez- Diaz –. The residual voltage of each model, implying 5kA, 10kA and 20kA 8/20 μ s impulse current, is compared with the manufacturers' datasheet. The models were also used to study the lightning performance of a distribution line; the arresters were implemented on every pole and was calculated their failure probability. The results show that all the models function with a satisfactory accuracy; the differences among the models arise in the difficulties of the parameters' estimation.[7]



Figure 2.1: A ZnO surge arrester

2.2 Surge arrester model

The most used equivalent circuit models, that reproduce adequately the arresters performance are:

- The IEEE model [1],
- The Pinceti–Giannettoni model [2],
- The Fernandez–Diaz model [3].

The IEEE Working Group 3.4.11 [1] proposes the model of Figure 2.2, including the non-linear resistances A_0 and A_1 , separated by an R-L filter. For slow front injected surges the filter impedance is low and the non-linear resistances are in parallel. For fast front surges the filter impedance becomes high, and the current flows through the non-linear resistance A_0 . The other two models are simpler forms of the IEEE model. The

Pinceti–Giannettoni model [2] has no capacitance and the resistances R_0 and R_1 are replaced by one resistance at the input terminals, as shown in Figure 2.3. In the Fernandez–Diaz model [3] A_0 and A_1 are separated by L_1 , while L_0 is neglected. C is added in arrester terminals and represents terminal-to-terminal capacitance of the arrester. The computation of the parameters for each circuit model is performed according to the procedures described in [1], [2] and [3], correspondingly.

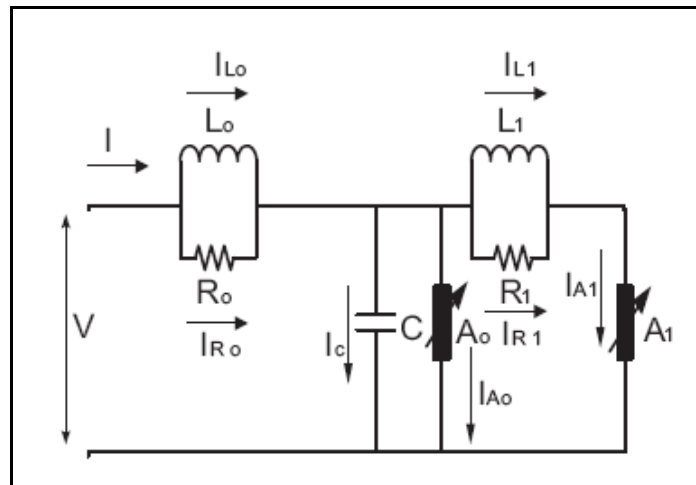


Figure 2.2: The IEEE model [1]

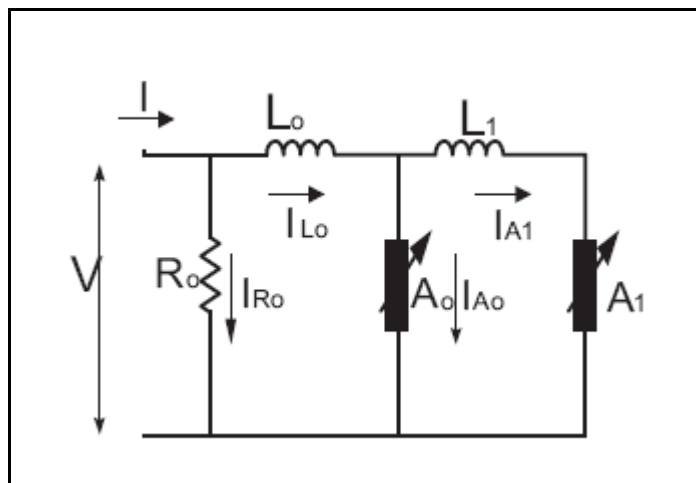


Figure 2.3: The Pinceti–Giannettoni Model [2]

2.3 The Fernandez-Diaz Model

It is also based on IEEE model. In this model A_0 and A_1 are separated by L_1 , while L_0 is neglected figure 2.4. C is added in arrester terminals and represented terminal to terminal capacitance of the arrester.

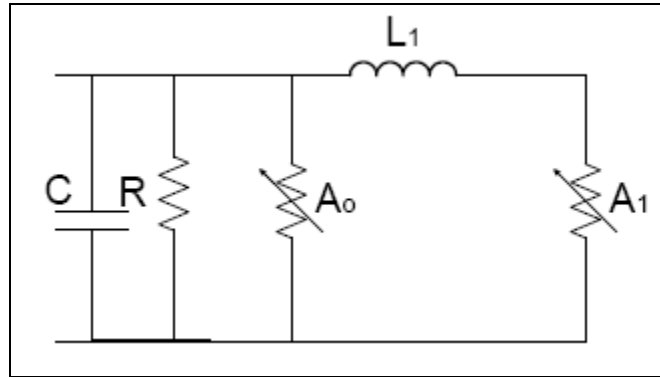


Figure 2.4: The Fernandez – Diaz Model [3]

This model does not require iterative calculations since the required data are obtained from the manufacturer's datasheet. The procedure for the computation of the parameters is given in [3]. The V-I characteristics for A_0 and A_1 are calculated using manufacturers' data and considering a ratio I_0 to I_1 equal to 0.02. The inductance L_1 is given as:

$$L_1 = nL_1'$$

where n is a scale factor and L_1' can be found in [3], computing the percentage increase of the residual voltage as:

$$\Delta V_{res}(\%) = \left(\frac{V_{r(1/T2)} - V_{r(8/20)}}{V_{r(8/20)}} \right) 100$$

where $V_{r(8/20)}$ is the residual voltage for an 8/20 lightning current and $V_{r(1/T2)}$ is the residual voltage for a 1/T2 lightning current with the nominal amplitude.

Table 2.1: parameter for Fernandez – Diaz Model [3]

L_1	$1.07\mu\text{H}$
C	94.74pF
R	$1\text{M}\Omega$

2.4 Detail specification

The frequency-dependent model, such as proposed by IEEE in [1], is shown in Figure 2.5. The two non-linear resistances A0 and A1 are separated by a RL filter. For arrester discharge currents with slow rising time, the influence of the filter is negligible; thus A0 and A1 are essentially in parallel and characterize the static behavior of the MOSA. For fast rising surge currents, the impedance of the filter becomes more significant, indeed the inductance L_1 derives more current into the non-linear branch A0. Since A0 has a higher voltage for a given current than A1, the model generates a higher voltage between its input terminals, what matches the dynamic characteristics of MOSAs.

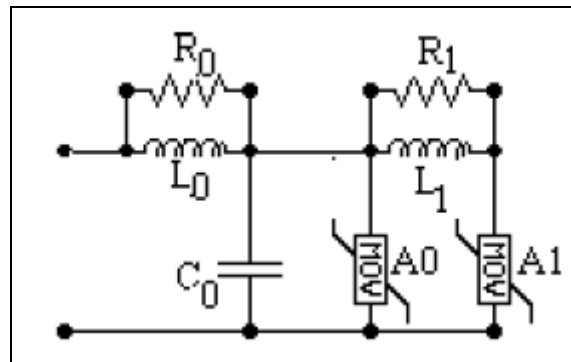


Figure 2.5: Frequency-dependent model, as proposed in [1].

The proposed curves for A0 and A1 are shown in Figure 2.6. The per-unit values are referred to the peak value of the residual voltage measured during a discharge test with 10 kA lightning current impulse ($U_{r,8/20}$). These curves are to be adjusting to get a good fit with the published residual voltages for switching surge discharge currents. The inductance L_0 represents the inductance associated with the magnetic fields in the

immediate vicinity of the arrester. The resistor R_0 is used to avoid numerical oscillations when running the model with a digital program. The capacitance C_0 represents the external capacitance associated to the height of the arrester. Starting from the physical dimensions of the arrester, some formulas are given in [1] to calculate L_0 , R_0 , C_0 and R_1 . The parameter L_1 has the most influence on the result and a formula, starting from the physical dimensions, is also suggest in [1]. However this constitutes only an initial value and L_1 should be adjusted by a try- and error procedure to match the residual voltages for lightning discharge currents published in manufacture's catalogue. This model can give satisfactory results for discharge currents within a range of times to crest for 0.5 ms to 45 ms [1]. A different, straightforward approach to determine L_1 , starting from electrical data of the arrester, is also proposed in [2]. In this case, the authors report relative errors between calculated and measured residual voltages lower than 4.5% for discharge currents with time-to-crest ranging from 1 ms to 30 ms.

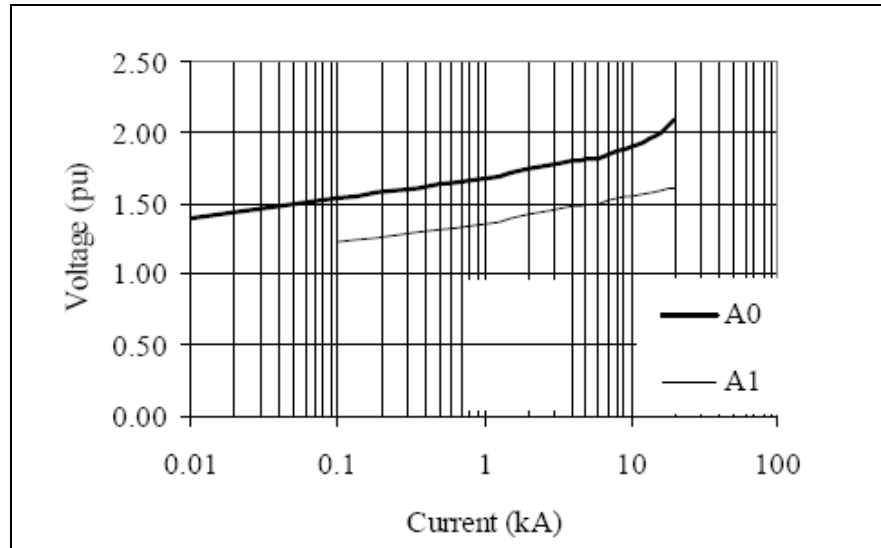


Figure 2.6: Non-linear characteristic for A0 and A1. The voltage is in p.u. referred to the $U_{r,8/20}$.

2.4.1 The Model Fernandez Adjustment

The Fernandez model is shown in Fig.2.7 and derives from that in [1]. It is intended for the simulation of the dynamic characteristics for discharge currents with front times starting from 8 ms. As in [3], between the non-linear resistances A0 and A1 only the inductance L1 is taken into account. R0 and L0 are neglected. C0 represents the terminal-to-terminal capacitance of the arrester. The resistance R in parallel to A0 is intended to avoid numerical oscillations. The model in Figure 2.4 works essentially in the same way as that proposed in [1]. To explain the principle of the new proposal, it will be referred in a first approach to only one arrester valve block.

- a) Assumptions for the parameters adjustment.

The following principle explains the adjustment procedure proposed in this contribution: The non-linear characteristics of A0 and A1 are to be adjusted to match the residual voltages for the lightning discharge currents [4] of the protection V-I-characteristic provided by the manufacturer; besides, an additional condition should be respected: the ratio (g) of the currents I_0 to I_1 through A0 and

A1 respectively remains constant all over the voltage range of their protection characteristic. If we now consider currents of a given amplitude but front times faster than 8 ms, these additional restriction guaranties that the percent voltage increase between the input terminals depends only of the inductance L_1 . The election of L_1 can then succeed straightforward through the use of predefined curves, which are generated in the next item.

b) Selections curves for L_1

Two ideal, elementary valve blocks with a rated voltage of 1 kV for lightning discharge currents of 5kA and 10 kA respectively were considered. A ratio g of 0.02 was found to be adequate for the response of the model. Because the value of g will determine the finally value of L_1 , it will indirectly influence the time lag of the residual voltage peak and indeed the form of the well known [2, 3] hysteresis cycle. The Table 2.2 summarizes the V-I characteristic for these valve blocks and the currents into the branches A0 and A1.

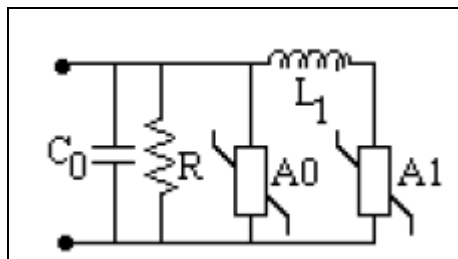


Figure 2.7: Fernandez model.

Table 2.2: Maximum residual voltages for elementary valve blocks of 1 kV rated voltage with lightning discharge nominal current of 5 and 10 kA. Ratio I₀ to I₁ equal to 0.02.[3]

Maximum residual voltage [kV]		8/20 μ s lightning discharge current [A]		
5kA block	10kA block	I	I ₀	I ₁
2.87	2.73	1500	30	1470
3.07	2.90	3000	60	2940
3.27	3.07	5000	100	4900
3.60	3.33	10000	200	9800
4.27	3.77	20000	400	19600
5.30	4.53	40000	800	39200

2.5 Lightning Problems in Power System

Generally, lightning is the main factor leading to outage in transmission and distribution lines. The problem of lightning can be classified a transient event. When lightning strikes a power line, it is like closing a “big switch” between a large current source and power-line circuit. Sudden closing of the “big switch” causes sudden change in circuit conditions, creating a transient. There is also the case where lightning strikes power-line vicinity, and large magnetic field generated by lightning current causes mutual coupling between the power line and the lightning [8]. The event alters conditions of the power-line circuit, producing an electrical transient. Three possible discharge paths that can cause surges on line are:

- a) The first discharge path is from leader core of lightning strike, to earth. Capacitance between the leader and earth is discharged promptly, and capacitances from leader head to earth wire and to phase-conductor are ultimately discharged by travelling-wave action, developing voltage across insulator string, known as induced voltage (due to lightning-strike to nearby ground); not a significant factor in lightning performance of systems above about 66 kV, but causes considerable trouble on lower voltage systems.

- b) The second discharge path is between lightning head and earth conductor, discharging capacitance between the two. The resulting travelling-wave comes down the tower and acts through its effective impedance, raising potential of tower top to a point where difference in voltage across insulation is sufficient to cause flashover from tower back to conductor. This type of strike is called back flashover.
- c) The third type of discharge is between leader core and phase conductor, where capacitance is discharged between the two, the main discharge current injected into the phase conductor, developing surge-impedance voltage across insulator string. At relatively low current, insulation strength is exceeded, and discharge path to earth is completed through tower. This type of strike is known as shielding failure (or, direct strike to phase-conductor).

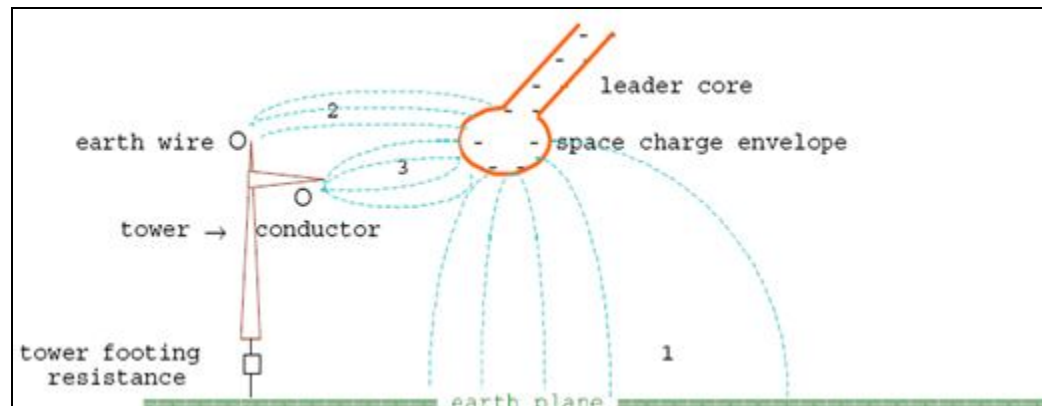


Figure 2.8: Lightning leader strike and transmission line[12]

2.6 Transmission Line

In recent years, theories proposed by researchers abound, on modeling of transmission tower. One of the more well-known models is the multistory model designed by Masaru Ishii [9]. A multistory tower model basically is composed of distributed parameter lines with parallel RL circuits and has been recommended by the Japanese Guideline of insulation design/coordination against lightning. This model is widely used for lightning surge analysis in Japan. Figure 2.9 shows the multistory tower model.

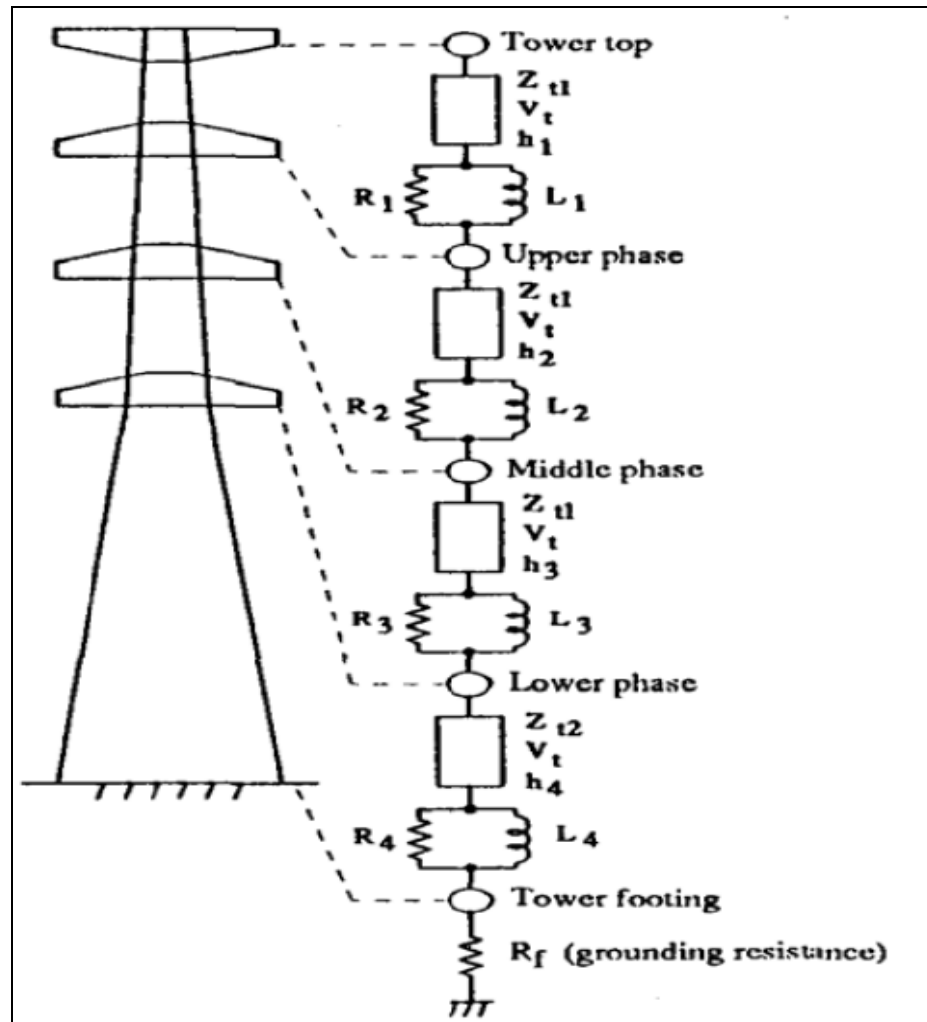


Figure 2.9: Multistory Tower Model[11]

However, design of the multistory tower model was based on 500kV transmission line. Hence, multistory tower model is not applicable to Malaysia's lower voltage (such as 132kV and 275kV) transmission line system. A Simple Distributed Line Model is sufficient representation of a low-voltage transmission line system model in ATPEMTP software, thus this model will be used to design this work's transmission tower. To represent a real transmission tower, a cross-arms model and an insulator-strings model need also be included. Figure 2.10 shows a simple distributed line model without cross-arms and insulator strings.

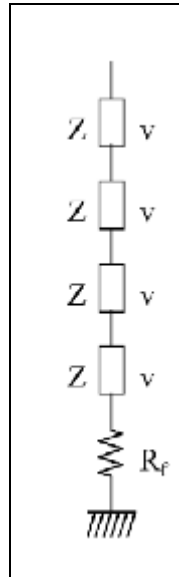
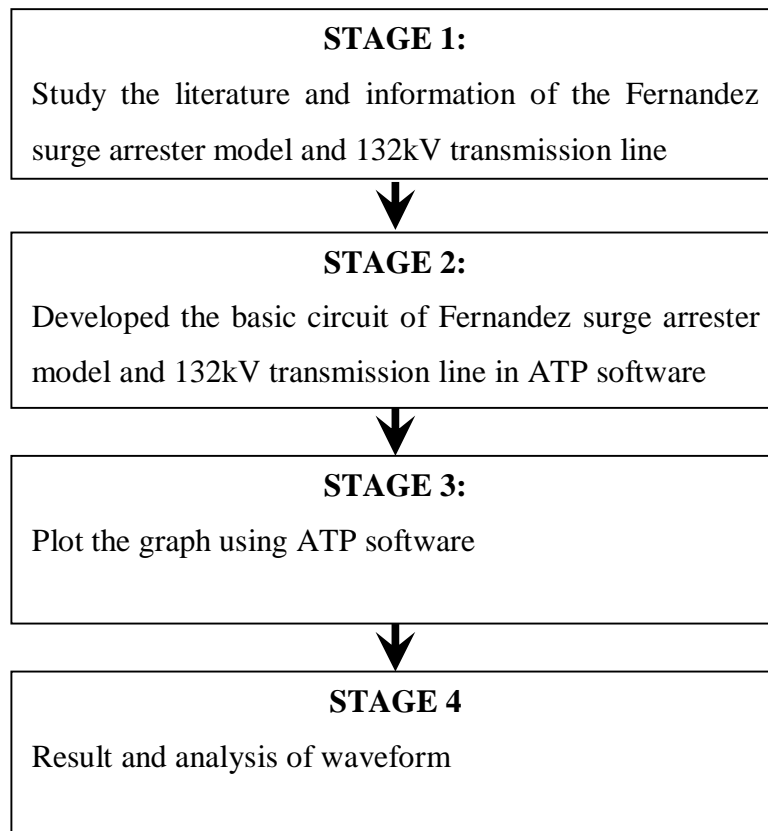


Figure 2.10: simple distributed line model without cross-arms and insulator strings[12]

CHAPTER 3

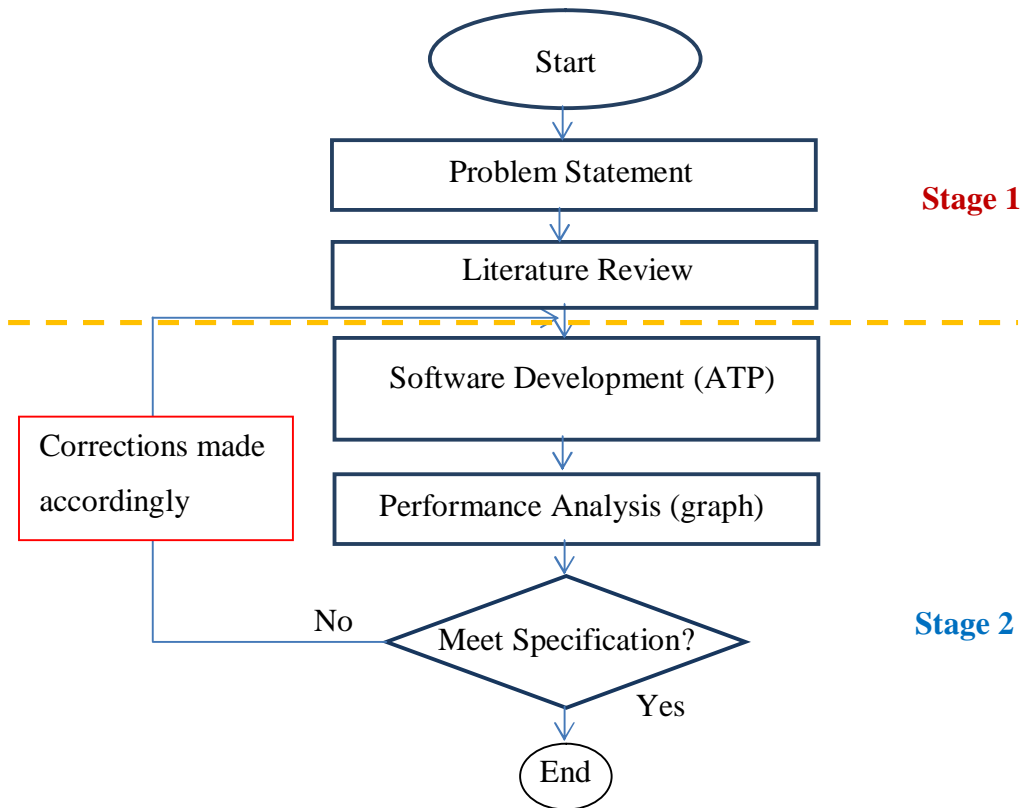
SIMULATION LIGHTNING PROTECTION: METHODOLOGY

In this chapter, the ideas introduced previously will be used in ATP software. In order to fulfill the scope of this project, the development process fast transient simulation of Fernandez surge arrester model on a 132kV transmission line.



3.1 Flowchart

In this part consists of the general flowchart of project, process flow of the system software with details explanation.



3.2 Fernandez model

The Fernandez Model is also simplified in this model. This time, both electrical and physical parameters are necessary. The two parallel resistances are substituted for only one, in parallel to a capacitance, and one of the inductive devices is eliminated. The relation between the A0 and A1 currents and their voltages must necessarily.

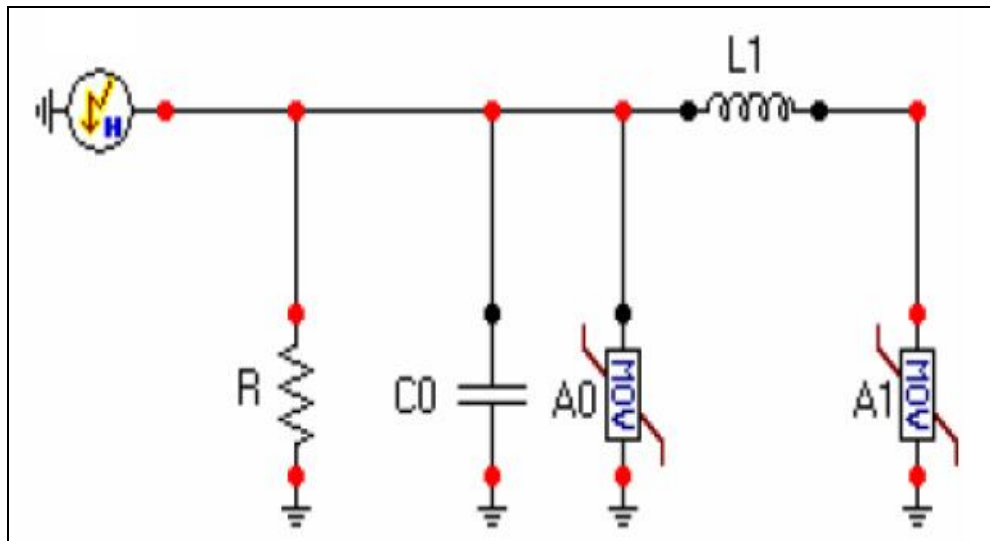


Figure 3.1: The Fernandez and Diaz model in ATP software

3.3 Model implementation

The Fernandez and Diaz models were compared using the ATP Program. The other models were not considered, because their results were not accurate. The waveforms used in the simulations were developed with the ATP Source 15 – Heidler Type. The use of Source 13 does not demonstrate the frequency dependent characteristic, where the current signal leads the voltage signal. The other sources available did not allow correct modeling of the desired waveform. To compare models, the ABB EXLIM P was used. The model parameters are shown in Table 3.1

Table 3.1: Model parameters the ABB EXLIM P

Power frequency voltage, kV rms					Maximum residual voltage with current wave, kV peak							
Nom. V _n (1)	Max. V _m (2)	Rating V _r (3)	MCOV (4)	TOV (5)		SPL (6)	LPL (7)					FOV (8)
				1 s	10 s	30/60 μs	8/20 μs					0.5 μs
							3 kA	5 kA	10 kA	20 kA	40 kA	10 kA
46.0	49.2	61	49	81.6	81.6	104	116	119	126	127	150	122
46.0	48.3	60	48	71.7	68.4	115	127	132	138	152	166	147
46.0	48.3	72	57	86.0	82.0	138	153	158	166	183	199	177
69	72.5	54	42	64.5	61.5	104	115	118	125	137	150	133
69	72.5	60	48	71.7	68.4	115	127	132	138	152	166	147
69	72.5	72	57	86.0	82.0	138	153	158	166	183	199	177
69	72.5	90	70	107	102	172	191	197	207	228	249	221
69	72.5	96	76	114	109	184	204	210	221	243	265	236
115	123	90	70	107	102	172	191	197	207	228	249	221
115	123	96	76	114	109	184	204	210	221	243	265	236
115	123	108	84	129	123	207	229	236	249	274	299	266
115	123	120	98	143	136	230	254	263	276	304	332	294
115	123	132	106	157	150	252	280	289	304	334	365	324
115	123	144	115	172	164	265	305	315	332	365	398	353
138	145	108	84	129	123	207	229	236	249	274	299	266
138	145	120	98	143	136	230	254	263	276	304	332	294
138	145	132	106	157	150	252	280	289	304	334	365	324
138	145	144	115	172	164	265	305	315	332	365	398	353
138	145	168	131	200	191	333	356	368	387	426	464	412
161	170	132	106	157	150	252	280	289	304	334	365	324
161	170	144	115	172	164	265	305	315	332	365	398	353
161	170	168	131	200	191	333	356	368	387	426	464	412
161	170	172	140	205	196	341	364	376	396	436	475	422
161	170	180	144	215	205	357	381	394	414	456	497	441
161	170	192	152	222	211	360	407	420	442	486	530	471
230	245	180	144	215	205	357	381	394	414	456	497	441
230	245	192	152	222	211	360	407	420	442	486	530	471
230	245	228	180	272	259	451	483	499	525	577	630	559
230	245	240	190	286	273	475	508	525	552	608	663	588
345	362	258	209	308	294	529	546	564	594	653	713	632
345	362	264	212	315	300	541	559	577	606	666	729	647
345	362	276	220	329	314	565	585	604	635	699	762	677
345	362	288	230	344	328	590	610	630	663	729	795	706
345	362	294	235	351	335	602	623	643	677	744	812	721
345	362	312	245	372	355	639	661	682	718	790	862	765
400	420	300	240	358	342	615	635	656	690	759	828	735
400	420	312	245	372	355	639	661	682	718	790	862	765
400	420	330	267	394	376	676	699	722	759	835	911	809
400	420	336	272	401	383	688	711	735	773	851	928	824
400	420	360	288	430	410	737	762	787	828	911	994	882
500	550	396	318	473	451	811	838	866	911	1002	1083	971
500	550	420	335	493	482	860	889	918	966	1063	1160	1029
500	550	444	353	530	506	909	940	971	1022	1124	1226	1088

3.4 ATP software

ATP Draw for Windows application is a graphical pre-processor to the ATP version of the Electromagnetic Transients Program (EMTP). ATP Draw allows the user to create the electrical circuit to be simulated, through a mouse and selection of predefined components from an extensive palette. It will generate the input file for ATP simulation in the appropriate simulation-format. Usually, ATP Draw controls the naming process

for the circuit node. The user thus needs to give a name to the nodes of special interest. About 70 standard components and 28 TACS objects are available in ATP. Users can also create their own circuit objects by using MODELS or INCLUDE (Data Base Module). ATP Draw has a standard Windows layout, supports multiple documents, and offers a large Windows help file system that explains basic rules (which helps users use ATP Draw). Generally, it provides standard component that can be used to create both single-phase and three-phase systems. Other facilities of ATP Draw are:

- a) Built-in editor for ATP-file editing.
- b) Support of Windows clipboard for bitmap/metafile.
- c) New module for use of Line/Cable Constant punch files in ATP Draw.
- d) Tool-bar below main menu, containing the most-used selections together with the last 9 selected components.
- e) An extensive Undo/Redo handling with more than 100 steps.

Line/Cable modeling including KCLee, PI-equivalent, Semlyen, JMarti and Noda is also available in ATP Draw; the user can specify selected geometry and material data. There is an option for the user to view the cross section graphically and verify the model in the frequency domain. Objects for Harmonic Frequency Scan (HFS) are also included. There are also special objects that help the user in machine and transformer modeling, including the powerful UNIVERSAL MACHINE and BCTRAN features of ATP. ATP Draw supports hierarchical modeling, replacing with a single icon, a selected group of objects in unlimited numbers of layers. The PARAMETER feature of ATP is also implemented, allowing user to specify a text string as input in a components' data field and to assign numerical values to the texts strings. The circuit is stored on disk in a single project file which includes all the simulation objects and options needed to simulate the program. The project file is in zip-compressed format, facilitating file sharing. ATP Draw is thus most valued by new users of ATP-EMTP. It is also an excellent educational tool. Possibility of multi-layer modeling makes ATP Draw a powerful front-end processor for professionals in their analysis of electric power system transients.

ATP Draw has a standard Windows user interface. This chapter explains some of the basic functionalities of the Main menu and the Component selection menu, and two important windows: the Main window and the Component dialog box.

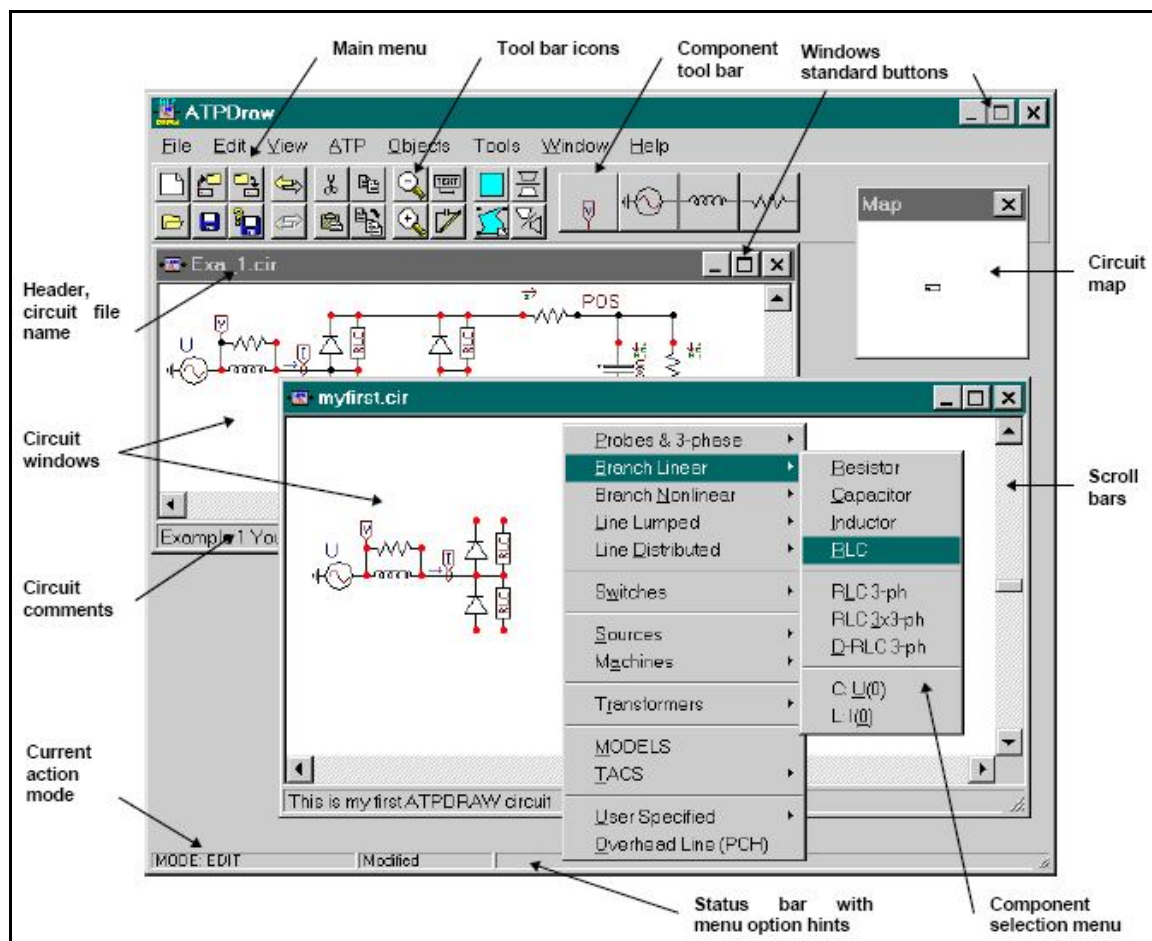


Figure 3.2: The Main window Multiple Circuit windows and the floating Selection menu.

The ATP Draw for Windows program has functionality similar to the DOS version. The Component selection menu is hidden, however, but appears immediately when you click the right mouse in the open area of the Circuit window. Figure 3.2 shows the main window of ATP Draw containing two open circuit windows. ATP Draw supports multiple documents and offers the user to work on several circuits simultaneously along with the facility to copy information between the circuits. The size

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