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COMPUTER AIDED LEARNING FOR TRANSIENT STABILITY OF ELECTRICAL POWER SYSTEMS+

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Abstract

The paper aims to solve instructional problems in the study of power system transient stability. The problem appears due to the presence of complex solution procedures which require time and effort, as well as the need for instructional media by which the power system stability can be determined. To satisfy these objectives, the computer aided learning technique is used by developing an assisted computerized instructional programs according to stages of the instructional design, which involve identification of the instructional goal, the conduction of the instructional analysis, the conduction of the learners analysis, the medium's suitability consideration, writing of the performance objectives, the criterion referenced tests development and the simulation strategy which was followed in developing of instructional strategy, in which the learner can observe the power system stability after the selection of its parameter values. Also the development of power system mathematical model, the display screen design and the flowcharts structure were achieved. Then the algorithm is implemented in BASIC using a the personal computer . The program is formatively evaluated to make the modifications on it by the conduction of the quality review and then seven staff monbers who teach thin subject matter were acked to determine the program efficiency by responding to questionnaire made for this purpose. In order to show the programs validity, twenty learners were subjected to pretest and they used the programs experimentally and then were subjected to posttest. After that the learners utility from the programs was tested by the questionnaire made for this purpose. From the evaluation we can deduce that the programs are considered to be good tools in the demonstration of the basic concepts, increasing the learners, motivation and their by responding to achievements was affected positively.

المستخلص

يهدف البحث إلى حل مشكلة تعليمية في دراسة مواضيع الاستقرارية العابرة لمنظومات القدرة الكهربائية تتمثل المشكلة بوجود إجراءات حل معقدة تستهلك وقتاً وجهداً كبيرين علاوة على وجود وسيله تعليمية يمكن بها توضيح الاستقرارية العابرة لمنظومة القدرة الكهربائية وتحديد تأثير كل معلم من معالمها في أستقرارياتها. ولتحقيق هذا الهدف فقد استخدمت تقنية التعليم بمساعدة الحاسب الإلكتروني عبر بناء برامج حاسوبية تعلميمية مساعدة باتباع مراحل التصميم التعليمي في بناء البرامج، وقد اشتملت هذه المراحل على تحديد الهدف التعليمي وأجراء التحليل التعليمي وإجراء تحليل المتعلمين ودراسة ملائمة الوسيلة التعليمية وكتابة الأهداف ألأدائية وبناء الاختبارات المرجعية المعيار وبناء الستراتيجية التعليمية اذ اتبعت ستراتيجية المحاكاة، التي يلاحظ بها المتعلم إستقرارية منظومة القدرة الكهربائيه

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والعوامل التي تؤثر فيها بعد اختياره أقيام معالم المنظومة. كذلك تم بناء النموذج الرياضي للمنظومة وتصميم شاشات العرض ورسم المخططات الانسيابية للبرامج. ومن ثم كتابة البرامج بلغة بيسك واستخدام الحاسب الإلكتروني الشخصي في تنفيذ البرامج. بعدها تم تقويم البرامج تكوينياً لأجراء التعديلات اللازمة عليها بأجراء المراجعة النوعية عليها ، من ثم تجريبها على سبعة من تدريسي المادة لغرض تحديد كفاءة البرامج بأستخدام استبيان معد لهذا الغرض، كذلك تم تجريب البرامج على عشرين من المتعلمين من الفئة المستهدفة بعد إخضاعهم للاختبار القبلي ومن ثم للاختبار البعدي لأجل تحديد مدى تحقق أهداف البرامج وكذلك لاستبيان وجهات نظرهم في تحديد مظاهر الانتفاع بالبرامج. وقد تبين من عمليه التقويم أن البرامج قد أسهمت في توضيح مفاهيم المادة العلمية وفي زيادة دافعيه المتعلمين نحو التعلم وزيادة معدل تحصيلهم نتيجة هذه البرامج.

Introduction

Transient stability studies of large power system involve extensive amount of numerical calculation and therefore require considerable computer time. The increased need for more efficient and economical solution procedures, to allow extensive studies in order to insure compatibility between design and operation, has motivated a search for faster solution techniques. Two possibilities for improving the speed of transient stability studies are investigated in this work.

In the first, a method of improving numerical integration techniques has been devised for use in the traditional step by step approach. In the second, a search has been undertaken for methods that make possible the prediction of the stability or instability of a power system, by solving the relevant differential equations up to the fault clearing time only. To obtain a time solution and observe whether the various machines tend to lose or maintain synchronism is a lengthy and time-consuming procedure.

However, in most transient stability studies, the important question is whether the system is stable or not in the post fault period without the need for considering the detailed behavior of the state variables in the time domain. Therefore, any method that can predict system stability with only partial use of the step by step integration procedure may reduce the computation time needed for solution [1].

Different international organizations like UNESCO, ALICSO and ASCISCO have called to use computers in education. Simulation programs cover principles of education programming represented by active output response, control of stimulus and instantaneous feedback, gradual advance and gradual decay information. Computer programs are also used to represent certain situations and expect the results through interaction of different factors, which follow a system, designed in advance [2]

The computer also helps in finding suitable environment and conditions to make the simulation operation successful especially for cases where it is impossible to be done practically because of its high cost or its danger to lives [3].

Computer Simulation and Engineering Education

Engineering education is more adopted to computers, many programs for teaching drawing and design have been developed like the computer aided design instruction (CADI) and computer aided design (CAD). Computers have been used in the field of artificial intelligence through experts system in different engineering sciences to achieve educational aims [4].

Computer simulation in education is considered as effective procedure in teaching some engineering phenomena, students may not be stimulated by simulation only but they learn also through interaction with the phenomenon as they do in actual life. Simulation procedure is used also to study system behavior or system dynamics to have the general concepts and understanding of such system [5]. Technical characteristics of computer helped in widening simulation applications in engineering education and helped in solving engineering design problems, which may have models of different degrees of detail [6].

To study a certain problem, simulation procedure is needed to represent the system behavior and logical mathematical relations between system variables. After obtaining a system (under study) in a completely controlled way, results obtained from change of different factors or variables affecting system behavior have to be looked at carefully [7].

Computer simulation advantages in engineering education may be summarized as follows:

(I) Possibility to study the system without using the actual one.
(II) Mathematical operations can be done very fast.
(III) Possibility of changing some of the parameters or quantities used.
(IV) Measurement of different variables.
(V) Different methods may be used to evaluate the results in a short time.
(VI)Some of the results may not give enough accuracy without repeating the solution many times.
(VII) Graphical results may be obtained [4,5].

Simulation has three educational modules

(I) Procedure simulation.
(II) Situational simulation.
(III) Process simulation

Each has its own way of teaching element and its own decisions for example in the procedure simulation there should be a context, representation, actions, reactions of the system or feedback, sequence of simulation, learner control and simulation completion [6,7].

Electrical power engineering education

In the present time electrical power systems are very large due to the interconnection of different power areas.

This leads to complicated problems, which need to be taught, and each is represented mathematically. Teaching subjects of power system analysis like load flow, short circuits, protection and stability for undergraduate and postgraduate require some details, in addition to long mathematical procedures, which take very long time with such studies which will not only introduce the student to interactive design methods and to the application of numerical techniques in system analysis, but it will be very much relevant to his future career.

Personal experience in teaching such type of study to students. Therefore the example to be taken here is about power system transient stability.

Transient Stability Problem

Transient stability study is concerted with the largest time allowed without loosing synchronism for a fault or a sudden disturbance to stay at the system without losing synchronism [8,9].

To teach the student the effect of different factors affecting transient stability, step by step methods are used to solve differential equations for analyzing electrical power system transient stability.

Rung-Kutta fourth order method is used. Rotor angle and rotor speed are calculated, graphs representing these variables are drawn to provide clear simulation of machine behavior and to overcome difficulties faced by the learner when studying transient stability [10,11].

Research Procedure

In order to write a workable program to be understood by students the following steps should be taken into consideration.

1- Program design stage. This stage includes

(I) aim of program.
(II) collection of references related to the subject.
(III) thinking how to write such a program.
(IV) organization of sequence of implementation of the program.

2-Program production stage. This stage includes

(I) production of necessary flow-charts.
(II) decision about which computer language that will be used in program. (In this work Fortran and Basic languages are used)
(III) decision about which graphs or figures that will be shown on the screen.

3-Program evaluation stage. This stage includes

(I) Revision of quality of program before demonstration
(II) Experimental tests.
(III) Final evaluation.

Flow charts are drown in three interrelated levels to reflect the simple flow of the computer training program.

First level flowchart does not include divisions and decision while the second level program adds to the first level program decisions and branches. The third level moves to the details related to programming.

APPENDIX A1 shows first, second, and third level flow charts to study details on power system stability.

User Interaction

1-Representation Production
(A) Writing of major texts

This includes, the principles and concepts of the text, denoted by T.

Symbol	main text
T1	concept of system stability.
T2	concept of steady state stability .
T3	concept of dynamic stability .
T4	concept of transient stability .
T5	understanding of swing equation .

Thus all necessary concepts and conditions are included to the subjectclear.

(B) Writing of secondary texts

These are instructions to direct the learner to interact with the program, denoted by D. What follows shows some of such secondary texts available in the program.

Symbol	Secondary text
D1	instruction to the learner to choose what is need from program.
D2	instruction to learner to interact with subparts of the program, it is possible to leave this part or come back to it according to the needs of the learner.

2-Application example

A single machine connected to infinite bus system is taken as example system, details are given in appendix (A2).

The learner may choose one of the available paths given, for example T4 a text that includes the concept of transient stability. For more details he may go to secondary text. This path represents procedure simulation of factors affecting the power system transient stability, This includes:

(I) initial conditions.
(II) critical clearing time.
(III) damping.
(IV) angular momentum.
(V) fault location.

When the learner chooses simulation of the effect of initial conditions, for example, the program shows the effect of changes in input when other factors are fixed. The learner will see the stability otherwise under the considered change in power.

Find out to know whether the learner is acquainted with this concept the program gives questions and directions so that the learner knows the correct answer. Feedback procedure is available for the learner to start from any point which he is not familiar with. Appendix (A3) gives one complete path chosen as an illustration of the method.

Conclusion

An instructional program for teaching the subject of power system stability is provided. The program not only deepens the understanding of the subject but also minimizes the time needed for teaching the subject to students.

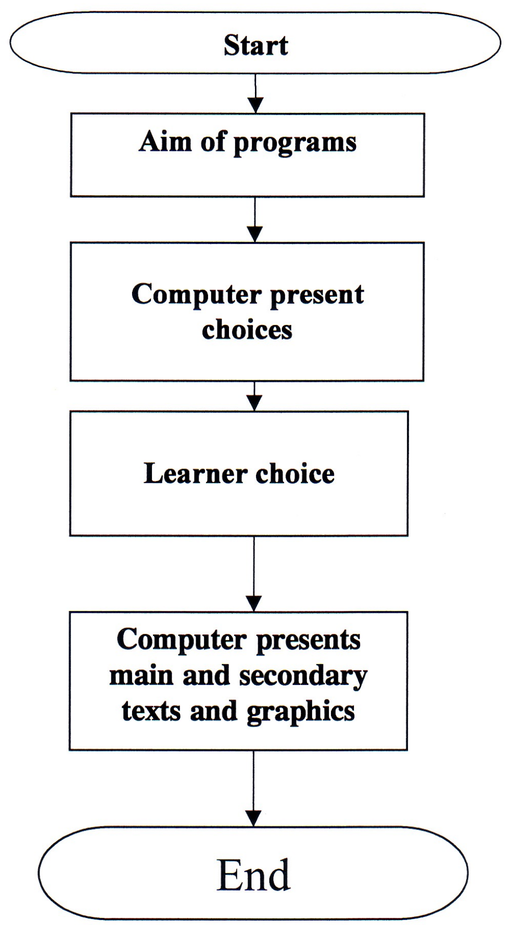
These conclusions stem from the results of a questionomaire is gives to undergraduate and postgraduate students, at the Foundation of Technical Education, College of Electrical & Electronic Technologies, Baghdad, who attended a two session demonstration of program.

It is observed that the program desire and rouses incentive to learn the subject. The program may also be useful to engineers interested in power system stability.

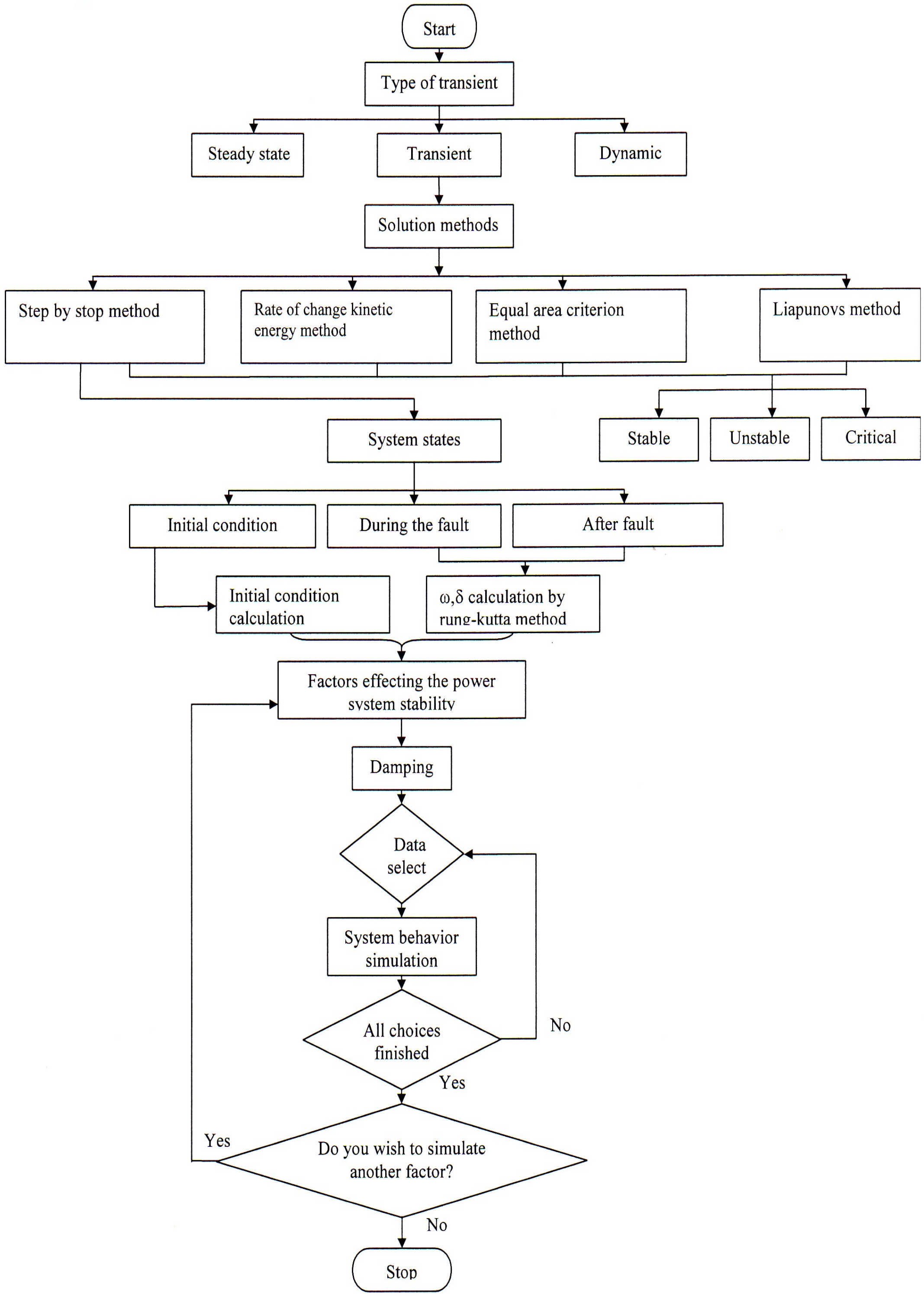
Appendix A1

Below is the first, second, third level flow chart to study details of power system stability.

First level flow chart

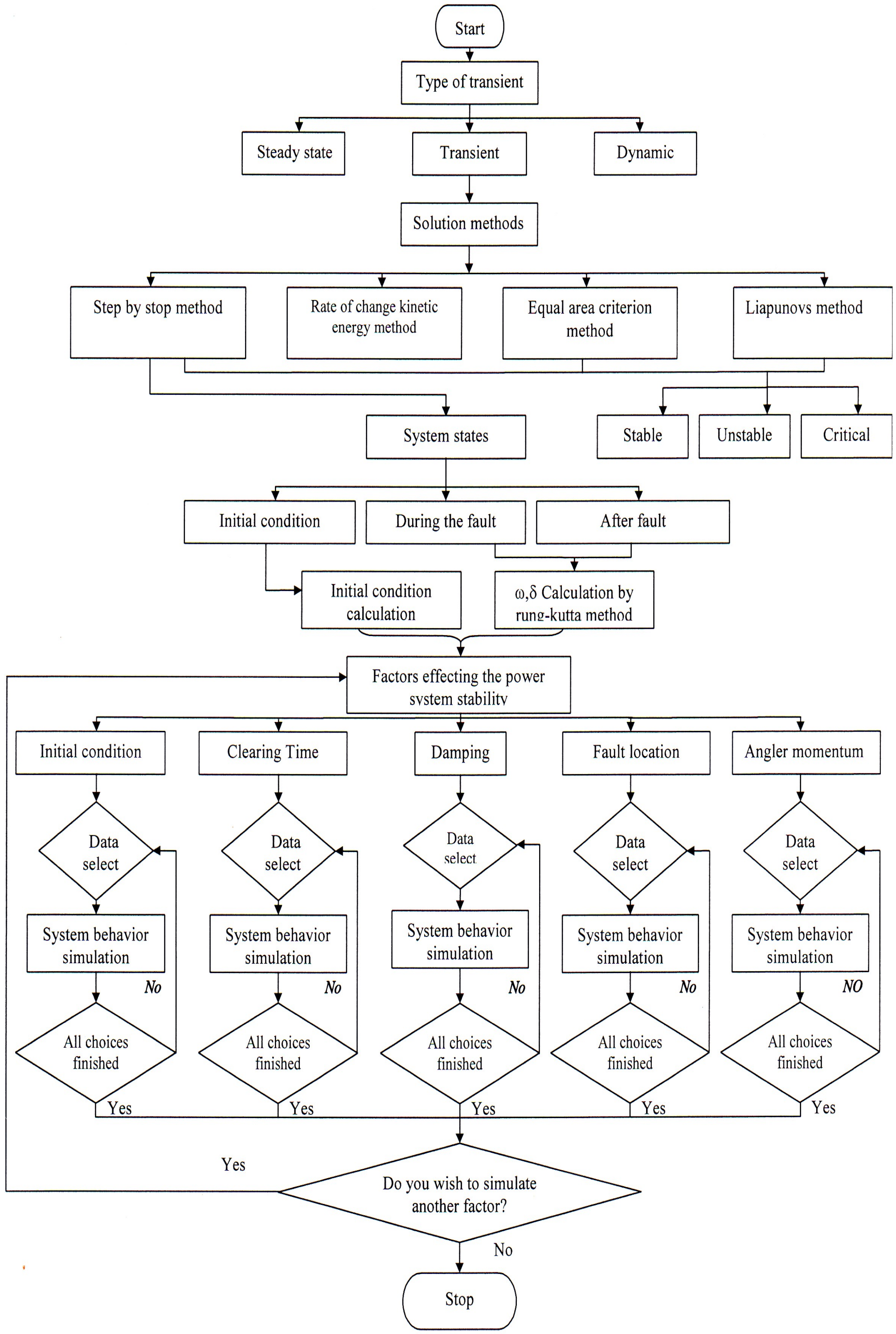


Appendix A1



Second level flow chart

Appendix A1



Third level flow chart

Appendix A3

THERE ARE FIVE FACTORS WHICH EFFECT
POWER SYSTEM STABLITY

1.INITIAL CONDITIONS
2.CLEARING TIME
3. DAMPING
4. ANGULAR MOMENTUM
5.FAULT POSITION

PRESS YOUR CHOICE (1-5)
THEN PRESS RETURN KEY?

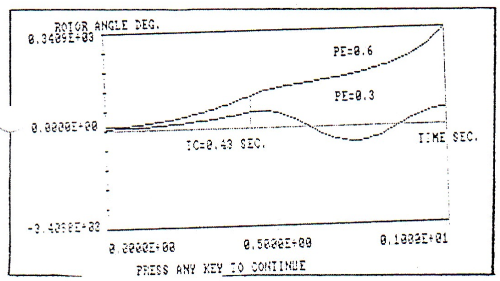
PRESS 6 TO EXIT MANUAL

FIRST GROUP OF DATA FILES
TO SIMULATE INITIAL CONDITIONS EFFECT ON POWER
SYSTEM STABLITY

	PE P.U	TC SEC.	DAMPING P.U	FAULT	MP.U
1-	0.5	0.43	0.0	DIRECT	0.03
2.	0.4	0.43	0.0	DIRECT	0.03
3.	0.3	0.43	0.0	DIRECT	0.03

PRESS YOUR CHOICE (1-3)
THEN PRESS RETURN KEY?

PRESS 4 TO EXIT MANUAL

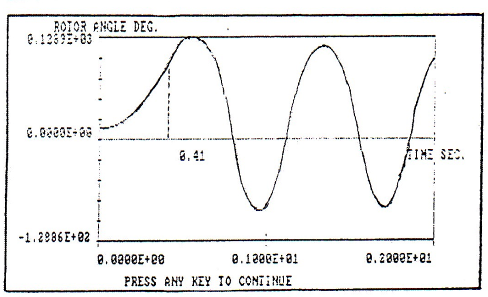


SECOND GROUP OF DATA FILES
TO SIMULATE FUALT CLEARING EFFECT TIME ON POWER
SYSTEM STABLITY

	TC SEC.	PE P.U	DAMPING P.U	FAULT	MP.U
1-	0.41	0.6	0.0	DIRECT	0.03
2.	0.42	0.6	0.0	DIRECT	0.03
3.	0.43	0.6	0.0	DIRECT	0.03

PRESS YOUR CHOICE (1-3)
THEN PRESS RETURN KEY?

PRESS 4 TO EXIT MANUAL

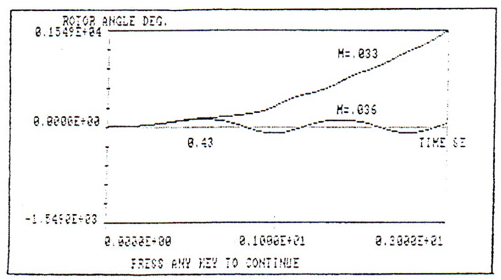


FOURTH GROUP OF DATA FILES
TO SIMULATE ANGULAR MOMENTUM EFFECT ON POWER
SYSTEM STABLITY

	MP.U	PE P.U	TC SEC.	FAULT	DAMPING P.U
1-	0.033	0.6	043	DIRECT	0.0
2.	0.036	0.6	0.43	DIRECT	0.0
3.	0.039	0.6	0.43	DIRECT	0.0

PRESS YOUR CHOICE (1-3)
THEN PRESS RETURN KEY?

PRESS 4 TO EXIT MANUAL

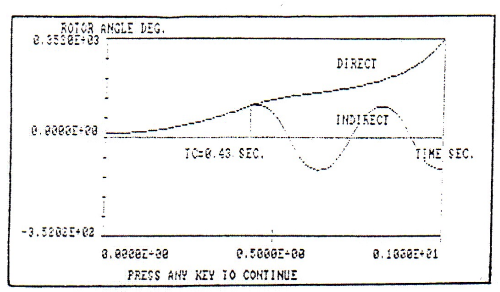


FIFTH GROUP OF DATA FILES
TO SIMULATE FUALT LOCATION EFFECT ON POWER SYSTEM
STABLITY

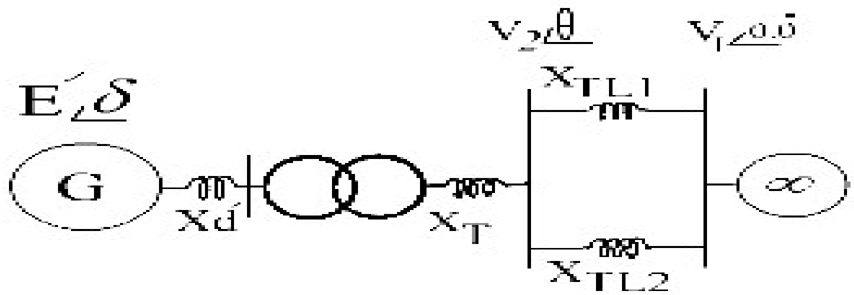
FAULT	TC SEC.	DAMPING P.U	MP.U	PE P.U
1. DIRECT	0.43	0.0	0.03	0.6
2. INDIRECT	0.43	0.0	0.03	0.6

PRESS YOUR CHOICE (1-2)
THEN PRESS RETURN KEY?

PRESS 3 TO EXIT MANUAL



Appendix A2



DATA FOR EST ANALYSIS

The principal data for the system (under study) are tabulated below.

Item	value
Generator rating	37.5 MVA 11.8 kV
Direct axis transient reactance, X_d'	0.232
Angular Momentum, M.	0.03374
Synchronous speed,ωo	314.2 Rad/sec.
Inertia constant, H	5.3 kW-sec/KVA

GENRATOR TRANSFORMER
AND TRANSMISSION LINE DATA

Item	value
Generator transformer reactance, xt	0.1323
Generator transformer resistance, Rt.	0.0056
Transmission line reactance, x1, x2	0.0468
Transmission line resistance,R1,R2	0.0172

All generator, generator transformer and transmission line reactances and resistances are expressed in per unit on a basis corresponding to the generator MVA rating.

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