COMPUTER SIMULATION TO SOLVE POLY PHASE CIRCUIT PROBLEMS

BY

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THIS PROJECT IS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF A DEGREE OF BACHELOR OF ENGINEERING.

DECLARATION

This is to declare that this project is carried out by me, OTEKALU, TOLULOPE .A. of the department of Electrical and Computer Engineering of the Federal university of Technology, Minna, under the supervision of Engr Tsado.

CERTIFICATION

This is to certify that OTEKALU TOLULOPE, in the department of Electrical and Computer Engineering, carried out this project work titled "computer simulation to solve poly phase circuit problems" under the supervision of Engr Tsado and submitted to the department of electrical and computer engineering in partial fulfillment of requirements for the award of Bachelor of Engineering (B.ENG) degree in Electrical and Computer Engineering.

....
Engr Tsado
Project supervisor

22-10-03
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Date

....
Dr Y.A Adediran
Head of Department

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Date

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External Examiner

....
Date

DEDICATION

I will like to dedicate this project work to the Almighty God and also to my lovely parents.

Dr and Mrs. D.E Otekalu.

ABSTRACT

A computer program in Turbo Pascal language has been developed for solving poly phase circuit problems. This program has been used in calculating the various parameters of a poly phase circuit. A well-written algorithm and flow charts drawn are used to simplify the program using mathematical formulas. The results obtained are presented and critically analyzed.

ACKNOWLEDGEMENT

I will like to first and foremost appreciate the Almighty God for His illimitable love towards me. I will like to thank my parents, Dr and Mrs. Otekalu for their indefatigable care and concern in all my undertakings, my brother olumide and sister, Funke.

I acknowledge the efforts of my supervisor, Engr Tsado, who took time to put me through this project, the authorities of the department and the school in general.

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I love you all and may God reward you.

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CHAPTER ONE
GENERAL INTRODUCTION

1.1 INTRODUCTION

A most dramatic change has occurred in the last couple of decades by which systems are analyzed by the use of computer programming. Their use has enabled very large systems to be analyzed and controlled much more effectively and economically.

The main advantages of a digital computer are that it can perform simply arithmetic many millions of times faster than the human bran and that the reliability of the answer is extremely high. Apart from reducing the cost of calculations, the use of computers has encouraged the application of numerical analytical techniques to problems, which are otherwise intractable.

A computer cannot solve a problem in the sense of applying intelligent reasoning but it can assist in the exploration of the range of possible solution.
In the design of an engineering component, for example, it cannot define the design criteria, but it can help to predict the consequences of selecting particular component geometry.

A Polyphase circuit, which comprises of more than one phase, in most cases 3 and 6, are used in power transmission. But the three phase happens to be the one that is most applicable in the world right now and is going to be the one with which our analysis will be carried out on. Due to the nature and number of phases involved in the 3 phase circuits, the connections to which the various phase could be arranged. Also putting into consideration the types of load involved in our day to day living makes analyzing the circuit in terms of its voltages, current, power, reactive power, complex power and power factor complex determining.

The application of programming is used to determine the necessary parameters of a given three-phase circuit. Hence the program is of a menu format, which consists of four subprograms, based on the various types of load arrangement afforded the three-phase circuit.

These connections are:

(1) The star – star load

(2) The delta – delta load

(3) The star – delta load

(4) The delta – star load

Considering the application of programming to engineering problems in general, it makes solutions to such problems accurate, highly reliable and time saving. Most especially, it serves as a good tool to students undergoing the Polyphase circuit yourself for the very first time whereby they will be opportune to use it as a check, whenever they bare solving problems association with Polyphase circuits.

Turbo Pascal 7.0, which is used for this project, is designed for microcomputers running the MS-DOS operating system, CP/M-80 or CP/M-86.It is more than a compiler; it is a system or environment in which you can create, edit, and execute programs. It was preferably chosen because when you execute a program in Turbo Pascal and a compile-time or run –time error occurs, you will find yourself automatically in edit mode in the file at the location where the error occurred. Thus Turbo Pascal compiler makes tracing and correcting bugs simpler.

1.2 PROJECT OBJECTIVES AND MOTIVATIONS

The main objectives of this project are:

(a) To analyze the Polyphase circuits with the aid of computers and to prepare a study tool suitable for engineers and students in areas of Polyphase circuit problems.

(b) To review the relevance of computer programming to areas in electrical engineering.

Since the process of analysis via a computer happens to be reliable, efficient and obtained results are accurate, it is expedient that an engineer will better prefer this program package since all he is concerned about is accurately designing and putting in place the electrical engineering services to provide a safe and comfortable environment as well as for cost effectiveness, stability, durability and maintainability. Thus the analysis was done, putting into consideration balanced load networks.

1.3 LITERATURE REVIEWS

In the early days, generation of electricity was by direct current source. Minimum power was transferred from the generating source to consumption source. Generation, transmission and distribution of dc electrical energy is not connected with magnetic phenomenon. Later, synchronous generator was invented however because of the low voltage associated with the generator, power transmission was not visible in bulk and so electrical energy was transmitted at low voltages.

With new industrialization, energy was given to be generated at a resource center, stepped up to a very high voltage and transported over a large distance through ac power lines to a generalized center, where synchronization and harmonization will take place and then distribution will begin.

Due to the fact that power generation is mainly from a three phase armature winding, most of the equipments and devices used in industrial areas and at the consumers level are three phase power transmission because it uses less materials for a given capacity and it is more efficient than a single phase transmission.

According to the loads to be connected, the three phases could be in star (3 phase, 4 wire) connection or delta (3phase, 3 wire) connection.

Interconnection of these two brings about the menu format, which are the various load connection types; star-star, star-delta, delta-delta, and delta-delta connections. The parameters required for knowledge in these load connections are compiled together through their mathematical expressions to form the computer simulation of the Polyphase circuit.

1.4 Project outline

Chapter one gives an insight into the application of the computer simulation in solving the various parameters of a ploy-phase circuit, the program language used and its preference to other languages, the motivations for the project and the literature review as a base for the polyphase circuits in power transmission lines.

Chapter two provides a general overview of the polyphase circuits, its inter-connections and the various load connection arrangements. It also tells us about the general economics of computing to engineering, its advantages and necessities.

Chapter three informs us about the mathematical models used in defining and designing the problems to be solved, the algorithm concept and outline, the flowcharts used to simplify the simulation

Chapter four gives the analysis of results got from the simulation.

Chapter five is the conclusion, and recommendation and reference.

The program module of the computer simulation is given.

CHAPTER TWO

GENERAL OVERVIEW OF POLYPHASE CIRCUITS &CONNECTION

2.1 *POLYPHASE CIRCUITS*

These are circuits that contain more than one armature winding in terms of their voltage supply and this produce many independent voltage waves as the number of the windings or phases. These windings are displaced from one another by equal angles, the values or these angles being determined by the number of phases or windings. The word' poly' means many windings or circuits.

In a 3-phase alternator, as the name implies, has three independent armature windings which are 120 mechanical degrees apart. With exception of two-phase windings, it can be stated that is general, the mechanical displacement between phases is 360/n where in is the number of phases or windings.

Three phase systems are the most common, thus making it to be our case study in this write-up, although for certain special jobs, greater number of phases are used.

For large power transmission, three phase is used due to the fact that it is more efficient, uses less material for a given capacity and it costs less than single-phase transmission.

2.2 *POLYPHASE CIRCUIT CONNECTIONS*

Due to the fact that power generation is mainly from a three phase armature winding. Most of the equipments I devices used in industrial areas and also at the consumers level are three phase power equipments. This gives rise to the various types of connections that can be made with the three-phase supply.

2.2.1 *THE STAR OF WYE (Y) CONNECTION*

In this method of interconnection, similar ends say start ends of three coils (it could be finishing ends also) are joined together at point N. A single conductor known as neutral conductor replaces the three conductors meeting at point N. Such an interconnection is known as four wire, 3-phase system. If this three-phase voltage system is applied across a balanced symmetrical load, the neutral wire will be carrying three currents, which are exactly in magnitude but are 120^0 out of phase with each other hence their vector sum is zero.

Due to its mode of connection of its 3 phase, it is thrown that the phase voltage differs in magnitude from the line voltage being that, the line voltage is taken from two terminals of the three terminals that are available, while that of the phase voltage is that of a single line together with the neutral point N.

Also the current, this time has the same magnitude for both the phase and line current, the manner in which these coils are arranged gave rise to this effect.

Taking into consideration the characteristics of a star connection 3-phase circuit, one can easily deduce the specific areas in which such node of arrangement of the coils will be applicable.

2.2.1 *DELTA OR MESH CONNECTION (D)*

In this form of connection, the dissimilar ends of three phase windings are joined to the finishing end of the other phase. In other word, the three windings are joined in series to form a closed mesh. It might look as if these sort of inter connection results in short-circuiting the three windings. However if the system is balanced then sum of three voltages round the closed mesh is zero hence no current of fundamental frequency flows when the terminals are open. It should be understood that at any instant, the emf in one phase is equal and opposite to the resultant of those in other two phase. This type of connection is referred to as 3 phase, 3-wire system.

Due to its mode of arrangement, it is seen that the phase voltage and the line voltage both have the same magnitude. This is so because each of a coil in this type of connection is always terminating into line terminals thereby making the phase voltage being equal to the line voltage.

Considering this arrangement in terms of flow of current we can see that the line current flowing in, when it gets to any of the terminals, it branches into two different branches whereby ach branch happens to be a phase, due to this effect we conclude that the line current and phase current of a mesh connected 3 phase circuit differ in magnitude.

2.3 INTERCONNECTION OF STAR AND DELTA 3- PHASE ARRANGEMENT

From above we can see that a star connected 3-phase circuit has characteristics that differ from that of a 3- phase mesh connected circuit.

Since generally various equipments appliances require different supplies, it then makes it necessary to give such equipments, their desired mode of supplies. So as not to be having a single supply for each equipment where their supplies might be needed. We came up with the interconnection of the two known modes of 3 phase arrangement making it possible for a single supply when interconnected properly feed equipment which requires a supply from that of a mesh connected and also feed that of a star connection.

2.3.1 ***STAR-STAR CONNECTION***

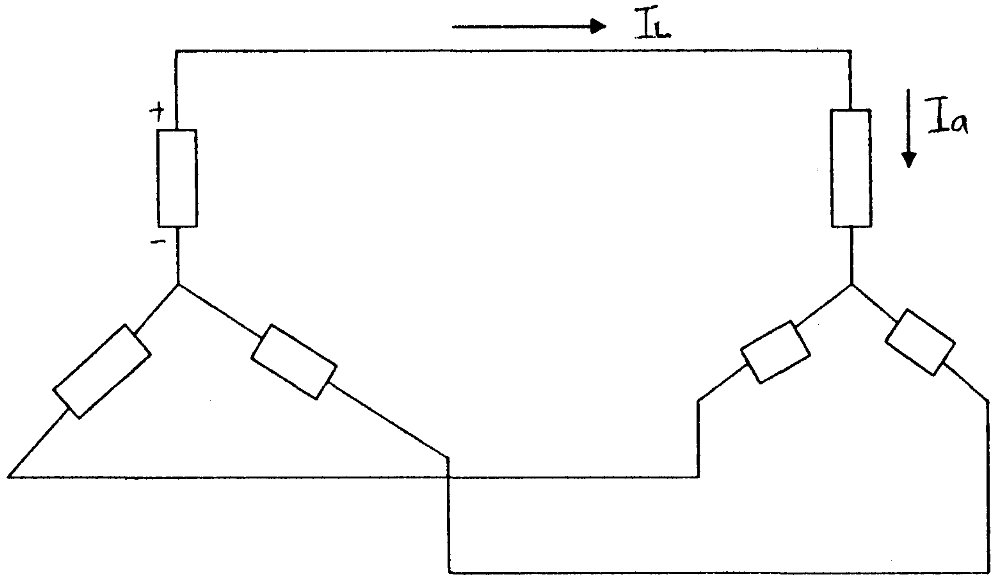


Fig 2.1: star-star connection

In this type of connection where the load involved happens to be in the star arrangement, consisting of three phase four-wire system where the fourth wire is the neutral, the path through which the resultant current from the phases flows back. Taking a close look at the star connected circuit above. We can see that the phase current is equal to the line current.

The fact is utilized in many industrial situations in which motors present a balanced load to the supply and many installations use a three-phase three-wire supply system, which does not employ a neutral wire

Also this type of connection is most economical for small high voltage transformers because the number of turns per phase and amount of installation required is minimum (as phase voltage is only 1/3 of line voltage).

2.3.2 ***DELTA-DELTA CONNECTION***

In this type of connection the load involved does not make use of a neutral wire, which is meant to be the return path for resulted current. The supply, which is in delta arrangement, feeds a load also of the Delta arrangement. Here the phase and line voltage are the same but the line current coming in differs from the phase current.

In most applications, installations requiring very large power due to the design of the equipment are meant to be fed with line voltage. Such type of installation makes use of this type of connection.

It is also applicable in transformer arrangement where the primary as well as the secondary sides of the transformer is arranged using the delta connection. Transformers of this type are being used in low voltage applications.

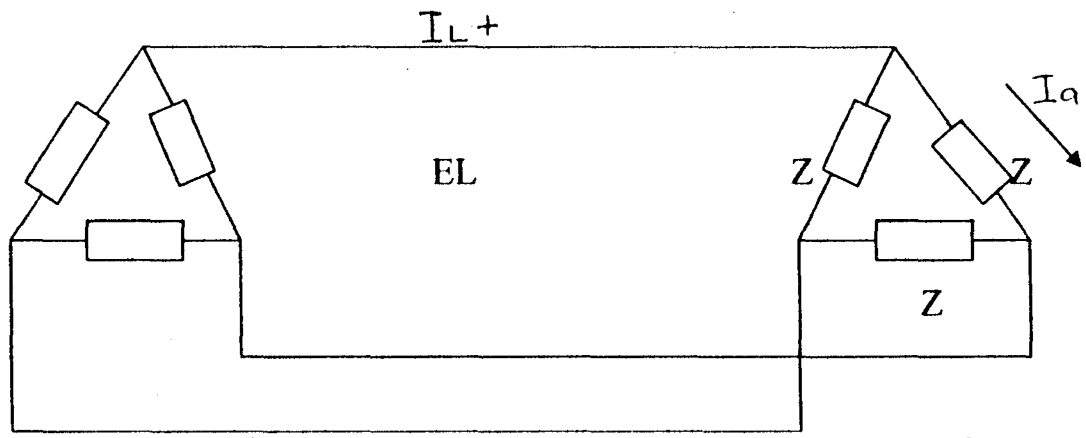


Fig 22: Delta – Delta connection

2.3.3. *THE DELTA / STAR LOAD CONNECTION*

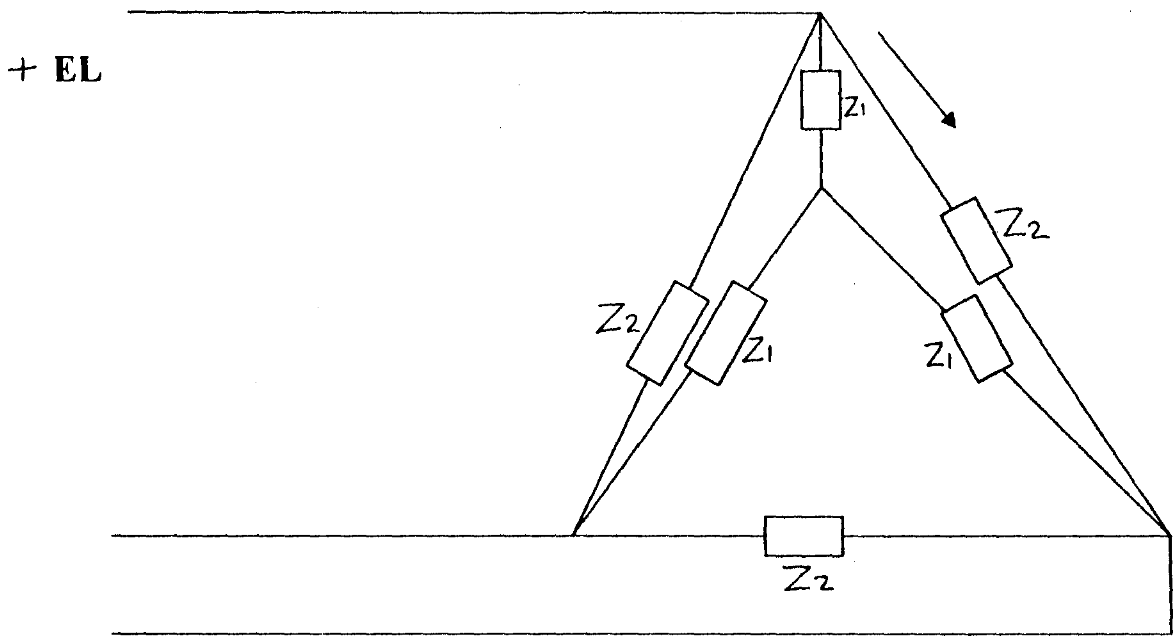


Fig 2.3: Delta star load connection

In this type of connection, the load comprises of two different arrangements. The two arrangements are the delta as well as the star.

Situations do arise at times that the load involved to supply voltage will be one that will as a three phase three phase four wire system as well as a three phase three wire system which happens to be neglecting the neutral return path. It is applicable in industries as well as private consumers where a particular equipment will require just the three phase supply (mostly motors) and require to supply as well as the neutral wire, for the return path of resultant current.

2.3.4 *DELTA – STAR CONNECTION*

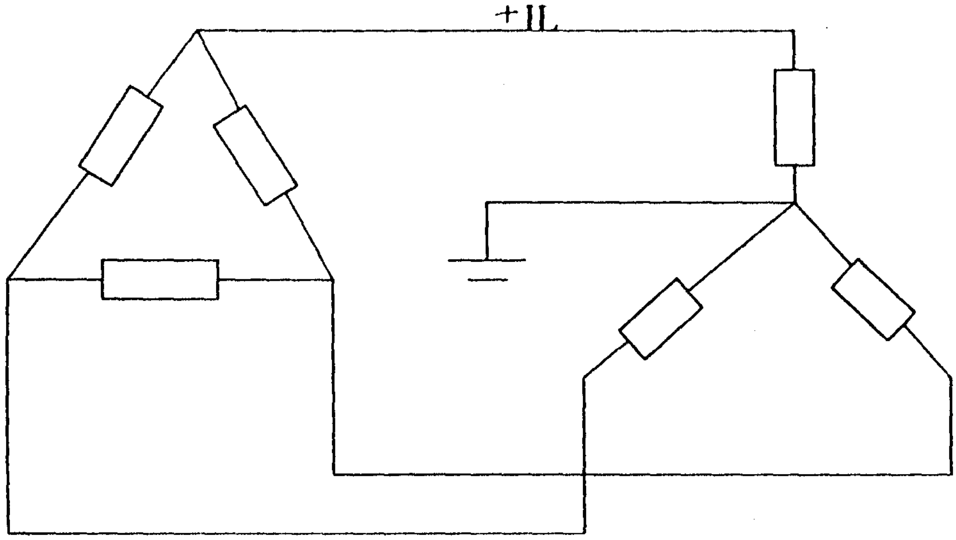


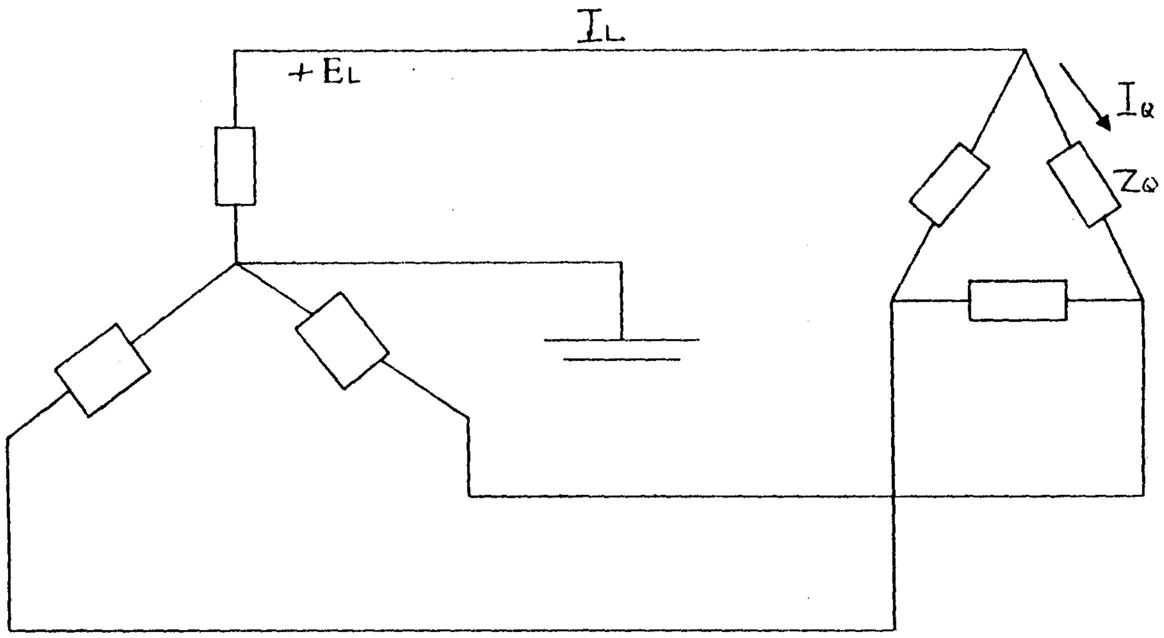
Fig 2.4: delta star connection

This type of connection is mostly is mostly applicable in transformer arrangement. It is generally employed where it is necessary to step up the voltage as for example of the beginning of high-tension transmission system. In practice the neutral of the secondary is grounded for providing three-phase four wire service. This connection has gained considerable popularity because it can be used to serve both the three phase power equipment and single phase lightening circuits.

2.3.5 *STAR – DELTA CONNECTION*

This type of connection is applicable at the substation end of transmission line where the voltage is to be stepped down.

The star winding which happens to be the primary has its neutral grounded. The ratio between the secondary and primary line voltage is 1/3 times the transformer ratio.



2.4 ***GENERAL ECONOMICS OF COMPUTING TO ENGINEERING***

While computers perform arithmetic very much more cheaply than human labor, there are a number of important economic aspects to engineering computing.

Because of the enormously high speeds achieved it is now possible to solve problems that are previously regarded as intractable, since they world take many years to solve by hand clearly the economic advantages of computed solutions should be considered in relation to the costs of developing and using the programs. In developing a program and particularly one, which uses substantial amounts of computing time, there is a tendency to concentrate on reducing this time to a minimum.

The cost of time required for compilation and execution but rather on a combination of time, amount of fast data store requested and the quantity and type of input and output involved.

2.4 *PROGRAMMING*

For computer to play a part in problem solving, it is necessary to establish some communication between the computers and their users. The users have very limited set of operations communicating with the computer entering a few specific types of data and reading the routine responses that are displayed. In such situations it has been possible to design and build specific system and procedures into the machine for all the required operations.

Usually, a computer program will be written in a high level language. The instruction set of which is more compatible with human languages and human thought processes. Some of such languages are BASIC, FORTRAN, PASCAL and COBOL. There are also various high level languages whose instruction sets are specially designed for a particular type of application. As a rule, a single instruction in a high level language will be equivalent to several instructions in machine language.

CHAPTER THREE

PROGRAM DESIGN AND PROCEDURE

3.1 *DESIGN OF THE PROBLEM*

In the development of any program, language rules and guidelines are followed and in stages. Below are the main stages involved in the design.

3.1.1 *DEFINITION OF PROBLEM TO BE SOLVED*

In solving these problems, the following parameters will be determined:

(i.) Phase voltage

(ii.) Phase current

(iii.) Line current

(iv.) Power per phase

(v.) Reactive power per phase

(vi.) Total reactive power

(vii.) Total real power

(viii.) Complex power

(ix.) Power factor

3.1.2 *CONSTRUCTION OF AN PPROPRIATE MATHEMATICAL MODEL.*

In trying to solve these problems, a relevant mathematical equation ought to be constructed to describe the problems.

3.1.2.1 ***MATHEMATICAL MODEL FOR A STAR CONNECTED LOAD.***

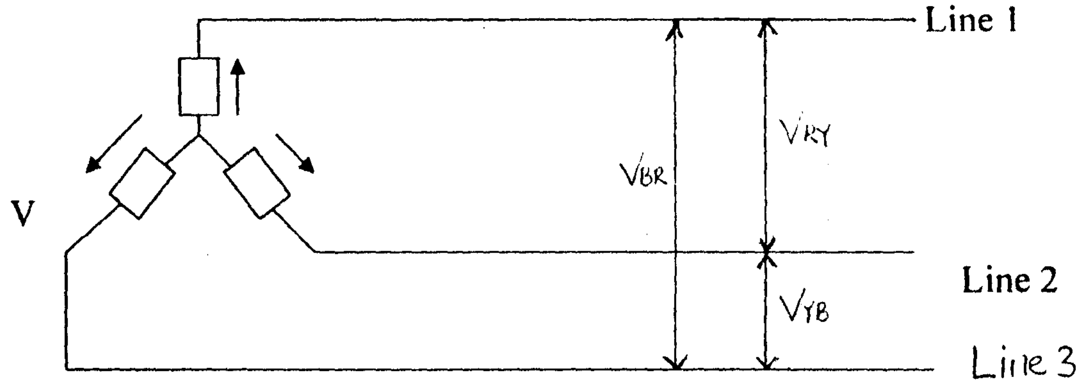


Fig 3.1:star connected load showing its independent voltages

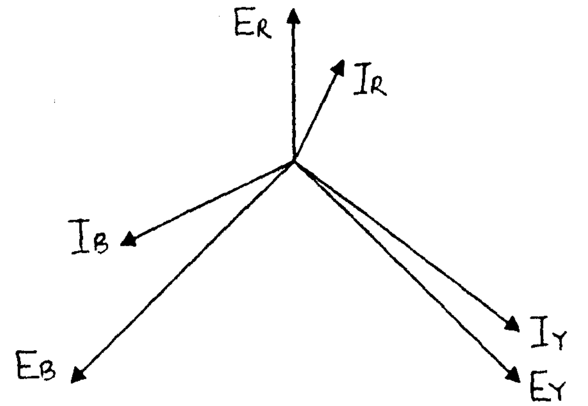


Fig 3.1b: Orthogonal connection of line currents and voltages

Voltage induced in each winding is called the phase voltage and current in each phase is likewise known as phase current flowing in each line is called line current.

As seen from fig 3.1a in this form of connection there are two phase windings between each pair of terminals and happen to be opposition to each other.

The potential difference between any two terminals is arithmetic difference of the two –phase e.m.fs concerned. However, the RMS value of this potential difference is given by the vector difference of the two-phase e.m.fs.

In a balanced system, ER = EY = EB = Ephase.

Line voltage VRY, which is between line 1 and line 2 from the above diagram is the vector difference of ER and EY. Line voltage YRB, which is between line 2 and 3 is the vector difference of EY and EB. Line voltage VYB, which is between line 3 and line 1 is the vector difference of EB and ER.

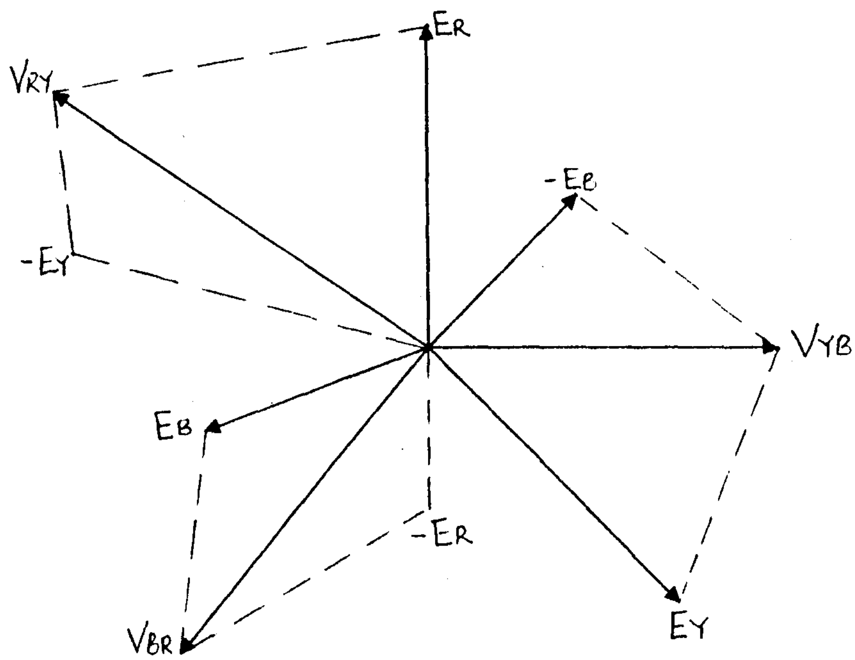


Fig 3.1.c: Expression of line and phase voltage of star connected load.

Considering fig 3.1c above with respect of the line voltage, the p.d between lines 1 and 2 is:

$$VRY = ER - EY$$

Hence VRY is found compounding ER and EY reversed and its value is given by the diagonal of the parallelogram of fig 3.1c.. The angle between ER and EY reversed is 60. Hence if ER =EY = EB = Eph (the phase emf)

Then Vry = 2* Eph * cos (60/2)

$2 * Eph * \cos 30 = 2 * Eph * \sqrt{3}/2 = \sqrt{3}\ Eph$

Similarly, $VYB = EY - EB = \sqrt{3}\ Eph$

And VBR = EB - ER = $\sqrt{3}$ Eph

Now VRY = VYB = VBR = line voltage, say Vl. Hence in star connection = Vl = $\sqrt{3}$ Eph

Currents in each is series with its individual phase winding, hence the line current in each line is the same as the current in the phase winding to which the line is connected.

IR = IY = IB = Iph – the phase current. Line current = phase current .The total active power in the circuit is the sum of the three phase powers, hence total active power = 3* phase power or $\sqrt{3}$ * Vph IL cos O

Similarly the total reactive power Q = $\sqrt{3}$ IL VL

Where the total apparent or complex power of the three phases is

S = $\sqrt{3}$ LIL or S = $\sqrt{(p^2 + Q^2)}$

3.1.2.2 ***MATHEMATICAL MODEL FOR A DELTA CONNECTED LOAD***

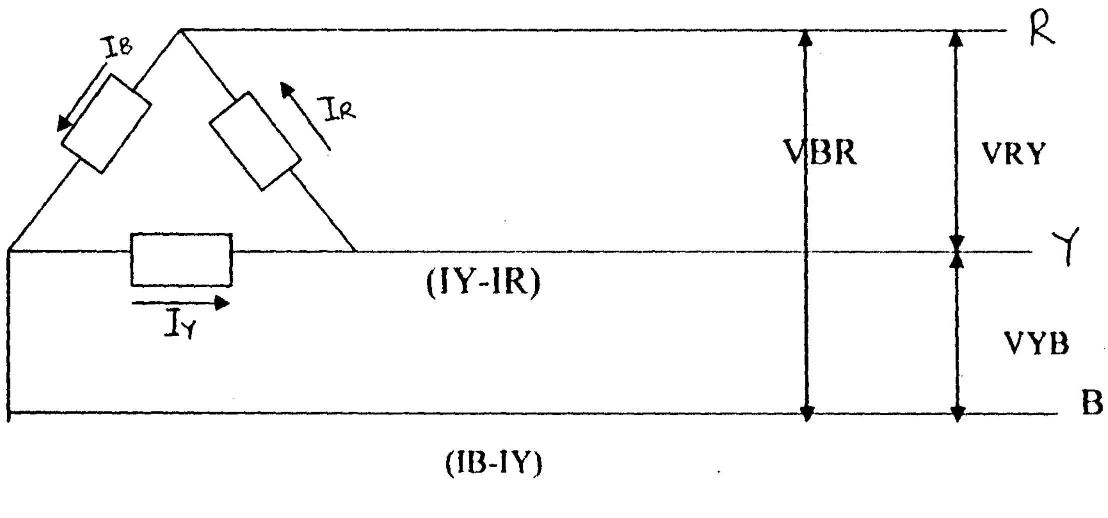


Fig 3.2:Delta connected load showing its independent current

It is seen from fig 3.2a above that there is only one phase winding completely included between any pair of terminal. Hence in delta connection, the voltage between any pair of lines is equal to the phase voltage of the phase winding connected between the two lines considered.

Calling the voltages between line 1 and 2 as VRY, line 2 and 3 as VRB and line 3 and 1 as VBY. Sine they are all equal for a balanced system, i.e VRY = VYB = VBR = line voltage VL. Then it is seen that VL = Vph for a delta connection.

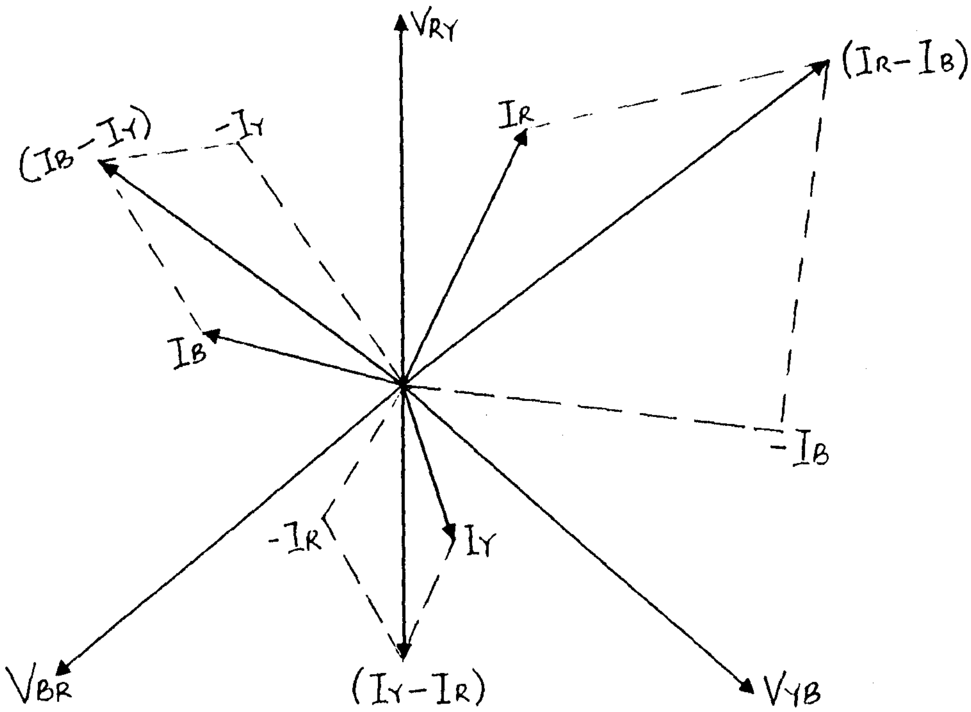


Fig 3.2b:Expression of line and phase current in a delta connected load.

It will be seen from fig 3.2a that current in each line is the vector difference of the two-phase currents is flowing through that lines. For example, current in line 1

Is 1i = IR – IB

Current in line 2 is I2 = IY-IR

Current in line 3 is I3 = IB – IY

Current in line 1 is found by compounding IR and IB reversed on its value is given by the diagonal of the parallelogram of fig 3.2b. the angle between IR and IB reversed is 60^0 If IR = IY = phase current Iph, then I1 = 2x Iph x cos (60/2) = 2xIph x $\sqrt{3}/2 = \sqrt{3}$ Iph

Current in line 2 is

I 2 = IY – IR = $\sqrt{3}$ Iph

And current in line 3 is

I3 =IB – IY = $\sqrt{3}$ Iph

Since all the line currents are equal in magnitude

i.e I1 = I2 = I3 = IL

Therefore IL = $\sqrt{3}$ I phase

Power is the same as that of the star connection whereby p = 3 VL IL cos O

Q = $\sqrt{3}$ VL IL sin O

And S = $\sqrt{p2 + Q2}$

3.2 *THE ALGORITHM CONCEPT*

The algorithm concept is one of the principal notions computer programming the word algorithm may be defined as a set of unambiguous rules that defines how a particular problems or class of problem.

THE ALGORITHM OUTLINE

(1) Read choice

(2) Display choice option

(3) Read in voltage and phase impedance, in terms of Resistance of reactance values.

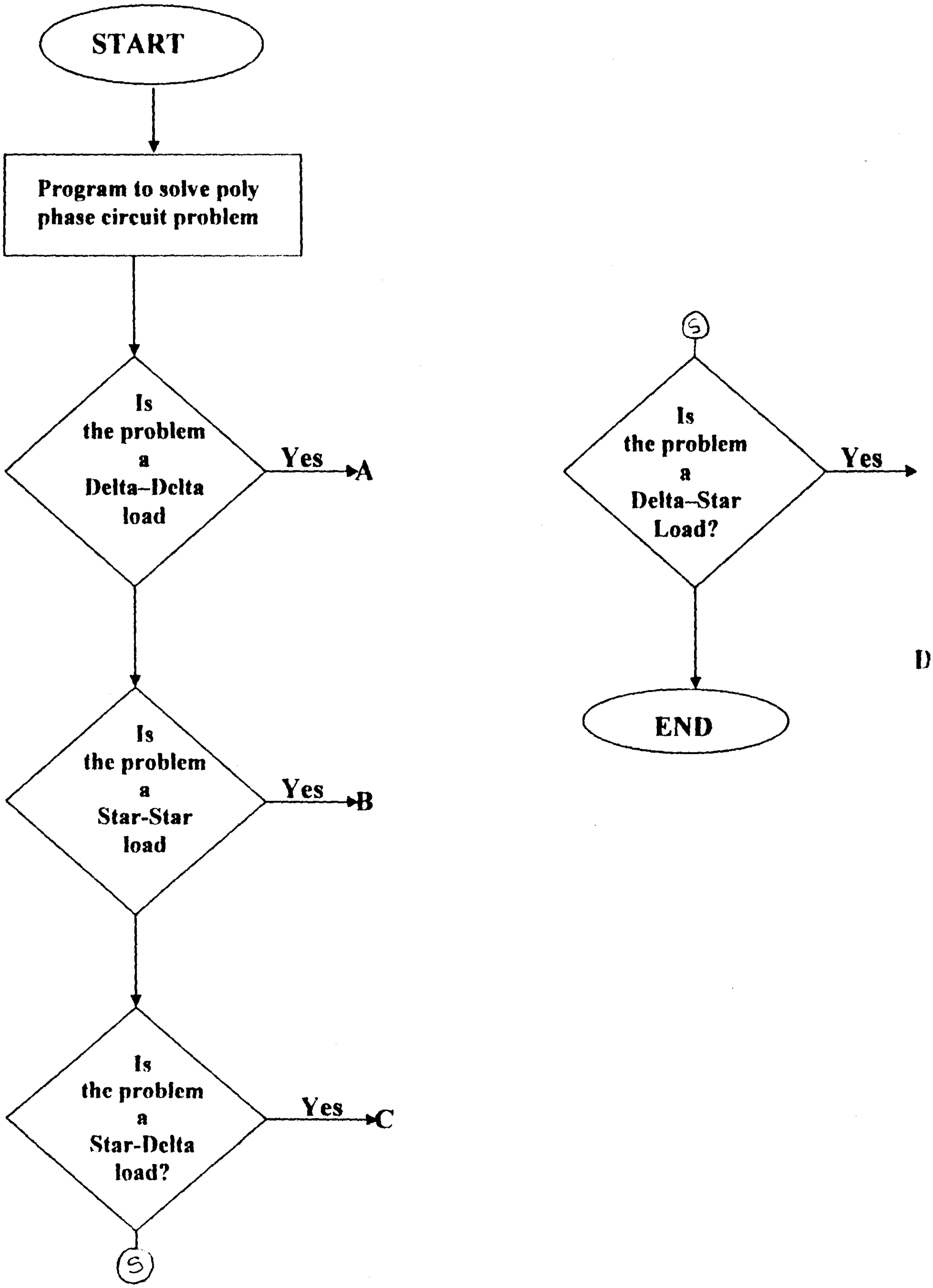
(4) Computer phase voltage, line current, phase current. active power per phase, reactive power per phase, total active power, total reactive power, complex and power factor.

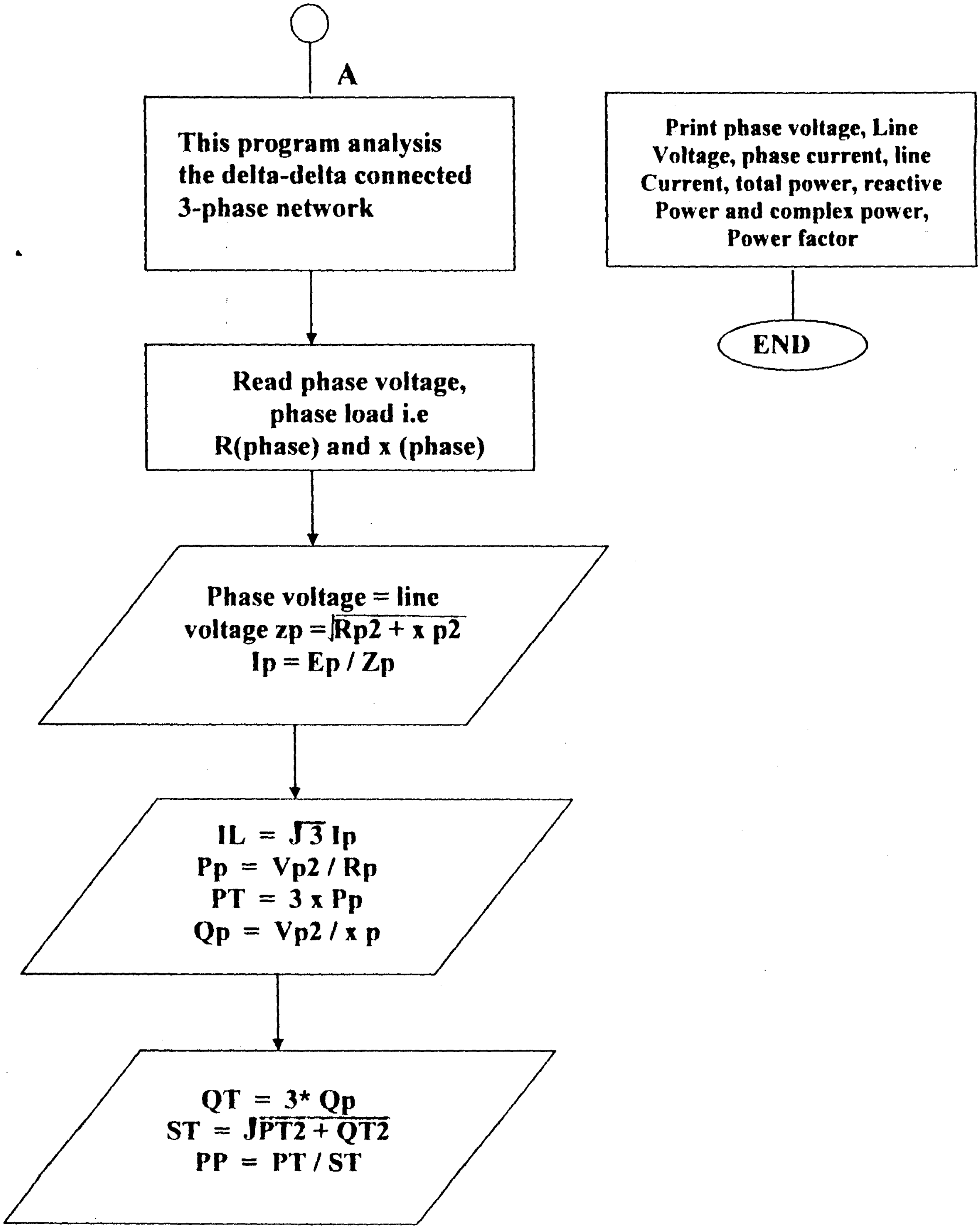
(5) Display values of the calculated parameters

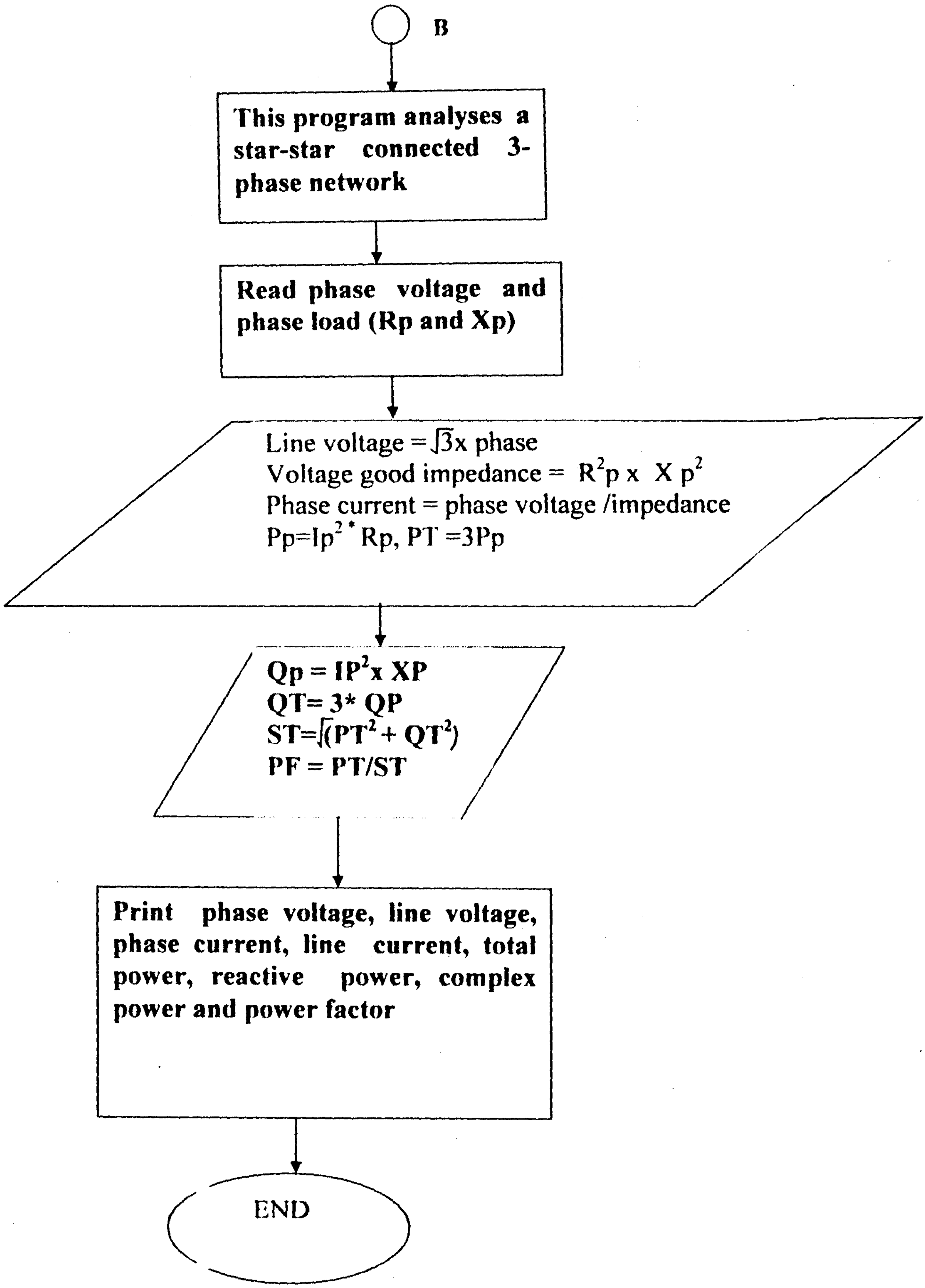
3.3 THE DESIGN FLOWCHART

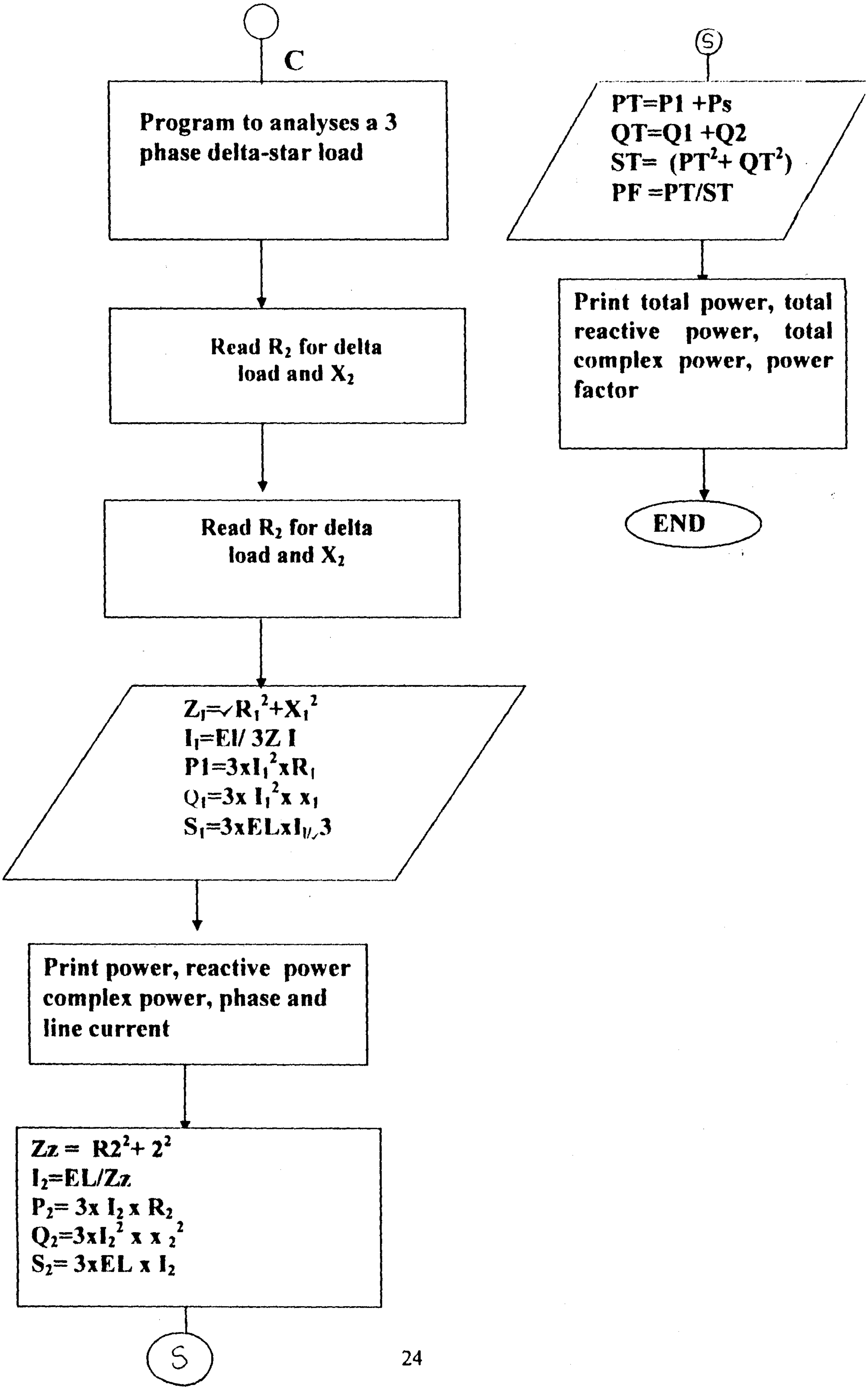
The flow chart is a graphical representation of sequence steps of an algorithm of the design

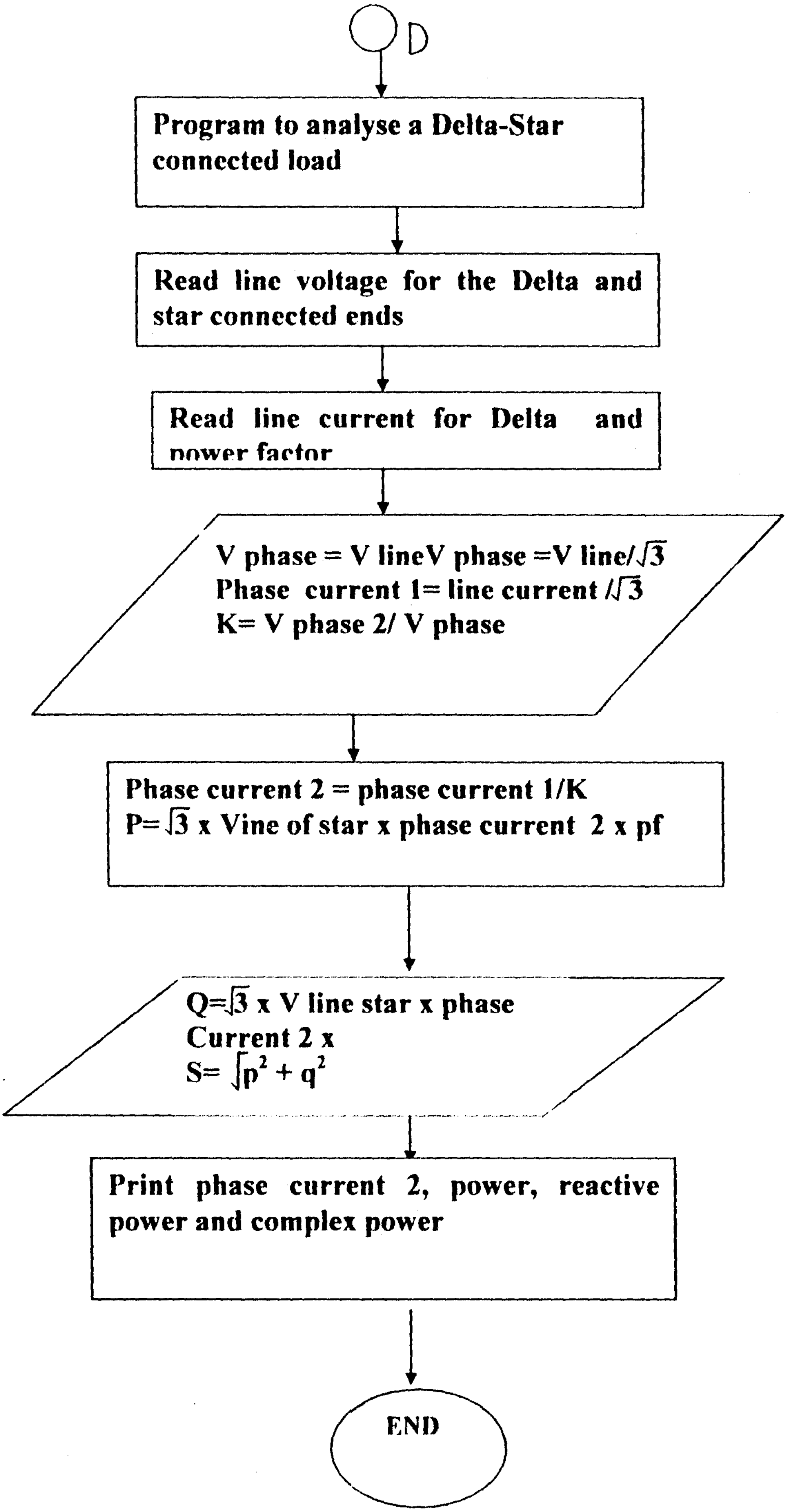
THE FLOW CHART




A
This program analysis the delta-delta connected 3-phase network
Read phase voltage, phase load i.e R(phase) and x (phase)
Phase voltage = line voltage zp = √Rp2 + x p2
Ip = Ep / Zp
IL = √3 Ip
Pp = Vp2 / Rp
PT = 3 x Pp
Qp = Vp2 / x p
QT = 3* Qp
ST = √PT2 + QT2
PP = PT / ST
Print phase voltage, Line Voltage, phase current, line Current, total power, reactive Power and complex power, Power factor
END


B
This program analyses a star-star connected 3-phase network
Read phase voltage and phase load (Rp and Xp)
Line voltage = √3x phase
Voltage good impedance = R²p x X p²
Phase current = phase voltage /impedance
Pp=Ip² * Rp, PT =3Pp
Qp = IP²x XP
QT= 3* QP
ST=√(PT² + QT²)
PF = PT/ST
Print phase voltage, line voltage, phase current, line current, total power, reactive power, complex power and power factor
END


C
Program to analyses a 3 phase delta-star load
Read R₂ for delta load and X₂
Read R₂ for delta load and X₂
Z₁=√R₁²+X₁²
I₁=El/ 3Z I
P1=3xI₁²xR₁
Q₁=3x I₁²x x₁
S₁=3xELxI₁/√3
Print power, reactive power complex power, phase and line current
Zz = R2²+ 2²
I₂=EL/Zz
P₂= 3x I₂ x R₂
Q₂=3xI₂² x x ₂²
S₂= 3xEL x I₂
S
S
PT=P1 +Ps
QT=Q1 +Q2
ST= (PT²+ QT²)
PF =PT/ST
Print total power, total reactive power, total complex power, power factor
END


D
Program to analyse a Delta-Star connected load
Read line voltage for the Delta and star connected ends
Read line current for Delta and power factor
V phase = V lineV phase =V line/√3
Phase current 1= line current /√3
K= V phase 2/ V phase
Phase current 2 = phase current 1/K
P= √3 x Vine of star x phase current 2 x pf
Q=√3 x V line star x phase
Current 2 x
S= √p² + q²
Print phase current 2, power, reactive power and complex power
END

CHAPTER FOUR

ANALYSIS OF RESULT

4.1 CASE 1: STAR-TO-STAR LOAD

In this case, the line current was found to be equal to the phase current which agreed with the initial assumptions made earlier about a star connected load in terms of its line and phase currents .The line voltage and the phase voltage differ by a magnitude than both the real and reactive power.

4.2 CASE 2:DELTA TO DELTA LOAD

In this case, the line voltage was found equal to the phase voltage, while the line current and phase current differ by a magnitude of $\sqrt{3}$.

4.3 CASE 3: STAR TO DELTA LOAD

In this case, each connection was handled individually initially and later went on in considering both of them together. The initial individual result showed their respective characteristics in terms of voltage and current of their various connections. When then combined together, their results were added together, now neglecting their individual characteristics.

4.4 CASE 4: DELTA TO STAR LOAD

In this case, a ratio was obtained in terms of the line voltage of both connections. This was then used in computing the line current of star, which then gave rise to the various powers of the system.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The study showed that any programming language could be used to express, analyze and to solve any electrical circuit problem, once its mathematical model expressions can be achieved.

The results obtained when computed manually were found to be accurate. Since we are in the era of computerization, every aspect of study or work like research, design work and others can be easily executed on the computer. This is because of its accuracy, speed, timesaving, reduced cost of design, easy and most importantly, storage of information.

5.2 RECOMMENDATION

Students should be encouraged and allowed to have access to computers since this kind of project is basically computer oriented. They should also be given the opportunity to attend practical classes, which they are already undergoing.

Since the language used is TURBO PASCAL,I recommend that someone else use another language in analyzing the poly phase circuit problems and should also consider the unbalanced load situation.

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```
program connection (input, output) ;
const pi = 22/7 ;
var
I1,I2,I3: real;
a,b,starr, reply : integer;
response : char ;
function R (var a : integer ; b: integer) : real;

begin

R := sqrt (sqr (a *cos (b)) + sqr (a * sin (b))) ;
end;

procedure star_star;
var
      vp, r, x, LineVoltage, LoadImpedance, LoadCurrent, PowerPerPhase : real;
       TotalPower, rppp, trp, ComplexPower, PowerFactor, LineCurrent : real;
write ('Supply the phase voltage =>') ;
readln (vp);
write ( 'For The phase load, supply R (phase) and x (phase) respectively =>');
readln (r,x);
LineVoltage := sqrt (3*vp);
LoadImpedance := sqrt (sqr (r) + sqr (x));
LoadCurrent := vp / LoadImpedance;
PowerPerPhase := sqr (LoadCurrent) * r;
TotalPower := PowerPerPhase * 3;
rppp := sqr (LoadCurrent) * x;
trp := rppp * 3;
ComplexPower := sqrt (sqr (TotalPower) + sqr (trp));
PowerFactor := TotalPower/ComplexPower;
LineCurrent := LoadCurrent;

        (*OUTPUT*)
        (*clrscr; *)
        WRITELN (' Result Of The Star To Star Connection') ;
        writeln ;
        writeln (' The load current is, ',LoadCurrent :8:2 ,'A');
        writeln (' The  total power is, ',TotalPower : 8:2, 'W');
        writeln (' The reactive power per phase is, ',rppp :8:2, 'varr' );
        writeln (' The total reactive power is, ',trp :8:2, ' varr');
        writeln (' The complex power is, ' ,ComplexPower :8:2, 'va');
        writeln (' The line current is ',LineCurrent :8:2, 'A');
        writeln;
        writeln;
end;
procedure delta_delta;
var
vp, r, x, LineVoltage, LoadImpedance, LoadCurrent, PowerPerPhase : real;
TotalPower, rppp, trp, ComplexPower, PowerFactor, LineCurrent : real;
begin
```

```
write ('Supply the phase voltage =>') ;
 readln(vp);
 write(' For the phase load,supply the R(phase) and X =>' );
 readln(r,x) ;
  Linevoltage := vp ;
  LoadImpedance :=sqrt (sqr(r)  + sqr(x) ) ;
   LoadCurrent := vp / LoadImpedance ;
   PowerPerPhase := sqr (LoadCurrent) * r;
    TotalPower := PowerPerPhase * 3;
   rppp := sqr (LoadCurrent) * x;
    trp := rppp * 3;
     ComplexPower := sqrt (sqr (TotalPower) + sqr (trp)) ;
     PowerFactor := TotalPower/ComplexPower ;
     LineCurrent := sqrt (3*LoadCurrent) ;

        (*OUTPUT*)
        (*clrscr; *)
        writeln ( ' The output of Delta To Delta Connection = >');
        writeln;
        writeln ( ' The load current is, ' ,LoadCurrent : 8:2, 'A');
        writeln ( ' The total power is, ' ,TotalPower : 8:2, 'W');
        writeln ( ' The reactive power per phase is, ' ,rppp :8:2, 'VARR');
        writeln ( ' The total reactive power is, ' ,trp:8:2, 'VARR') ;
        writeln ( ' The complex power is, ',ComplexPower : 8:2, 'VA ');
        writeln ( ' The line current is ' ,LineCurrent : 8:2, 'A');
        writeln;
        writeln;
 end;
 procedure star_delta;
 var
        LineVoltage, r1,r2,x1,x2, LoadImpedance1,PhaseVoltage1, LoadCurrent1:real;
        TotalPower1,TotalReactivePower1, ComplexPower1 : real;
        LoadImpedance2, PhaseVoltage2, LoadCurrent2, TotalPower2 : real;
        TotalReactivePower2, ComplexPower2 : real;
        TotalPower, TotalReactivePower, TotalComplexPower, PowerFactor : real;
 begin
        write (' Supply the line voltage =>');
        readln (LineVoltage);
        writeln ( 'For the star connection, supply r(phase)and x (phase) respectively =>');
              readln (r1, x1) ;
        write ( 'For the delta connection, supply r(phase)and x (phase) respectively =>');
        readln (r2, x2);

        (*For The Star Connection *)
        LoadImpedance1 := sqrt (sqr (r1) + sqr (x1));
        PhaseVoltage1 :=LineVoltage/sqrt (3);
        LoadCurrent1 := PhaseVoltage1/LoadImpedance1;
        TotalPower1 := 3 * sqr (LoadCurrent1) * r1;
        TotalReactivePower1 := 3 * sqr (LoadCurrent1) * x1;
        ComplexPower1 := sqrt (sqr (TotalPower1) + sqr(TotalReactivePower1));
```

```
(*For The Delta Connection *)
LoadImpedance2 := sqrt (sqr (r2) + sqr (x2));
PhaseVoltage2 := LineVoltage ;
LoadCurrent2 := PhaseVoltage2/LoadImpedance2;
TotalPower2 := 3 * sqr (LoadCurrent2) * r2;
TotalReactivePower2 := 3 * sqr (LoadCurrent2) * x2;
ComplexPower2 :- sqrt (sqr (TotalPower2) + sqr (TotalReactivePower2));

(*For The Combine System *)
TotalPower := TotalPower1 + TotalPower2 ;



TotalReactivePower := TotalReactivePower1 + TotalReactivePower2;
TotalComplexPower := ComplexPower1 + ComplexPower2;
PowerFactor := TotalPower/TotalComplexPower;

(*OUTPUT*)
writeln;
writeln;
writeln ( ' RESULT FOR THE STAR CONNECTION PART') ;
WRITELN;
writeln;
writeln ( ' The load current is ' ,LoadCurrent1 : 8:2, 'A');
writeln ( ' The Phase Voltage is ' ,PhaseVoltage1 : 8:2, 'V');
writeln ( ' The Total Power is ' ,TotalPower1 :8:2, 'W') ;
writeln ( ' The Total Reactive power is ' ,TotalReactivePower1 : 8:2, 'VARR') ;
writeln ( ' The complex power is ',ComplexPower1 : 8:2, 'VA' ) ;
writeln;
writeln (' Press Enter key to Continue');
readln;
writeln;
writeln;
writeln (' RESULT FOR THE DELTA CONNECTION PART' );
WRITELN;
WRITELN;
writeln ('The load current is  ',Loadcurrent2 :8:2,'A');
writeln ( ' The Phase current is ' ,PhaseVoltage2 : 8:2, 'A');
writeln ( ' The Total Power is ' ,TotalPower2 :8:2, 'W') ;
writeln ( ' The Total Reactive power is ' ,TotalReactivePower : 8:2, 'VARR') ;
writeln ( ' The complex power is ',ComplexPower2 : 8:2. 'VA') ;
writeln:
writeln (' Press Enter Key To Continue');
readln;
writeln;
writeln;
writeln (' RESULT FOR THE COMBINE SYSTEM');
WRITELN;
```

```
        WRITELN;
        writeln ( ' The Total Power is ', TotalPower : 8:2, 'W') ;
        writeln ( ' The Total Reactive power is ' ,TotalReactivePower : 8:2, 'VARR') ;
        writeln ( ' The Total Complex power is ',TotalComplexPower : 8:2, 'VA') ;
        writeln ( ' The Power Factor is ' , TotalPower/TotalComplexPower : 8:2);

end;
procedure delta_star;
var

        s,q,po,k,pf,vL1,vL2,iL1,iL2,spv,dpi,dpv,spi,sli,slv,ArcCospf : real;

begin
write ( ' Supply Delta Line Voltage => ');
readln (vL1);
write ( ' Supply Star Line Voltage =>');
readln (vL2);
write ( ' Supply Delta Line Current =>') ;
readln (iL1) ;
write ( ' Supply Star Line Current =>') ;
readln (iL2) ;
write ( ' Supply Power Factor');


        readln(pf);

        ArcCospf := ArcTan (sqrt  (1-sqr  (pf)) / pf) ;
        ArcCospf := ArcCospf * (pi/180) ;

        dpv := vL1;
        spv := vL2/sqrt (3) ;
        k := spv/dpv ;
        dpi := iL1/sqrt (3);
        spi := dpi/k ;
        sli := spv ;
        slv := spv ;
        po := sli *slv*sqrt (3) *pf ;
        q := vL2 *iL2 *sqrt (3) * sin (arcCospf) ;
        s :=po/pf ;

writeln ( ' The Answers For Delta Star Connection are => ');
writeln;
writeln ( ' Star Phase Current is = ' , spi : 8:3) ;
writeln ( ' Star Line Current is = ' ,sli : 8:3) ;
writeln ( ' Power Output is = ' , po : 8:3) ;
writeln ( ' Reactive Power is ' , q : 8:3);
writeln ( ' Complex Power is ', s: 8:3) ;

end;
```

```
begin
repeat
(*clrscr;*)
writeln ( ' Select Your Option ') ;
writeln ( ' 1 : Star to Star Connection') ;
writeln ( ' 2 : Delta to Delta Connection ' ) ;
writeln ( ' 3 : Star to Delta Connection ' );
writeln ( ' 4 : Delta to Star Connected Load') ;
        readln (reply);
        case reply of
            1 : star_star ;
            2 : delta_delta ;
            3 : star_delta ;
              4 : delta_star ;
        end;
writeln ( ' Do You Wish To Continue (y/n) ') ;
readln (response) ;
until response = 'n' ;
end.
```