T.C.

BAHÇEŞEHİR ÜNİVERSİTESİ

DETERMINATON OF POWER TRANSFER CAPABILITY

Master's Thesis

Mutlu YILMAZ

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Asst. Prof. Dr. Tunç BOZBURA
Director

This is to certify that we have read this thesis and that we find it fully adequate in scope, quality and content, as a thesis for the degree of Master of Science.

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To my parents

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ABSTRACT

DETERMINATION OF POWER TRANSFER CAPABILITY

Yılmaz, Mutlu

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In this master's thesis, we study how to determine power transfer capability of transmission lines. Power transfer between areas is a major function of a running electric power system. However, transmission networks have limited capability to transfer power. The maximum amount of power transfer, which is the limit of the capability, is called power transfer capability. In fact, transfer capability measures the maximum power transfer. The determination of transfer capability is mostly based on computer simulations of various scenarios of operations. These simulations are performed by power-flow solutions. The computer simulations of such scenarios envisioned here are to provide us indispensible information for successful operations of power systems under various amount of power transfer.

We propose to build scenarios for the calculation of power transfer capability. These scenarios contribute to practical and easy computations of power transfer capability. The purpose of our scenarios is to estimate power transfer capability in a practical manner. To assess the transfer capability, we first obtain the power-flow solution for the given data by running the power-flow program that we have developed. We try to implement the power-flow program in a modular way. Thus, the power-flow program is very efficient and easy to extend to any additional purposes related to power flow. The program is run for the power-flow solutions of the test cases, which are the 20-bus IEEE test system and the 225-bus system of Istanbul Region. We obtain power-flow solution using Newton-Raphson method with and without reactive power limits of generators.

First option solves the power-flow program with no limits and the second one obtains the solution, taking into account reactive power limits of generators. These options depend on user's demand. In addition, we use the highly sparse and vectorized computation techniques to construct the Jacobian matrix. The technique we have used provides high speed and reliable converge for our power-flow

program. Power-flow programs determine the voltage magnitudes and phase angle at each bus of the network under steady-state operating conditions. For the given data of network, generation, and load, the program obtains the base case solution. The base case is accepted as power system operating condition at which the power transfer is applied.

After obtaining power-flow solutions for the base case, we start to run the program for the scenarios in order to determine power transfer capability of the transmission lines between a generator bus and a load bus of interest. According to our scenario, we choose two buses; at the generator bus, power is injected and at the load bus, power is demanded. We specify amount of increment in injected power and demanded power. The amount of injected power and that of demanded power must be equal owing to conservation of power. Following the selection of the two buses, we increase the generation at the generator bus and the demand at the load bus by same amount of increment. Then, the power-flow program is executed for the changed case. If the increment is small enough, we get convergent solutions of power-flow. We continue the process of adding increments to generation and load at the selected buses and running the program for the changed cases until the convergence of the power-flow does not occur. In this way, the maximum power transfer capability is exceeded. Thus, the power transfer capability is determined. The generation or load level at the selected buses beyond which the power flow does not convergence specifies the power transfer capability between the selected generator and load buses. Indeed, the total increment from the base case to the final case provides the power transfer capability. This research work helps system operators and power marketers use the existing transmission lines efficiently.

Keywords: Power Transfer Capability, Power-Flow Program, Base Case Power-Flow Solution

ÖZET

Yılmaz, Mutlu

Elektrik-Elektronik Mühendisliği

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Yüksek lisans tezimizde, iletim hatlarının güç aktarım kapasitesinin belirlenmesi üzerine çalışmaktayız. Bölgeler arası güç aktarımı, çalışan elektrik güç sisteminin temel bir işlevidir. Ancak, iletim ağlarının güç aktarım kapasitesi sınırlıdır. Maksimum güç aktarım miktarına, güç aktarım kapasitesi denir. Aslında, aktarım yeterliliği maksimum güç aktarımını ölçer. Güç aktarımın belirlenmesi çoğunlukla çeşitli işletim senaryoların bigisayar simülasyonlarına dayanır. Bu simülasyonlar güç-akış çözümleri sonucu elde edilir. Burada öngörülene benzer senaryoların bilgisayar simülasyonları, güç sistemlerinin değişik miktarlardaki yük aktarımı altında başarılı işletilmesi için hayati bilgiler sağlar.

Güç aktarım kapasitesini hesaplamak için çeşitli senaryolar önermekteyiz. Bu senaryolar güç aktarım kapasitesinin kolay ve pratik hesaplanmasına katkıda bulunur. Amaçladığımız senaryolar güç aktarım kapasitesini pratik bir biçimde kestirmek içindir. Aktarım kapasitesini değerlendirmek için öncelikle, geliştirdiğimiz güç-akış programını çalıştırarak, eldeki veriye karşı düşen güç-akış çözümünü elde ederiz. Bahsedilen güç-akış programını modüler bir şekilde gerçekleştirmeyi denemekteyiz. Böylece güç-akış programı, güç akış konularıyla ilgili ek amaçlar için genişletilmek üzere çok uygun ve kolay hale gelmiştir. Program, 20 baralık IEEE ve 225 baralık İstanbul Bölgesi deneme sistemlerinin güç-akış çözümü için çalıştırılmıştır. Güç-akış çözümünü, Newton-Raphson yöntemini kullanarak, üreteç reaktif güç sınırlarını hesaba katarak da katmayarak elde ederiz.

İlk seçenek güç-akış programını reaktif güç sınırlarını hesaba katmayarak, ikinci seçenek ise reaktif güç sınırlarını göz önüne alarak çözer. Bu seçenekler kullanıcının isteğine bağlıdır. Ayrıca, Jakobiyen matrisi seyrek matris ve vektörel hesaplama tekniklerini kullanarak oluştururuz. Kullandığımız teknikler, güç-akış programımız için yüksek hız ve güvenilir yakınsama sağlar. Güç-akış programları sürekli durum koşulları altında her baradaki voltaj genliklerini ve açılarını saptar.

Program, verilen şebeke, üretim ve yük verileri için temel durum çözümünü elde eder. Temel durum güç sistemini işletme koşulunda güç aktarımı uygulandığı durum olarak kabul edilir.

Temel durum için güç-akış çözümleri elde ettikten sonra programı, değişik senaryolar için ilgili üretim ve tüketim baraları arasındaki güç aktarım kapasitesini hesaplamak için çalıştırırız. Senaryomuza göre iki bara seçeriz; bunlar enerji üreteç barası ve enerjiyi talep eden tüketim barasıdır. İletilecek olan gücün artırım değeri ile harcanacak olan gücün artırım değerini belirleriz. Enerjinin korunumu yasasına göre iletilecek olan enerjinin değeri ile harcanacak olan gücün değerine eşit olmalıdır. Seçilmiş iki bara takip ederek üretim barasındaki üretim miktarı ile tüketim barasındaki talep edilen güç miktarı aynı değerde arttırırız. Sonra, güç-akış programını değişmiş durum için çalıştırılır. Eğer güç artışı yeteri kadar küçükse, güç-akışı için yakınsayan bir çözümünü elde ederiz. İşleme, seçilmiş üretim ve tüketim baralarına güç eklemesi yaparak devam ederiz ve değişmiş durumlar için güç-akış programını çalıştırmayı, yakınsama ortadan kalkıncaya kadar sürdürürüz. Bu şekilde, maksimum güç aktarım kapasitesi aşılmış olur. Böylece güç aktarım kapasitesi saptanır. Seçilmiş baralardaki, üretim ya da yük seviyesi, bu seviyenin ötesinde güç akışının yakınsamaması durumunda, şeçilmiş üreteç ve yük baraları arasındaki güç aktarım kapasitesini belirler. Gerçekten temel durumdan son duruma kadar olan toplam artış güç aktarım kapasitesini verir. Bu araştırma çalışması sistem operatörlerinin ve elektrik güç satıcılarının var olan iletim hatlarını verimli kullanabilmelerine yardımcı olur.

Anahtar Kelimeler: Güç Aktarım Kapasitesi, Güç Akış Programı, Temel Durum Güç Akış Çözümü

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LIST OF ABBREVIATIONS

Institute of Electrical and Electronics Engineering	: **IEEE**
Active Power Voltage	: **P-V**
Reactive Power Voltage	: **Q-V**
Continuation Power Flow	: **CPV**
Open-Access Same Time Information System	: **OASIS**
North American Electric Reliability Council	: **NERC**
Federal Energy Regulatory Commission	: **FERC**
Available transfer capability	: **ATC**
Total Transfer Capacity	: **TTC**
Capacity Benefit Margin	: **CBM**
Existing Transmission Comments	: **ETC**
First Contingency Total Transfer Capability	: **FCTTC**
First Contingency Incremental Transfer Capability	: **FCITC**
Türkiye Elektrik İşletmeleri Anonim Şirketi	: **TEİAŞ**

1. INTRODUCTION

1.1. BACKROUND

Transfer capability is the measure of the ability of interconnected electric systems to reliably transmit power one area to another over all transmission lines between those areas under specified system condition [NERC,1996]. Transfer capability is measured in megawatts (MW).

Power transfer capability is mainly a function of some limits such as line thermal limits, bus voltage limits, steady-state stability limits and transient stability limits. According to NERC, thermal limits demonstrate the maximum amount of electrical current on a transmission line or transformer without violating the current carrying capability of the facility. Voltage limits state that system voltages and fall or rise of voltages must be sustained within maximum or minimum allowable limits. Stability limit establishes that the maximum allowable transfer capability through a transmission line such that loss of a transmission element due to a fault does not result in either a rapid voltage collapse or a slow voltage recovery [NERC,1996]. ‘‘The first two limits are accepted soft limit, because a power system can be operated under violation of soft limit for a period. The last two limits are accepted hard limits, since power system instability occurs when either one of hard limits violated’’. [Chow, Fu, and Mamoh, 2005, p.66].

The determination of the power transfer capability accurately plays a vital role for large scale power systems. However, the estimate of power transfer capability accurately has many engineering challenges. Technical challenges of computation power transfer capability discuss in Thirtieth Annual Hawaii International Conference [Sauer 1997]. It is well known that the nature of electric power systems is highly nonlinear and extremely complex. In recent years, electric power systems have been operating under heavy loads. Due to all of these factors, the power system leads to unstable behaviors. Unstable conditions indicate the potential for voltage collapse. “Voltage collapse is the process by which the sequence of events accompanying voltage instability leads to low unacceptable voltage profile in a significant portion of the power system” [Kundur

1993, p.27]. There is a close relationship between voltage collapse and maximum power transfer. Limits of the voltage stability, in general, determine the maximum power transfer through the transmission lines. Exceeding such limits results in voltage collapse.

Methods for assessing proximity to voltage instability are based on some measure of how close the Jacobian of power flow is to singularity condition, because the singularity of the Jacobian implies that there is no unique solution. In this respect, power-flow based methods, PV and QV curves are widely used voltage stability analysis tools today. PV curve or nose curve compute the nose point for monitoring system voltage of a critical bus in each region as a function of system total load change in consumed in the region. Plotting the voltage at a specified bus as the load is adjusted to base case to loadability limit. In fact, we indicate that estimating maximum transferable power can lead to a nose point or a point of maximum loadability.

1.2. STATEMENT OF THE PROBLEM

In deregulated environment of power systems, transmission lines are to be utilized more efficiently than before, because power transaction has become more frequent in the system. Under these circumstances, knowing power transfer capability of transmission lines is of great importance. We determine power transfer capability between the selected areas of a given power system using power-flow solution. The area is a section of a large power system or power system of one power. Our thesis presents to maximize power transfer between specific generator(s) and load(s) without affecting system security. The maximizing power transfer is limited by the system security constraint. The system security constraints are power flow equations and system operation limits. The system security constraints make the maximizing power transfer rather challenging.

Another essential problem is that the power transfer capability must be calculated at high speed with reliable accuracy. The combination of speed and accuracy make the determination of power transfer capability more complex. In addition, the ability to determine power transfer capability accurately provides essential information for all transmission providers of energy market. In today's deregulated environment, transmission lines tend to be more stressed because of increasing power transactions between areas.

1.3. GOAL OF THESIS

The primary goal of this thesis is to determine the power transfer capability of the transmission lines that are of interest. Developing the power-flow program is one of the important part our thesis. We intend to increase converge speed of the power-flow program. Therefore, we have developed very compact and quite efficient codes for computation of power-flow analysis. In particular, the Jacobian matrix is constructed using techniques of sparse matrices. In addition, we aim to develop the power-flow program in a modular way so that the program is easily expandable with new applications when necessary.

1.4. METHODOLOGIES

Power flow analysis is a very essential and fundamental tool for the analysis of any power system as it is used in the planning, operating and controlling. To determine power transfer capability, we develop the software program of power-flow using MATLAB. We perform power-flow calculations under changing the injected bus power. The power-flow program, which we have developed, is a general one that can find the power-flow solutions of a given power system independent from the number of buses. However, for the determination of transfer capability, we basically focus on two power systems; one is the 20-bus IEEE system and the other is the 225-bus system of Istanbul Region. The steps of the power-flow program are summarized as follows: initially, the file of the power-flow data given in IEEE common format is read; then, it is converted to MATLAB format in a MATLAB function file. In this way, all necessary data are easily accessible by MATLAB codes. As known, the bus numbers of a power system are, in general, arbitrary numbers. We call these numbers external numbers. However, we convert them into internal ones, which are consecutive numbers. Conversion from external bus numbers to internal bus numbers is executed by our program. Subsequently, the program builds the Y_{bus} matrix, using network information. Note that the Y_{bus} matrix is the one that connects the vector of bus voltages to the vector of bus injection currents.

We know that the power-flow is a nonlinear problem. The power-flow problem requires the solution of a large set of nonlinear equations for bus voltages and bus phase angles. Nonlinear problems are usually solved through a process of linearization and iterative methods. Our power-flow solutions provided by the program are based on the Newton-Raphson iterative solution method. The main purpose to use Newton-Raphson method here is that it has good converge characteristics. The Newton-Raphson method for power-flow solutions starts iterations with an initial guess; that is, all voltage magnitudes and voltage angles are set to 1.0 per unit and zero degrees, respectively. In solving power-flow equations, tolerance is taken as 0.001 per unit of power mismatch. As a part of the Newton-Raphson method, the program constructs the Jacobian matrix, which results from linearization of nonlinear power-flow equations. The Jacobian matrix gives the linearized relationship between small changes in voltage angle and voltage magnitude with the small changes in real and reactive power. After finding solution at each iteration, the program checks the tolerance if acceptable with calculating power mismatches. In case that tolerance is acceptable, then calculated reactive power of each generator is checked whether it is within upper and lower limits. When the generator reactive limit is reached, the load bus will be changed into a generator bus. The columns and rows of the Jacobian matrix that are corresponding to this generator bus are deleted, since, the voltage magnitude of the generator bus is known. Throughout the program, this process continues until the convergence reach the within the required tolerance. Also, note that methods of sparse matrices and the vectorized version of power-flow are utilized. Thus, significant reduction in computation time is observed at the power-flow program that we have developed.

The power-flow solution is obtained at the end of these computations. Obtaining the power-flow solution is essential task for our scenarios. Based on our scenarios, power transfer is expressed between two areas or buses. We select two buses; at one of which power is injected and the other one, power is demanded.

First, we take an initial value to formulate our solution algorithm. This value is set to zero. After selecting the candidate buses, we give a value of amount of increment. Now, the initial value equals to the value of amount of increment. We start with this current value. The current value is added to the generator bus and the load bus. The power-flow program is run for this case. We obtain new values for each incremental change. These incremental changes are added to the generator and load bus. In fact, we increase generation at the generator bus and the demand at the load bus gradually. However, for each incremental change the power-flow program is performed to get power flow solutions. The process of running the power-flow under incremental changes accomplish iteratively. The new value of the incremental changes is extracted from the old value of the incremental changes. In this way, the power transfer capability of regarding buses is obtained. We continue to increase amount of power until the power-flow solution does not exist. Therefore, the maximum power transfer capability is exceeded. In summary, we increase the amount of the power gradually from the base case until a point corresponding to the maximum transferable power. The amount of the increment is specified before power-flow calculations are performed. The smaller the amount of the increment is the more accurate the determination of the transfer capability is. However, the more accurate calculations result in time-consuming computations. In many cases, estimating the transfer capability roughly might be good enough.

1.5. RELEVANT LITERATURE

H. P. ST. Clair's paper was the first essay conception of loadings which can be expected of modern transmission line [Clair 1953]. He has made premium beneficence in illustrating the basis for normal and heavy-loading curves and extension showing the kilovar and ampere characteristics of such loaded transmission lines. He gives number of fundamental instruments which limit or calculation of a transmission line. Then, St.Clair's results were confirmed and lengthened from a more conjectural basis [Dunlop, et. al., 1979]. The earlier fast calculations of power transfer capacity using power flow solution and linear programming techniques is used by [Landgren, et. al., 1972], [Landgren and Anderson, et. al., 1973], [B.Scott, et. al., 1979], [Garver, et. al., 1979], [Sauer 1981].

The concept of determination of power system capability is defined in North American Electric Reliability Council [NERC 1995], [NERC 1996]. NERC leads to new definitions and creates a common terminology to determine power transfer capability for electric industry. NERC has been careful to distinguish the word "capacity" from the world "capability" [Sauer 1997]. These terms are ATC, TTC, TRM, CBM and ETC. According to NERC, ATC is a measure of the transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses, Total Transfer Capacity (TTC) is defined as amount of electric power that can be transferred over the interconnected transmission network in reliable manner while meeting all of a specific set of define pre- and post- contingency system conditions, Transmission Reliability Margin (TRM) is defined as that amount of transmission transfer capability necessary to ensure that the interconnected transmission network is secure under a reasonable range of uncertainties in system conditions, Capacity Benefit Margin (CBM) is defined as that amount of transmission transfer capacity reserved by load serving entities to ensure access to generation from interconnected system to meet generation reliability requirements, Existing

Transmission comments (ETC) is described sum of existing transmission commitments (which includes retail customer service) [NERC 1996]. In addition, First Contingency Total Transfer Capability (FCTTC) and First Contingency Incremental Transfer capability (FCITC) is described NERC's Transfer Capability reference document. The FCTTC was defined to be the amount of electric power, incremental above normal base power transfer [NERC 1995]. The FCTTC was defined to be total amount of electric power (normal base power transfers plus FCITC) that can be transferred between two areas satisfying the above criteria [NERC 1995]. Available transfer capacity is expressed mathematically as follows:

$$ATC = TTC- TRM- ETC-CBM \quad \textbf{(1.1)}$$

''In order to obtain ATC, the total transfer capability (TTC) should be evaluated first where TTC is the largest flow through selected interfaces or corridors of the transmission network which causes no thermal overloads, voltage limit violations, voltage collapse or any other system problems such as transient stability'' [Shaaban, Ni, Wu, 2000].

Power Systems Engineering Research Center prepared a document which is called Electric Power Transfer Capability: Concept, Applications, Sensitivity, Uncertainly [Dabson, et. al, 2001]. The goals of this document are to give some concepts and determination of power transfer capability. This document proposes to give a resource introduction to some standard transfer capability concepts and leads to some new methods in power transfer capability.

Voltage stability has become one of the essential problems in the power transfer capability related issues. In general terms, voltage stability is defined that "voltage stability is the ability of a power system to maintain steady acceptable voltages all buses in the system under normal operating conditions and subjected to a disturbance" [Kundur 1993, p27]. Phabha Kundur goes on to say, "the main factor causing instability is the inability of the power system to meet demand for reactive power and the heart of the problem is usually the voltage drop that occurs when active power and reactive power flow through the inductive reactance associated with the transmission network" [Kundur 1993, p27]. "Other factors contributing to voltage stability are the generator reactive power limits, the characteristics of load, the characteristics of reactive power compensation devices and the action of the voltage control devices" [Cutsem and Vournas 1998]. The dynamic power system analyses have been extensively investigated. The book suggests dynamic models to the power system tools and means to analysis the stability of it. [Andersen and Fouad 2008]. All aspects of modern complex power system control and stability issues filled in [Iliç and Zaborszky 2000].

The maximum power transfer limits amount of reactive power. This resource is about understanding fundamental of voltage phenomena and reactive power issues [Taylor 1994]. In addition, the reactive power has both negative and positive impact of power system. The reactance of transmission lines causes the reducing of power transfer capability. Transfer of the reactive power is difficult because the reactive power must flow from the source to the load. Thus, this action serves to increase reactive losses. The bulk of information which is discussed reactive power issues is available in book [Miler and Malinowski 1993].

1.6. THESIS OUTLINE

The thesis comprises three chapters. It is organized as follows. In the current chapter, we first present general background information about determination of power system transfer capability. Then we state our research problem. After we review the objectives for conducting this research, we explain our relevant literature.

The second part is concerned with presentation of classical power flow analysis of the given system. We obtain the calculation of power flows and voltages of a transmission network for specified terminal or bus conditions. Such calculations are required for the determination of the power system transfer capability.

The third part is concerned with computing the power system transfer capability. In this chapter, we present all our results on according to own scenario.

2. REVIEW OF POWER-FLOW ANALYSIS

2.1. INTRODUCTION

There are many types of analysis regarding planning, operations and controls of power systems. One of them, which is the most common one, is the power-flow analysis. It is also called load-flow analysis in former power engineering literature. Power-flow is a major issue for power systems; it is of great importance in planning the future expansion of power systems as well as in determining the best operation of existing systems. The information we obtain from power-flow studies is magnitude and phase angle of the voltage at each bus and real and reactive power flow in each line.

The power-flow problem is characterized by depending on these four variables. The four variables are associated with at each bus active power flow *P*, reactive power flow *Q,* bus voltage magnitude *V,* and phase angle of voltage δ. These parameters are applied to solve power-flow equations. In particular, the power-flow calculation is based on Kirchoff's law. Resulting from Kirchoff's voltage and Kirchoff's current law the sum of the power entering at a bus or node is zero. In fact, the power at the each bus must be conserved. It is well known that the power consists of real and reactive components. The *power-flow equations* are given by

$$0 = \Delta P_i = P_i - V_i \sum_{j=1}^{n} V_i Y_{ij} \cos(\theta_i - \theta_j - \phi_{ij}) \quad \textbf{(2.1)}$$

$$0 = \Delta Q_i = Q_i - V_i \sum_{j=1}^{n} V_j Y_{ij} \sin(\theta_i - \theta_j - \phi_{ij}) \quad \textbf{(2.2)}$$

$$i = 1, \ldots\ldots, n$$

where P_i , Q_i are the nodal active and reactive power injected at the bus *i* respectively. The values of V_i and V_j are nodal voltage at bus *i* and bus *j*. The $Y_{ij} \angle \phi_{ij}$ represents the $(ij)^{th}$ element of the nodal admittance matrix Y_{bus}. The constant *n* is also number of the buses in system or *n*-dimensional system. All the currents, voltages, real and reactive powers are stated as complex variables.

The power-flow problem is a nonlinear problem. The power-flow is therefore expressed as a set of nonlinear algebraic equations. Iterative techniques are needed to solve the set of nonlinear algebraic equations. Iterative techniques convert nonlinear power-flow equations to a linear form before a solution is attempted. There are two the most common iterative methods solve the power-flow equations such as Gauss-Seidel method and Newton-Raphson method. Both of them have some advantages and disadvantages. The Gauss-Seidel iterative method simply presents [Scott.B 1974] and the Newton-Raphson method introduced in [Tinney.W.F and Hart.C.E 1969]. We use the Newton-Raphson method for our study.

2.2. POWER-FLOW PROBLEM

Before the describing the problem, we need to explain some considerations about the power-flow problem. The important component that is necessary for power-flow analysis is the nodal admittance matrix, ***Y***. The nodal admittance matrix defines the form of nodal voltages to nodal current injections. The system array is based on expressing Ohm's Law to a vector of the voltage and current values

$\hat{V} = \begin{bmatrix} V_1 \\ V_2 \\ . \\ . \\ V_n \end{bmatrix}$ and $\hat{I} = \begin{bmatrix} I_1 \\ I_2 \\ . \\ . \\ I_n \end{bmatrix}$, with V and I representation the complex value of bus voltage and current. The system can be characterized as

$$\hat{I} = \boldsymbol{Y}\hat{V} \qquad \textbf{(2.3)}$$

where ***Y*** is a $n \times n$ matrix. The formulation in equations in (2.1) and (2.2) are known *polar* form of the power-flow equations. The element of Y can be represented *rectangular* form for (complex) admittance such as $Y_{ij} = G_{ij} + jB_{ij}$. The power-flow equations can be rewritten with real and imaginary components of nodal admittance matrix:

$$P_i - V_i \sum_{j=1}^{n} V_j (G_{ij} \cos(\theta_i - \theta_j) + B_{ij} \sin(\theta_i - \theta_j)) = 0 \quad \textbf{(2.4)}$$

$$Q_i - V_i \sum_{j=1}^{n} V_j (G_{ij} \sin(\theta_i - \theta_j) - B_{ij} \cos(\theta_i - \theta_j)) = 0 \quad \textbf{(2.5)}$$

We have already known that the power-flow is a nonlinear problem. Power-flow equations for steady-state operation of the system are nonlinear algebraic equations. They are nonlinear with the voltage and phase angle. Introduction of *P* and *Q* also produces a set of nonlinear equations. Accordingly, the power-flow problem has *2n* nonlinear algebraic equations in *2n* unknowns for an *n*-bus power system. The solution of this problem requires numerical solutions, since the equations are multivariable and nonlinear.

In solving a power-flow problem, the system buses are generally classified into three types. The first type is a *load bus*, also called a *PQ* bus. At load buses, the real and reactive power injections are specified or known; the magnitude and phase angle of the bus voltages are unknowns. At each bus of this type, the equation is written which corresponds to the real power injection and the other one to the reactive power injection. The specified complex power injection at the bus *i* is expressed in terms of the current injected into the bus and the bus voltage phasor, respectively.

$$S_i^{specified} = P_i^{specified} + jQ_i^{specified} \quad \textbf{(2.6)}$$

$$S_i = P_{G_i} - P_{L_i} + j(Q_{G_i} - Q_{L_i}) = V_i I_i^* \quad \textbf{(2.7)}$$

The second type is a *generator bus*, also called a *PV* bus. At these buses, the real bus power and the voltage magnitude are specified. The reactive power and phase angle of the voltage is unknown.

$$P_i^{specified} = P_{G_i} - P_{L_i} \quad \textbf{(2.8)}$$

$$|V_i| = V_i^{specified} \quad \textbf{(2.9)}$$

The generators constrained to operate within their power generation capabilities. The reactive power generation is able to support the bus voltage; that is, the reactive power stays within operating limits. Otherwise, the bus voltage is allowed to seek its proper bus voltage value. With these new estimates of the bus voltage, the process proceeds to the next iteration. At the end of each iteration, the reactive power output of generator bus is checked and if it falls within acceptable limits the bus is converted into a generator bus. We know that any generators violating their reactive power limit are considered as a load bus. These iterations are repeated until the power injected errors of all the buses are within specified tolerance, and all the generators are satisfying their generator limits.

Third type is *swing bus* or *slack bus*. At a swing bus, voltage magnitude and phase angle of voltage are specified. In real power systems have no swing bus and it is always accepted a fictitious idea. It is selected an arbitrary generator bus as a swing bus and we do not know its real power injection. In fact, we can not specify the real power injected at every bus. The real power generation can be expected to supply the difference between total system load and plus estimating of I^2R losses and total injected real power fixed at the generator bus. The system losses are not known until the final solution is calculated. Voltage angle of the swing bus is chosen as a reference phasor. Voltage magnitude is always taken 1.0 per unit and its angle is 0^o .

$$|V_{swing}| = 1.0\,pu \quad \textbf{(2.10)}$$

$$\delta_{swing} = 0^o \quad \textbf{(2.11)}$$

2.3. CONSTRUCTING THE ADMITTANCE MATRIX

All of the system interconnections between nodes are combined into a single matrix known as the $\boldsymbol{Y}_{BUS}$ or bus admittance matrix. Represent of bus admittance matrix plays an important role in power-flow problem. We use the Norton's Theorem to represent of the $\boldsymbol{Y}_{BUS}$ matrix. The circuit has the voltage source V_s with a source (series) impedance of $Z_{s.}$ Using Norton's Theorem this equivalent circuit are modeled by a current source I_s with a parallel admittance of Y_s as shown in Figure 2.1.

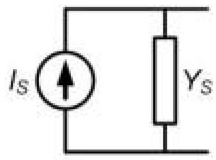

Figure 2.1
Resource: http://nptel.iitm.ac.in

Converting series impedance to series admittance is given by:

$$Y_S = \frac{1}{R + jX} = \frac{1}{Z_S} \tag{2.12}$$

As we know that a power system has many different components such as generators, transmission lines, transformers, loads and circuit breakers. Thus, *one-line* or *single-line* diagram is very fashionable method to represent three phase power system by a single phase power system. To explain the basic concept of bus admittance matrix, a power system representing one-line diagram of four buses is shown in Figure 2.2. A generator is connected each of first two buses, and an electrical load is connected to the third and four buses.

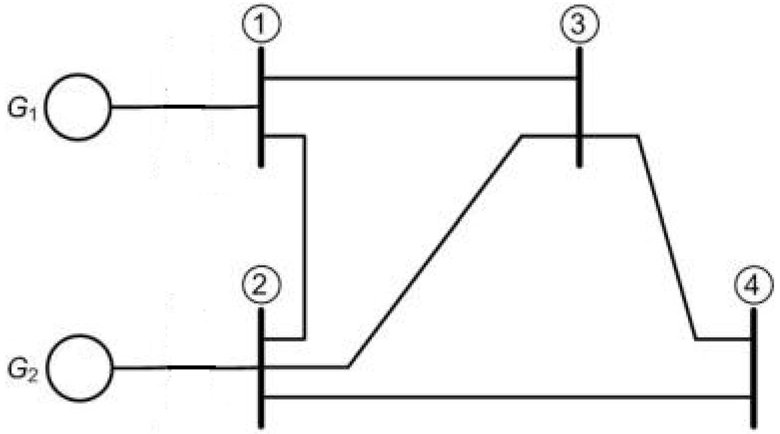

Figure 2.2
Resource: http://nptel.iitm.ac.in

Kirchhoff's current law is applied to each node of the network of Figure 2.2 describing with the sum of current into a node equals the sum of current out of the node.

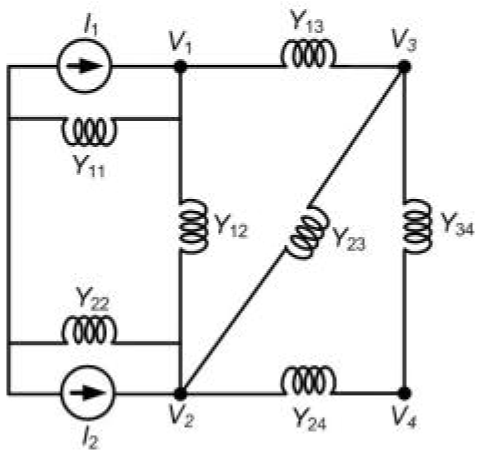

Figure 2.3
Resource: http://nptel.iitm.ac.in

The figure 2.3 is called the system admittance diagram. The nodal formulations of Kirchhoff's current law for four bus system of Figure 2.3 are calculated as follows:

$$\begin{aligned} I_1 &= Y_{11}V_1 + Y_{12}(V_1 - V_2) + Y_{13}(V_1 - V_3) \\ I_2 &= Y_{22}V_2 + Y_{12}(V_2 - V_1) + Y_{23}(V_2 - V_3) + Y_{24}(V_2 - V_4) \\ 0 &= Y_{13}(V_3 - V_1) + Y_{23}(V_3 - V_2) + Y_{34}(V_3 - V_4) \\ 0 &= Y_{24}(V_4 - V_2) + Y_{34}(V_4 - V_3) \end{aligned} \qquad \textbf{(2.13)}$$

These equations can be expressed,

$$\begin{aligned} I_1 &= (Y_{11} + Y_{12} + Y_{13})V_1 - Y_{12}V_{12} - Y_{13}V_3 \\ I_2 &= -Y_{12}V_1 + (Y_{22} + Y_{12} + Y_{23} + Y_{24})V_2 - Y_{23}V_3 - Y_{24}V_4 \\ 0 &= -Y_{13}V_1 - Y_{23}V_2 + (Y_{13} + Y_{23} + Y_{34})V_3 - Y_{34}V_4 \\ 0 &= -Y_{24}V_2 - Y_{34}V_3 + (Y_{24} + Y_{34}) \end{aligned} \qquad \textbf{(2.14)}$$

The above four equations can be written in matrix form as:

$$\begin{bmatrix} I_1 \\ I_2 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} Y_{11} + Y_{12} + Y_{13} & -Y_{12} & -Y_{13} & 0 \\ -Y_{12} & Y_{22} + Y_{12} + Y_{23} + Y_{24} & -Y_{23} & -Y_{24} \\ -Y_{13} & -Y_{23} & Y_{13} + Y_{23} + Y_{34} & -Y_{34} \\ 0 & -Y_{24} & -Y_{34} & Y_{24} + Y_{34} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix} \qquad \textbf{(2.15)}$$

Hence, the bus admittance matrix is assembled as follows:

$$\mathbf{Y}_{\mathrm{BUS}} = \begin{bmatrix} Y_{11} + Y_{12} + Y_{13} & -Y_{12} & -Y_{13} & 0 \\ -Y_{12} & Y_{22} + Y_{12} + Y_{23} + Y_{24} & -Y_{23} & -Y_{24} \\ -Y_{13} & -Y_{23} & Y_{13} + Y_{23} + Y_{34} & -Y_{34} \\ 0 & -Y_{24} & -Y_{34} & Y_{24} + Y_{34} \end{bmatrix} \qquad \textbf{(2.16)}$$

For a large scale system, it might need hundreds of elements to form $\mathbf{Y}_{\mathrm{BUS}}$ matrix. Thus, full admittance matrix can be extended as:

$$
\begin{bmatrix} I_1 \\ I_2 \\ \vdots \\ I_i \\ \vdots \\ I_n \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} & \cdots & Y_{1i} & \cdots & Y_{n} \\ Y_{21} & Y_{22} & \cdots & Y_{2i} & \cdots & Y_{2n} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ Y_{i1} & Y_{i2} & \cdots & Y_{ii} & \cdots & Y_{in} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ Y_{n1} & Y_{n2} & \cdots & Y_{ni} & \cdots & Y_{nn} \end{bmatrix} \qquad \textbf{(2.17)}
$$

The relation between the injected bus currents and the bus voltages is given by

$$
\mathbf{I}_{BUS}=\mathbf{Y}_{BUS}\mathbf{V}_{BUS} \qquad \textbf{(2.18)}
$$

where I_{BUS} is vector of injected bus currents and V_{BUS} is vector of the bus voltages. $\mathbf{I}_{BUS}$ matrix is a type of source current vector that injects a current that accounts for generation less load at the each of the *n* system buses. $\mathbf{Y}_{BUS}$ matrix contains all transformers and transmission lines network information. In addition, $\mathbf{Y}_{BUS}$ matrix is described as symmetric. Y_{ii} is sum of the primitive admittances of all components connected to *ith* bus. It is called self-admittance (diagonal terms). Y_{ij} is the negative of primitive admittance of all directly connected between buses *i* and *j*. It is also called mutual admittance (off-diagonal terms). These are also called transfer admittance.

Another important characteristic of $\mathbf{Y}_{BUS}$ is that elements in the matrix are zero unless have a direct connection. Large scale power systems have many buses and few lines to each bus. If we have more than zero elements in $\mathbf{Y}_{BUS}$ matrix, it is defined a *sparse matrix.* $\mathbf{Y}_{BUS}$ matrix is highly sparse matrix. A matrix is called sparse if it has less than 15% nonzero elements [Gross,1976].

2.4. TAP TRANSFORMERS

The tap transformers or tap changing transformers are required in power system to regulate active and reactive power flow. The value of a transformer rated voltage may not match to the system voltage hence it is necessary to supply a desired voltage to the certain load. In the modeling of power systems, tap ratios and phase shifts are represented as alternations to the network admittance matrix. A transformer with turn ratio t connected to nodes i and j is represented by the ideal transformer and the transformer leakage admittance as Figure 2.4.

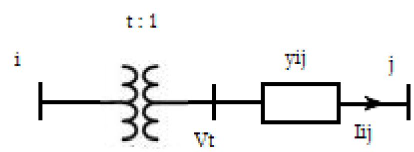

Figure 2.4
Resource: Arrillaga and Arnold, 1990

We assume that the transformer is on nominal tap (τ = 1), the node-voltage equations for the circuit are

$$I_{ij} = y_{ij}V_i - y_{ij}V_j$$
$$I_{ji} = y_{ij}V_j - y_{ij}V_i \quad \textbf{(2.19)}$$

In this case, $I_{ij} = -I_{ji}$

We can write the node-voltage equations for off-nominal tap

$$V_t = \frac{V_i}{\tau}$$
$$I_{ji} = y_{ij}(V_j - V_t) \quad \textbf{(2.20)}$$
$$I_{ij} = -\frac{I_{ji}}{\tau}$$

Manipulating V_t between equations (2.19) and (2.20) we rewrite

$$I_{ji} = y_{ij}V_j - \frac{y_{ij}}{\tau}V_i$$

$$I_{ij} = -\frac{y_{ij}}{\tau}V_j + \frac{y_{ij}}{\tau^2}V_i \quad \textbf{(2.21)}$$

2.5. BACKROUND ON NEWTON-RAPHSON METHOD

The Newton-Raphson method converges most rapidly of any of the power flow solution techniques. It has excellent converge characteristic. The Newton-Raphson method is to solve a set of nonlinear equations in an equal number of unknowns. This method solves the each iteration for perturbed variables and the nonlinear equations are approximated by the linear equations. According to the method, a state vector is computed by the Newton-Raphson iteration. The current state vector and elements of Jacobian matrix terms are predicted and subtracted from the residual vector. The recalculating residual vector is required to compute a new state vector. This process is repeated until the solution converges is within specific tolerance. It is important remark that the performance of the Newton-Raphson method is related with the degree of problem nonlinearity.

To find out the Newton's method considers the equation:

$$f(x) = 0 \quad \textbf{(2.22)}$$

where f is vector equation of the vector unknown variables x. A function can be estimated in a neighborhood using the Taylor's series expansion. The Newton-Raphson method uses first two terms of the Taylor's series. The function of $f(x)$ is expressed by Taylor's series at point x^0 as follows:

$$f(x) = f(x^0) + \frac{1}{1!}\frac{df(x^0)}{dx}(x - x^0) + \frac{1}{2!}\frac{df^2(x^0)}{dx^2}(x - x^0)^2 + \cdots\cdots \quad \textbf{(2.23)}$$

Our first estimate of the unknown is calculated by neglecting the series after the first derivative. We write to:

$$x^1 = x^0 - \frac{f(x^0)}{\frac{df(x^0)}{dx}} \quad \textbf{(2.24)}$$

We generalized the above equation with a recursion formula:

$$x^{k+1} = x^k - \frac{f(x^k)}{\frac{df(x^k)}{dx}} \quad \textbf{(2.25)}$$

Streamline the function as follows:

$$f(x^k) = f^k$$
$$\frac{df(x^k)}{dx} = f_x^k \quad \textbf{(2.26)}$$

Finally we obtain to:

$$x^{k+1} = x^k - \frac{f^k}{f_x^k} \quad \textbf{(2.27)}$$

Now, we rewrite the Newton Raphson method to two equations in two variables

$$f(x, y) = 0$$
$$g(x, y) = 0 \quad \textbf{(2.28)}$$

The functions of $f(x, y)$ and $g(x, y)$ developed by Taylor's series about a point x^k and y^k.

$$f(x, y) = f^k + \frac{1}{1!}\frac{\partial f(x^k, y^k)}{\partial x}(x - x^k) + \frac{1}{1!}\frac{\partial f(x^k, y^k)}{\partial y}(y - y^k) + \cdots \quad \textbf{(2.29)}$$

$$g(x, y) = g(x^k, y^k) + \frac{1}{1!}\frac{\partial g(x^k, y^k)}{\partial x}(x - x^k) + \frac{1}{1!}\frac{\partial g(x^k, y^k)}{\partial y} + \cdots \quad \textbf{(2.30)}$$

Simplify the notation as follows:

$$f(x^k, y^k) = f^k$$
$$g(x^k, y^k) = g^k \qquad \textbf{(2.31)}$$

$$\frac{\partial f(x^k, y^k)}{\partial x} = f_x^k$$
$$\frac{\partial f(x^k, y^k)}{\partial y} = f_y^k \qquad \textbf{(2.32)}$$

$$\frac{\partial g(x^k, y^k)}{\partial x} = g_x^k$$
$$\frac{\partial g(x^k, y^k)}{\partial y} = g_y^k \qquad \textbf{(2.33)}$$

$$\Delta x = x - x^k$$
$$\Delta y = y - y^k$$
$$\Delta f = f - f^k$$
$$\Delta g = g - g^k \qquad \textbf{(2.34)}$$

Thus, we obtain from the equations (2.29), (2.30)

$$\Delta f = f_x^k \Delta x + f_y^k \Delta y$$
$$\Delta g = g_x^k \Delta x + g_y^k \Delta y \qquad \textbf{(2.35)}$$

We rewrite the equation (2.35) in a matrix form

$$\begin{bmatrix} \Delta f \\ \Delta g \end{bmatrix} = \begin{bmatrix} f_x^k & f_y^k \\ g_x^k & g_x^k \end{bmatrix} \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix} \qquad \textbf{(2.36)}$$

The above coefficient matrix is called Jacobian matrix. Alternatively, it is expressed

$$\begin{bmatrix} \Delta f \\ \Delta g \end{bmatrix} = \begin{bmatrix} J^k \end{bmatrix} \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix} \quad \textbf{(2.37)}$$

Firstly, we solve the equation (2.37) for *k*th iteration. We wish to do $f = 0$ and $g = 0$

We compute

$$\Delta f^k = 0 - f^k$$
$$\Delta g^k = 0 - g^k \quad \textbf{(2.38)}$$

We need to obtain Δx^k and Δy^k. We apply the equation (2.37) for the solution

$$\begin{bmatrix} \Delta x^k \\ \Delta y^k \end{bmatrix} = \begin{bmatrix} J^k \end{bmatrix}^{-1} \begin{bmatrix} \Delta f^k \\ \Delta g^k \end{bmatrix} \quad \textbf{(2.39)}$$

We set the estimated value for *x* and *y* to:

$$x^{k+1} = x^k + \Delta x^k$$
$$y^{k+1} = y^k + \Delta y^k \quad \textbf{(2.40)}$$

We now solve the equation (2.37) for (*k*+1) iteration. As we know, there are 2*n* equations and 2*n* unknowns to solve. We start to prepare the equations for power flow problem.

$$f_i(\hat{x}, \hat{y}) = 0; i = 1, 2, \ldots n \quad \textbf{(2.41)}$$

$$g_i(\hat{x}, \hat{y}) = 0; i = 1, 2, \ldots n \quad \textbf{(2.42)}$$

where the unknown $\hat{x}$ and $\hat{y}$ vectors are represented:

$$\hat{x} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} \text{ and } \hat{y} = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} \quad \textbf{(2.43)}$$

The equation (2.36) is modified for $2n$ variables as follows:

$$\begin{bmatrix} \Delta f_1^k \\ \Delta f_2^k \\ \vdots \\ \Delta f_n^k \\ \\ \Delta g_1^k \\ \Delta g_2^k \\ \vdots \\ \Delta g_n^k \end{bmatrix} = \begin{bmatrix} \frac{\partial f_1^k}{\partial x_1} & \cdots & \frac{\partial f_1^k}{\partial x_n} & \frac{\partial f_1^k}{\partial y_1} & \cdots & \frac{\partial f_1^k}{\partial y_n} \\ \vdots & & \vdots & \vdots & & \vdots \\ \frac{\partial f_n^k}{\partial x_1} & \cdots & \frac{\partial f_n^k}{\partial x_n} & \frac{\partial f_n^k}{\partial y_1} & \cdots & \frac{\partial f_n^k}{\partial y_n} \\ \\ \frac{\partial g_1^k}{\partial x_1} & \cdots & \frac{\partial g_1^k}{\partial x_n} & \frac{\partial g_1^k}{\partial y_1} & \cdots & \frac{\partial g_1^k}{\partial y_n} \\ \vdots & & \vdots & \vdots & & \vdots \\ \frac{\partial g_n^k}{\partial x_1} & \cdots & \frac{\partial g_n^k}{\partial x_n} & \frac{\partial g_n^k}{\partial y_1} & \cdots & \frac{\partial g_n^k}{\partial y_n} \end{bmatrix} \begin{bmatrix} \Delta x_1^k \\ \Delta x_2^k \\ \vdots \\ \Delta x_n^k \\ \\ \Delta y_1^k \\ \Delta y_2^k \\ \vdots \\ \Delta y_n^k \end{bmatrix} \tag{2.44}$$

Alternatively,

$$\begin{bmatrix} \Delta\hat{f}^k \\ \Delta\hat{g}^k \end{bmatrix} = \begin{bmatrix} J_{fx}^k & J_{gx}^k \\ J_{gx}^k & J_{gy}^k \end{bmatrix} \begin{bmatrix} \Delta\hat{x}^k \\ \Delta\hat{y}^k \end{bmatrix} \tag{2.45}$$

Then, we can easily find $\Delta\hat{x}$ and $\Delta\hat{y}$ from (2.45):

$$\begin{bmatrix} \Delta\hat{x}^k \\ \Delta\hat{y}^k \end{bmatrix} = \left[J^k \right]^{-1} \begin{bmatrix} \Delta\hat{f}^k \\ \Delta\hat{g}^k \end{bmatrix} \tag{2.46}$$

2.6. POWER-FLOW SOLUTION BY NEWTON-RAPHSON

In general, the Newton-Raphson method is defined in section 2.5. We now need to apply this method to power flow problem. We describe:

$$\hat{x} = \hat{\delta}$$
$$\hat{y} = \hat{V} \tag{2.47}$$

The solution of the Newton-Raphson method is employed, in each iteration, it is required to calculate

$$\mathbf{J}\begin{bmatrix}\Delta\delta \\ \Delta V\end{bmatrix} = \begin{bmatrix}\Delta P \\ \Delta Q\end{bmatrix} \tag{2.48}$$

where

$$\Delta P = P^{sch} - P^{cal}$$
$$\Delta Q = Q^{sch} - Q^{cal} \tag{2.49}$$

In this equation ΔP and ΔQ are called real power reactive power mismatches or power difference, between the calculated power values, as functions of voltage and phase angle, and the actual injected powers. The formulation of mismatch equations is also defined the equations (2.1) and (2.2). The Newton-Raphson iteration checks, this mismatch are became zero until the power leaving a bus, computed from the voltages and phase angles, equals the injected power.

In Newton-Raphson method, elements of the Jacobian matrix are calculated from standard expressions, which are functions of bus voltage, bus real and reactive powers and the elements of bus admittance matrix. The diagonal and off-diagonal elements of the four submatrixes are computed from different expressions, which do not have physical significance as follows:

$$\mathbf{J}=\begin{bmatrix} J_1 & J_2 \\ J_3 & J_4 \end{bmatrix}=\begin{bmatrix} \frac{\partial \Delta P}{\partial \delta} & \frac{\partial \Delta P}{\partial V} \\ \frac{\partial \Delta Q}{\partial \delta} & \frac{\partial \Delta Q}{\partial V} \end{bmatrix} \quad \textbf{(2.50)}$$

Each submatrix shows the partial derivates of each of the mismatch equations with respect to each of the unknowns. The following eight type partial derivatives are required to construct the Jacobian matrix. These partial derivates have two mismatch equations. One of them is for diagonal element and second element is off-diagonal elements. The entry *i-j* of the Jacobian exists only if there is a branch connecting buses *i* and *j* . Note that the angles are given in *radians* and not degrees.

$$\frac{\partial f_i}{\partial x_i}=\frac{\partial \Delta P_i}{\partial \delta_i}=V_i\sum_{j=1}^{n}V_jY_{ij}\sin(\delta_i-\delta_j-\phi_{ij})+V_i^2Y_{ii}\sin\phi_{ii} \quad \textbf{(2.51)}$$

$$\frac{\partial f_i}{\partial x_j}=\frac{\partial \Delta P_i}{\partial \delta_j}=-V_iV_jY_{ij}\sin(\delta_i-\delta_j-\phi_{ij}) \quad \textbf{(2.52)}$$

$$\frac{\partial f_i}{\partial y_i}=\frac{\partial \Delta P_i}{\partial V_i}=-\sum_{i=1}^{n}V_jY_{ij}\cos(\delta_i-\delta_j-\phi_{ij})-V_iY_{ii}\cos\phi_{ii} \quad \textbf{(2.53)}$$

$$\frac{\partial f_i}{\partial y_j}=\frac{\partial \Delta P_i}{\partial V_j}=-V_iY_{ij}\cos(\delta_i-\delta_j-\phi_{ij}) \quad \textbf{(2.54)}$$

$$\frac{\partial g_i}{\partial x_i}=\frac{\partial \Delta Q_i}{\partial \delta_i}=-V_i\sum_{j=1}^{n}V_jY_{ij}\cos(\delta_i-\delta_j-\phi_{ij})+V_i^2Y_{ii}\cos\phi_{ii} \quad \textbf{(2.55)}$$

$$\frac{\partial g_i}{\partial x_j}=\frac{\partial \Delta Q_i}{\partial \delta_j}=V_iV_jY_{ij}\cos(\delta_i-\delta_j-\phi_{ij}) \quad \textbf{(2.56)}$$

$$\frac{\partial g_i}{\partial y_i}=\frac{\partial \Delta Q_i}{\partial V_i}=-\sum_{j=1}^{n}V_jY_{ij}\sin(\delta_i-\delta_j-\phi_{ij})+V_iY_{ii}\sin\phi_{ii} \quad \textbf{(2.57)}$$

$$\frac{\partial g_i}{\partial y_j}=\frac{\partial \Delta Q_i}{\partial V_j}=-V_iY_{ij}\sin(\delta_i-\delta_j-\phi_{ij}) \quad \textbf{(2.58)}$$

Initializing a power-flow program, we set suitable fixed initial values for values of V and δ values. This type is referred to as the swing bus. That is, we set the voltage to 1.0 per unit and phase angle of its voltage to zero. This initialization means that there is no iteration at this type. The first estimates are then used to calculate the corrections of the variables results from the first iteration, ΔV and $\Delta\delta$. The voltage corrections ΔV and $\Delta\delta$ are then needed to compute the next estimate.

$$\begin{bmatrix} \delta^{k+1} \\ V^{k+1} \end{bmatrix} = \begin{bmatrix} \delta^{k} \\ V^{k} \end{bmatrix} + \begin{bmatrix} \Delta\delta \\ \Delta V \end{bmatrix} \tag{2.59}$$

The vectors δ^{k+1} and V^{k+1} are updated for the (k+1) iteration, δ^{k} and V^{k} are results from the previous k^{th} iteration. In other words, the first estimate of solution are entered as $\begin{bmatrix} \delta^{0} \\ V^{0} \end{bmatrix}$ and then used to first correction vector $\begin{bmatrix} \Delta\delta \\ \Delta V \end{bmatrix}$. The second iteration's estimates are thus obtain and then used to calculate the next estimates. The process is repeated until converge is obtained. The solution is generally considered converged once the correction vector becomes small enough to fall within a tolerance value set by the user.

Another important point is size of Jacobian matrix. If we show that the number voltage controller bus is n_g the Jacobian matrix is of order $(2n-2-n_g) \times (2n-2-n_g)$. We reduce the swing bus then the Jacobian matrix is of order $(2n-1-n_g) \times (2n-1-n_g)$. The submatrix of the Jacobian matrix can be 2×2, 1×2, 2×1 or 1×1.

Lastly, the basic iterative algorithm for solution power flow analysis by the Newton-Raphson method as follow:

Step 1: Form the nodal admittance matrix $\mathbf{Y}_{BUS}$

Initialize the iteration counter k = 0

Initialize voltages and angles V^k and δ^k, k=1…,n

Step 2: Calculate the current injections $\mathbf{I}_{BUS=}\mathbf{Y}_{BUS}\mathbf{V}_{BUS}$

Calculate the active reactive power mismatches equations

Calculate the Jacobian matrix

Step 3: If the max (ΔP , ΔQ) $\leq$ tolerance:

then Go to step 5

else check the residuals ΔP_k , ΔQ_k

Update the bus voltages by using equation

Step 4: If k $\geq$ maximum number of iteration

then Go to step 5

else Go to step 2

Step 5: Show the results.

3. DETERMINATION OF POWER SYSTEM CAPABILITY

3.1. OVERVIEW

The term *power transfer capability* is identified as amount of power that can be transferred over interconnected system. In other words, the transfer capability is defined as maximum power that can be transferred. Transfer capability is important to the secure of deregulated power systems as it shows physical realities of the transmission system such as buyers demand level, network configuration, generation dispatch and transfer between neighboring systems. Power transfer calculated must be quickly to predict the capability of additional power transfer.

Power transfer capability calculations are required to enhance security of large-scale power system. Determining of the acceptable the flow of power on transmission network in permitting external power generation to displace internal power generation is a conventional application for power transfer capability calculations. Thus, system modeling of the network showing the unexpected conditions is predicted. For instance, the currently change in climate or exceptional weather condition is observed and the system restructure according to specific information. In addition, the aim of the power transfer capability calculation is to establish the amount of the uncertainly in scheduled real power generation that can be displaced by the possible energy reserves and security constraints in each conditions. Due to unexpected assumptions or losses at generation sources and sinks, the calculations are updated assuming the loss of branch elements, increasing load demands and a different network configuration.

3.2. COMPUTATION OF POWER TRANSFER CAPABILITY

To need quantify power transmission capability requires computations. We start to run the power-flow program to do these computations. Then, we obtain base case power-flow solution. The base case is assumed to be a kind of operating condition. The base case power-flow solution is that amount of electric power can be transferred in a reliable manner. On the other words, the base-case condition is that there is not MW flow into interconnected power system. The operating condition is obtained by specifying the powers generated or consumed at each bus. We calculate power flow quantities such as power flows on the transmission lines, line flows, bus voltage information and other power flow in network components. Finally, the base-case solution gives us information about system security condition. Power transfer capability is adjusted by changes in any of these assumptions.

In order to calculate the power transfer capability, we choose a generator bus and a load bus. These buses are also considered as a sending area and a receiving area. The formulation of our scenarios is expressed by these individual areas. Area to area transfer from a generator bus (source) and a load bus (sink) is indicated by increasing real power generation at source and reducing at sink bus to measure the real power transfer capability. Power transfer (P) is specified by changes in power injections at buses in the transmission network. The amount of power at load bus is reduced by P MW and power at generator bus is increased by P MW. The power-flow program is run for the P value. We continue the process of adding increments to generation and load at the specific buses. If P is further increased between two areas, the power-flow solution breaks down. There is a maximum transmissible power. Thus, power transfer capability is calculated. The system exceeds the P_{max}, the power flow does not convergence specifies the power transfer capability between the particular generator and load buses. Indeed, the total increment from the base case to the current case of P provides the power transfer capability. In addition, P_{max} value also means that there is no voltage stability margin available for this transmission line to carry more power. The relation between the bus voltage and the bus power transfer through the transmission line is shown in figure 3.1

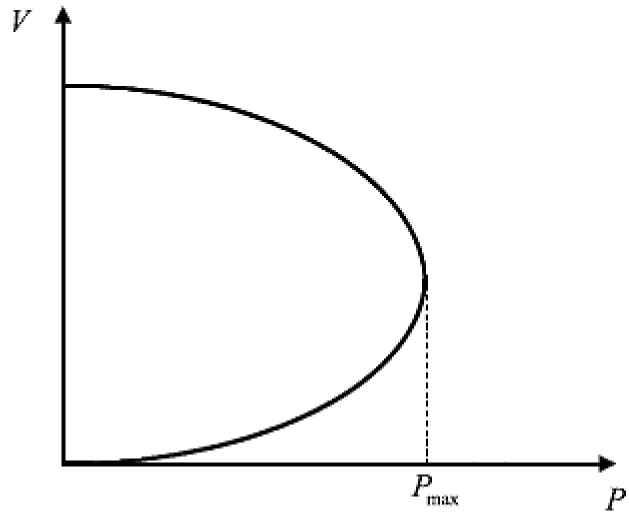

Figure 3.1
Resource: Ajjarapu.V, 2006

3.3. PROGRAMS

We have two main programs which are namely **solvepf.m** and **ptc.m** to compute power transfer capability. **solvepf.m** is the power-flow program. The power-flow program subdivides into eight functions which are namely **intrnum.m**, **extrnum.m**, **setdata.m**, **index.m**, **formYbus.m**, **nwtnpf.m**, **nwtnpf_Qlimit** and **reportpf.m.** In addition, **nwtnpf.m** and **nwtnpf_Qlimit.m** encapsulate three functions which are namely **jacobi.m**, **update.m** and **qlimit.**

The functions **jacobi_mdf.m** and **update_mdf.m** modify according to new pv and new pq buses. All the code segments are in m-files. You can see the main programs in appendix A and appendix B. If we explain shortly all of the functions:

intrnum.m: This function transforms the given external bus numbers to the consecutive internal ones that start at 1.

extrnum.m: This function transforms the consecutive internal bus numbers to the originals external ones.

setdata.m: All internal data type is defined and used to contain matrix variables. We give the name each column to use to other functions.

index.m: This function obtains the index list of swing, load and generator buses.

formYbus.m: This function builds the bus admittance matrix and branch admittance matrix. Each branch, transmission line, transformer and phase shifter are modeled as a standard π model.

nwtnpf.m: This function solves the power-flow problem using Newton-Raphson method. This program calculates the voltage magnitudes and voltage angle at each bus in a power system.

nwtnpf_ Qlimit.m: This function solves the power-flow problem using Newton-Raphson iteration with checking generator reactive power limit.

update.m: This routine updates the bus voltage.

qlimit.m: This function is for detecting generator vars outside limit. We set Q_g to zero if the limit exceeds after running the power-flow program, then we adjust to loads accordingly. The PV bus will turn into PQ bus with Qg at the limit. The program is re-run.

jacobi.m: This function calculates the Jacobian matrix of power flow using sparse matrix techniques. The change in complex power injection with bus voltage magnitudes and bus voltage angles are expressed by

$$\Delta S = V_{diag} * I_{conj} .* (\Delta V / |V_{diag}| + j\Delta\delta) + V_{diag} * Y_{conj} * V_{dconj} * (\Delta V / |V_{diag}| - j\Delta\delta)$$

$$= diag(V_{diag} * I_{conj}) * (\Delta V / |V_{diag}| + j\Delta\delta) + V_{diag} * Y_{conj} * V_{dconj} * (\Delta V / |V_{diag}| - j\Delta\delta)$$

where $V_{diag} = diag(V), V_{dconj} = conj(V_{diag}), I_{conj} = conj(I), Y_{conj} = conj(Y_{bus})$.

We now define $S_{diag} = diag(V_{diag} * I_{conj})$ and $S_x = V_{diag} * Y_{conj} * V_{dconj}$. Then, we form the Jacobian matrix:

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} -imag(S_{diag} - S_x) & real(S_{diag} + S_x) / \left| V_{diag} \right| \\ real(S_{diag} - S_x) & imag(S_{diag} + S_x) / \left| V_{diag} \right| \end{bmatrix} \begin{bmatrix} \Delta \delta \\ \Delta V_{mag} \end{bmatrix}$$

$$= \begin{bmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{bmatrix} \begin{bmatrix} \Delta \delta \\ \Delta V_{mag} \end{bmatrix}$$

$$J = \begin{bmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{bmatrix}$$

3.4. CONCLUSION

Power transfer is basic to appropriate operation of the system. There are inherent difficulties in estimating power transfer capability. We have presented power-flow calculations and simplified the computing of power transfer capability. However, the scenario in our thesis is very practical and useful. The maximum power transfer capability is computed efficiently. The result is obtained indicated that the proposed scenarios are effective. We believe that this help to identify of the transfer capability issues and would open doors to more realistic future research.

We use a 225- bus Istanbul Region interconnected system containing about 196 generators, 283 transmission lines, 28 loads, 163 transformers, 78 shunts. This data is provided by TEİAŞ. We confirm that obtaining predict values is very close to correct values of TEİAŞ.

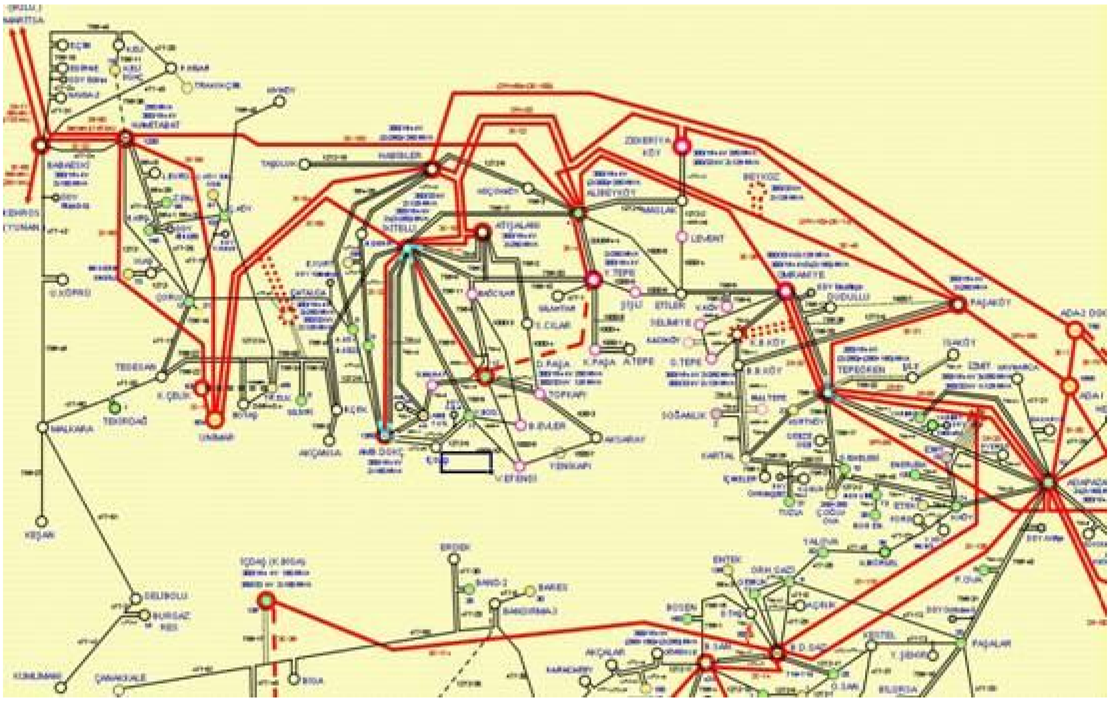

Figure 3.2
Resource: TEİAŞ

4. CONCLUSIONS

4.1. DISCUSSION OF THE RESULTS

The transfer capability computation presents a base case in which other power transfers are occurring. It is of interest how the value of these other power transfers influences the computed power transfer capability. We consider two areas to compute power transfer capability. Given a base case of the 225- bus Istanbul Region interconnected system, a proposed power transfer is described between the sending area (or bus) and receiving area. We select two arbitrary buses to discuss the our results.

Case 0

We writes command window of the Matlab to run the base case power-flow program for any IEEE data system. We perform the power-flow program in a modular way. Important reduction in solution time is observed at the programs. The solutions are shown in appendix C and appendix D.

```
>> solvepf ('istanbulm')

>> solvepf ('gr_data')
```

Case 1

We can increase the amount of power between in particular buses. Then the power flow program is recalculated for this incremental power injection. The filename represents the results of the power-flow program. The results are sent to a main folder automatically. The results are shown in appendix E.

```
>> solvepf ('istanbulm','filename', 1)

Enter the generator bus number = 214

Enter the load bus number = 189

Enter the real power increment = 100
```

Case 2

The power-flow program has an option for limit or no limit solution. If we want to obtain the no limit solution, we can write as follow. The results are displayed the appendix F.

```
>> solvepf ('istanbulm','filename', 1, 'nolim')

Enter the generator bus number = 214

Enter the load bus number = 189

Enter the real power increment = 100

If you type 1, you have solutions without generator limits = 1
```

Case 3

A power transaction between the bus 214 (source) and bus (sink) is considered. The objective is to obtain power transfer capability bus 214 (sending bus) and bus 189 (receiving bus). P_{max} is 600 MW between such the buses.

```
>> ptc ('istanbulm', 200)

Enter the generator bus number = 214

Enter the load bus number = 189

The power transfer capability is 600 MW.
```

Case 4

We have also a no limit option at this program. This program is used as follows:

```
>> ptc ('istanbulm', 200, 'nolim')

Enter the generator bus number = 214

Enter the load bus number = 189

The power transfer capability is 600 MW.
```

4.2. FUTURE RESEARCH

Increasing complexities in power systems and the growing need of the power industry has been pushing power system operation towards new and more efficiently programs. Our program provides efficient determination of power system capacity. On the other hand, speed is essential factor as accuracy for the calculating of power transfer capability. The power transfer capability must compute at high speed with a reliable accuracy. We know that speed and accuracy requirements for determination of power transfer capability make the task harder. Open research concerns are these factors how to use efficiently together.

APPENDIX

A. BASE CASE POWER-FLOW PROGRAM

```
function solvepf(casename,filename,pcapablty,nolim)

% Author  : Mutlu YILMAZ
% Date    : March 2010
% Purpose : Solving the power-flow program

% Start the total solution time clock
tst=clock;

global bus_num gen_num bus_type Qmax Qmin G_status S_from S_to

% Read data file in matrix format
[baseMVA, bus, gen, branch] = feval(casename);

if (nargin > 2 & pcapablty ==1)
    % Calculating power transfer cabability
    busn_inj=input('Enter the generator bus number= ');
    busn_load=input('Enter the load bus number= ');
    q=input('Enter the real power increment= ');

    busing=find(bus_num==busn_inj);
    if bus(busing,2)~=2
    error('Warning! It is not a generator bus')
    end
    businl=find(bus_num==busn_load);
    if bus(businl,2)~=1
    error('Warning! It is not a load bus')
    end
    genin=find(gen_num==busn_inj);
    gen(genin,2)= gen(genin,2)+ q;
    bus(businl,3)= bus(businl,3)+ q;
end

% Convert to external bus numbers into internal ones
% This program is extracted from Dr.Bulent Bilir's power-flow code.
[extr,bus,gen,branch]=intrnum(bus,gen,branch);

% Identify the elements of bus, gen, branch matrices
[bus_num, nbus, bus_type, Pd, Qd, Gs, Bs, B_area, Vm, Va, BaseKV...
          Zone, Vmax, Vmin, gen_num, ngen, Qmax, Qmin, Vsp, BaseMVA...
          G_status, fr, nline, to, R, X, B, rate_a, rate_b, rate_c...
          tap, shift, B_status]=setdata(bus, branch, gen);

% Obtain the index lists of swing, PQ and PV buses.
[pv,pq,swng,npv,npq,Pg,Pd,Qg,Qd]=index(bus,gen);

% Construct the bus admittance matrix
[Ybus]=formYbus(baseMVA,bus,branch,gen);

% Initialize the complex bus voltage
gon=find(G_status);
Vi=Vm.*exp(j*Va*pi/180);
Vi(gen(gon,1))=gen(gon,6)./abs(Vi(gen(gon,1))).* Vi(gen(gon,1));
Vbus=Vi;

% Start the iteration solution time
tsol=clock;

% Newton solver
if nargin < 4
```

```
[Vbus,conv_flag,itc,maxit,errr]=nwtnpf_Qlimit(baseMVA,Ybus,Vi,gen,bus,pq,pv);
else
     nolim=input('If you type 1, you have solutions without generator limits=
')
     if nolim ==1

[Vbus,conv_flag,itc,maxit,errr]=nwtnpf(baseMVA,Ybus,Vi,gen,bus,pq,pv);
    else

[Vbus,conv_flag,itc,maxit,errr]=nwtnpf_Qlimit(baseMVA,Ybus,Vi,gen,bus,pq,pv);
     end
end
% End the iteration solution time clock
etsol=clock;

% Compute all the line flows
if conv_flag==1
   Vm = abs(Vbus);
   Va = angle(Vbus);
   gon=find(G_status);
   swng_gen=find(gen_num==swng);
   Sg=Vbus(gen_num).*conj(Ybus(gen_num,:)*Vbus);
   Qg=zeros(size(bus_num,1),1);
   Qg(gen_num)=imag(Sg)*baseMVA+ Qd(gen_num);
   Pg(swng)=real(Sg(swng_gen))*baseMVA+Pd(swng);

   tap_index=ones(nline,1);
   Y = tap_index./(R+j*X);
   tps = tap_index.*exp(j*pi/180*shift);

% Complex power injected at "from" bus
   S_from = Vbus(fr).*conj((Vbus(fr) - tps.*Vbus(to)).*Y ...
            + Vbus(fr).*(j*B/2))./(tps.*conj(tps))*baseMVA;

% Complex power injected at "to" bus
   S_to = Vbus(to).*conj((Vbus(to) - Vbus(fr)./tps).*Y...
          + Vbus(to).*(j*B/2))*baseMVA;
end

% Convert to internal bus numbers back to the orginal values.
% This program is extracted from Dr.Bulent Bilir's power-flow code.
[bus,gen,branch]=extrnum(extr,bus,gen,branch);

if nargin < 2
    filename='';
end
if filename
    [fd, msg]=fopen(filename, 'wt');
    if fd==-1
       error(msg);
    else

reportpf(bus,branch,Vbus,Gs,Bs,tap,errr,itc,etsol,tsol,tst,nbus,nline,pv,pq,sw
ng,Pg,Qg,Pd,Qd,conv_flag,fd);
    end
    fclose(fd);
end
% Print out on the screen.
reportpf(bus,branch,Vbus,Gs,Bs,tap,errr,itc,etsol,tsol,tst,nbus,nline,pv,pq,sw
ng,Pg,Qg,Pd,Qd,conv_flag,1);
fd=fopen('printout.txt','w');
reportpf(bus,branch,Vbus,Gs,Bs,tap,errr,itc,etsol,tsol,tst,nbus,nline,pv,pq,sw
ng,Pg,Qg,Pd,Qd,conv_flag,fd);
fclose(fd);end
```

B. PROGRAM TO COMPUTE TRANSFER CAPABILITY

```
function ptc(casename,dq,nolim)

% Author  : Mutlu YILMAZ
% Date    : March 2010
% Purpose : Determination of the power transfer capability


global bus_num gen_num bus_type Qmax Qmin G_status

% Read data file in matrix format
[baseMVA, bus, gen, branch]=feval(casename);

busn_inj=input('Enter the generator bus number= ');
busn_load=input('Enter the load bus number= ');

if nargin < 2
    dq=10;
end
busing=find(bus_num==busn_inj);

if bus(busing,2)~=2
    error('Warning! It is not a generator bus')
end
businl=find(bus_num==busn_load);

if bus(businl,2)~=1
    error('Warning! It is not a load bus')
end
genin=find(gen_num==busn_inj);

% Convert to external bus numbers into internal ones
% This program is extracted from Dr.Bulent Bilir's power-flow code.
[extr,bus,gen,branch]=intrnum(bus,gen,branch);

% Identify the elements of bus, gen, branch matrices
[bus_num, nbus, bus_type, Pd, Qd, Gs, Bs, B_area, Vm, Va, BaseKV...
          Zone, Vmax, Vmin, gen_num, ngen, Qmax, Qmin, Vsp, BaseMVA...
          G_status, fr, nline, to, R, X, B, rate_a, rate_b, rate_c...
          tap, shift, B_status]=setdata(bus, branch, gen);

% Obtain the index lists of swing, PQ, PV buses.
[pv,pq,swng,npv,npq,Pg,Pd,Qg,Qd]=index(bus,gen);

% Construct the bus admittance matrix
[Ybus]=formYbus(baseMVA,bus,branch,gen);

% Initialize the complex bus voltage
gon=find(G_status);
Vi=Vm.*exp(j*Va*pi/180);
Vi(gen(gon,1))=gen(gon,6)./abs(Vi(gen(gon,1))).* Vi(gen(gon,1));
Vbus=Vi;


% Newton solver
if nargin < 3

[Vbus,conv_flag,itc,maxit,errr]=nwtnpf_Qlimit(baseMVA,Ybus,Vi,gen,bus,pq,pv);
else
     %nolim=input('If you type 1, you have solutions without generator limits
= ')
```

```
     if nolim ==1
[Vbus,conv_flag,itc,maxit,errr]=nwtnpf(baseMVA,Ybus,Vi,gen,bus,pq,pv);
    else
[Vbus,conv_flag,itc,maxit,errr]=nwtnpf_Qlimit(baseMVA,Ybus,Vi,gen,bus,pq,pv);
     end
end

% Convert to external bus numbers into internal ones
% This program is extracted from Dr.Bulent Bilir's power-flow code.
[bus,gen,branch]=extrnum(extr,bus,gen,branch);

q=0;
while conv_flag==1

    [baseMVA, bus, gen, branch]=feval(casename);

    q=q+dq;
    gen(genin,2)= gen(genin,2)+ q ;
    bus(businl,3)= bus(businl,3)+ q ;

    [extr,bus,gen,branch]=intrnum(bus,gen,branch);

    [Ybus]=formYbus(baseMVA,bus,branch,gen);

    gon=find(G_status);
    Vm=bus(:,8);
    Va=bus(:,9);
    Vi=Vm.*exp(j*Va*pi/180);
    Vi(gen(gon,1))=gen(gon,6)./abs(Vi(gen(gon,1))).* Vi(gen(gon,1));
    Vbus=Vi;

    if nargin < 3
[Vbus,conv_flag,itc,maxit,errr]=nwtnpf_Qlimit(baseMVA,Ybus,Vi,gen,bus,pq,pv);
    else
        %nolim=input('If you type 1, you have solutions without generator
limits = ')
         if nolim ==1
[Vbus,conv_flag,itc,maxit,errr]=nwtnpf(baseMVA,Ybus,Vi,gen,bus,pq,pv);
         else
[Vbus,conv_flag,itc,maxit,errr]=nwtnpf_Qlimit(baseMVA,Ybus,Vi,gen,bus,pq,pv);
         end
    end
[bus,gen,branch]=extrnum(extr,bus,gen,branch);

end

% Transfer capability
T=q-dq;

fprintf('\nThe power transfer capability is %d MW. \n',T);
```

C. POWER-FLOW SOLUTION OF THE 20-BUS IEEE SYSTEM

REPORT OF SYSTEM SUMMARY

```
MAXIMUM POWER MISMATCH           : 0.0000003706 pu.
ITERATIONS                       : 4
SOLUTION TIME                    : 0.265 sec.
TOTAL TIME                       : 0.452 sec.
BUSES                            : 20
GENERATOR BUS                    : 14
LOAD BUS                         : 5
SWING BUS                        : 1
BRANCHES                         : 31
SHUNTS                           : 5
SHUNT INJECTIONS(MW)             : -0.0
SHUNT INJECTIONS(MWAR)           : -468.5
TRANSFORMERS                     : 4
TOTAL REAL GEN CAPACITY(MW)      : 3257.28
TOTAL REACTIVE GEN CAPACITY(MVAR): 1827.74
TOTAL REAL POWER LOSSES(MW)      : 57.28
TOTAL REACTIVE POWER LOSSES(MVAR): -580.98
```

|=========================BUS INFORMATION=========================|

BUS	VOLTAGE		GENERATION		LOAD	
	VOLTS (pu)	ANGLE (deg)	REAL (MW)	REACTIVE (MVAR)	REAL (MW)	REACTIVE (MVAR)
1	1.020	17.574	750.00	273.99	0.00	0.00
2	1.020	17.574	750.00	273.99	0.00	0.00
3	0.996	13.339	0.00	0.00	0.00	0.00
4	0.967	0.570	0.00	0.00	0.00	0.00
5	0.941	-1.588	0.00	0.00	200.00	100.00
6	0.862	-8.215	0.00	0.00	1000.00	800.00
7	0.984	8.422	600.00	400.00	0.00	0.00
8	0.948	0.072	0.00	0.00	0.00	0.00
9	0.904	-4.253	0.00	0.00	300.00	150.00
10	0.903	-2.897	0.00	0.00	0.00	0.00
11	0.871	-7.273	0.00	0.00	1200.00	700.00
12	0.903	-1.318	800.00	482.49	0.00	0.00
13	1.030	-0.774	0.00	0.00	0.00	0.00
14	1.032	-0.841	0.00	0.00	0.00	0.00
15	0.981	-2.264	0.00	0.00	0.00	0.00
16	0.966	-3.521	0.00	0.00	100.00	50.00
17	0.949	-2.142	0.00	0.00	0.00	0.00
18	0.922	-7.034	0.00	0.00	200.00	75.00
19	0.906	-7.494	100.00	80.00	200.00	75.00
20	1.050	0.000	257.28	317.28	0.00	0.00
		TOTAL:	3257.28	1827.74	3200.00	1950.00

|==============================BRANCH INFORMATION=============================|

BRNCH	FROM BUS	T0 BUS	REAL FROM BUS (MW)	REACTIVE INJ (MVAR)	REAL TO BUS (MW)	REACTIVE INJ (MVAR)	REAL LOSS (MW)	REACTIVE LOSS (MVAR)
1	3	1	-750.00	-212.71	750.00	273.99	0.00	61.28
2	3	2	-750.00	-212.71	750.00	273.99	0.00	61.28
3	3	4	467.81	-86.57	-461.87	-145.74	5.94	-232.31
4	3	4	467.81	-86.57	-461.87	-145.74	5.94	-232.31
5	3	7	564.38	3.51	-561.13	-72.37	3.25	-68.86
6	4	5	685.77	520.15	-685.77	-480.57	0.00	39.58
7	4	8	93.81	131.28	-93.47	-214.22	0.34	-82.94
8	4	15	150.95	-171.32	-150.13	-57.65	0.83	-228.96
9	5	6	225.02	147.32	-220.87	-118.05	4.16	29.27
10	5	6	187.52	119.82	-184.06	-100.85	3.47	18.96
11	5	17	66.44	-66.73	-66.34	65.23	0.10	-1.50
12	6	9	-141.64	-73.82	142.99	79.45	1.34	5.63
13	6	11	-388.92	-185.79	389.74	187.29	0.82	1.50
14	6	19	-64.51	-172.73	65.61	158.22	1.10	-14.51
15	7	8	553.21	39.55	-546.51	-142.63	6.70	-103.08
16	7	10	607.92	142.15	-594.33	-229.33	13.59	-87.18
17	8	9	646.38	449.49	-646.38	-380.58	-0.00	68.90
18	9	11	98.50	53.67	-97.71	-52.84	0.79	0.83
19	9	11	98.50	53.67	-97.71	-52.84	0.79	0.83
20	10	11	600.27	312.38	-600.27	-256.24	-0.00	56.14
21	11	12	-816.00	-234.14	816.00	329.12	0.00	94.98
22	20	13	58.40	85.29	-58.40	-82.87	0.00	2.42
23	20	14	198.88	231.98	-198.88	-225.21	0.00	6.78
24	13	15	58.40	82.87	-57.77	-86.32	0.63	-3.45
25	14	16	99.44	112.60	-98.11	-109.61	1.33	2.99
26	14	16	99.44	112.60	-98.11	-109.61	1.33	2.99
27	15	16	207.89	143.97	-207.89	-137.32	0.00	6.65
28	16	17	-66.02	61.56	66.34	-65.23	0.32	-3.67
29	16	18	236.23	145.37	-233.73	-129.91	2.50	15.47
30	16	19	133.90	99.61	-132.04	-94.61	1.86	5.00
31	18	19	33.73	54.91	-33.57	-58.62	0.16	-3.71
							--------	-------
						Total:	57.28	-580.98

-

D. 225-BUS SYSTEM SOLUTION OF ISTANBUL REGION

REPORT OF SYSTEM SUMMARY

MAXIMUM POWER MISMATCH	:	0.0000303020 pu.
ITERATIONS	:	3
SOLUTION TIME	:	0.219 sec.
TOTAL TIME	:	0.562 sec.
BUSES	:	225
GENERATOR BUS	:	196
LOAD BUS	:	28
SWING BUS	:	1
BRANCHES	:	283
SHUNTS	:	78
SHUNT INJECTIONS(MW)	:	-9.3
SHUNT INJECTIONS(MWAR)	:	-14.3
TRANSFORMERS	:	163
TOTAL REAL GEN CAPACITY(MW)	:	3864.49
TOTAL REACTIVE GEN CAPACITY(MVAR)	:	880.33
TOTAL REAL POWER LOSSES(MW)	:	43.29
TOTAL REACTIVE POWER LOSSES(MVAR)	:	215.72

|==========================BUS INFORMATION========================|

BUS	VOLTAGE		GENERATION		LOAD	
	VOLTS (pu)	ANGLE (deg)	REAL (MW)	REACTIVE (MVAR)	REAL (MW)	REACTIVE (MVAR)
1	1.000	3.130	734.15	156.95	0.00	0.00
2	1.000	1.423	300.00	261.42	0.00	0.00
3	1.000	8.467	299.19	-61.47	0.00	0.00
4	0.997	1.712	0.00	0.00	0.00	0.00
5	1.010	3.117	0.00	0.00	0.00	0.00
6	1.012	1.439	0.00	0.00	0.00	0.00
7	1.012	1.439	0.00	0.00	0.00	0.00
8	0.997	1.749	0.00	0.00	0.00	0.00
9	0.983	-1.872	0.00	0.00	32.51	5.33
10	0.997	1.749	0.00	0.00	0.00	0.00
11	0.997	1.749	0.00	0.00	0.00	0.00
12	0.994	0.133	0.00	0.00	0.00	0.00
13	0.984	-2.727	0.00	0.00	32.50	5.07
14	0.984	-2.727	0.00	0.00	32.50	5.07
15	0.986	-0.680	0.00	0.00	0.00	0.00
16	0.966	-5.838	0.00	0.00	57.00	9.48
17	0.966	-5.838	0.00	0.00	57.00	9.48
18	0.990	-0.488	0.00	0.00	0.00	0.00
19	0.969	-5.949	0.00	0.00	38.26	5.33
20	0.979	-3.892	0.00	0.00	38.26	5.33
21	0.978	-3.862	0.00	0.00	38.26	5.33
22	0.990	-0.605	0.00	0.00	0.00	0.00
23	0.971	-5.876	0.00	0.00	37.00	4.38
24	0.971	-6.389	0.00	0.00	12.35	1.51
25	0.991	-0.309	0.00	0.00	0.00	0.00
26	0.988	-3.443	0.00	0.00	15.24	0.00
27	1.011	3.351	0.00	0.00	0.00	0.00
28	1.009	1.407	0.00	0.00	0.00	0.00
29	0.998	0.132	0.00	0.00	0.00	0.00
30	0.987	-2.343	0.00	0.00	12.19	2.37
31	1.020	4.413	0.00	0.00	0.00	0.00
32	1.020	4.413	0.00	0.00	0.00	0.00

33	1.020	4.413	0.00	0.00	0.00	0.00
34	0.954	-5.110	0.00	0.00	0.00	0.00
35	0.928	-11.713	0.00	0.00	42.67	5.92
36	0.996	1.114	0.00	0.00	0.00	0.00
37	0.986	-1.219	0.00	0.00	10.50	1.92
38	0.986	-1.219	0.00	0.00	10.50	1.92
39	0.987	-0.741	0.00	0.00	0.00	0.00
40	0.987	-0.885	0.00	0.00	1.02	0.00
41	1.005	0.911	0.00	0.00	0.00	0.00
42	0.997	-1.249	0.00	0.00	39.63	5.92
43	0.963	-3.994	0.00	0.00	0.00	0.00
44	0.961	-5.955	0.00	0.00	13.21	0.00
45	0.995	-0.142	0.00	0.00	0.00	0.00
46	0.995	-0.142	0.00	0.00	0.00	0.00
47	0.995	-0.142	0.00	0.00	0.00	0.00
48	1.001	0.942	0.00	0.00	0.00	0.00
49	0.997	-0.897	0.00	0.00	9.14	0.57
50	0.994	-2.675	0.00	0.00	9.14	0.57
51	0.992	0.217	0.00	0.00	0.00	0.00
52	0.982	-2.404	0.00	0.00	6.50	1.21
53	0.984	-1.578	0.00	0.00	6.50	1.21
54	0.984	-0.952	0.00	0.00	0.00	0.00
55	0.984	-0.952	0.00	0.00	0.00	0.00
56	0.984	-0.952	0.00	0.00	0.00	0.00
57	0.998	1.805	0.00	0.00	0.00	0.00
58	0.995	-0.142	0.00	0.00	0.00	0.00
59	0.992	-1.463	0.00	0.00	15.11	1.18
60	1.020	4.437	0.00	0.00	0.00	0.00
61	1.003	0.577	0.00	0.00	0.00	0.00
62	0.993	-1.563	0.00	0.00	21.34	4.74
63	0.995	0.205	0.00	0.00	0.00	0.00
64	0.995	0.205	0.00	0.00	0.00	0.00
65	0.995	0.205	0.00	0.00	0.00	0.00
66	0.959	-2.890	0.00	0.00	0.00	0.00
67	0.986	-4.893	0.00	0.00	0.00	0.00
68	0.982	-4.430	0.00	0.00	0.00	0.00
69	0.955	-10.566	0.00	0.00	62.00	15.34
70	0.950	-10.086	0.00	0.00	62.00	15.34
71	0.981	0.378	0.00	0.00	0.00	0.00
72	1.009	-1.910	0.00	0.00	0.00	0.00
73	1.046	-3.131	0.00	0.00	0.00	0.00
74	1.005	-3.280	0.00	0.00	16.12	1.80
75	1.043	-4.405	0.00	0.00	16.12	1.80
76	1.044	-3.625	0.00	0.00	0.00	0.00
77	1.013	-9.255	0.00	0.00	69.09	15.99
78	1.000	-1.861	0.00	0.00	0.00	0.00
79	0.973	-7.192	0.00	0.00	60.20	13.31
80	0.973	-7.192	0.00	0.00	60.20	13.31
81	0.973	-7.192	0.00	0.00	60.20	13.31
82	0.975	-0.104	0.00	0.00	0.00	0.00
83	0.998	-1.251	0.00	0.00	0.00	0.00
84	1.001	-1.606	0.00	0.00	0.00	0.00
85	1.000	-1.782	0.00	0.00	0.00	0.00
86	0.971	-0.458	0.00	0.00	0.00	0.00
87	1.036	-4.461	0.00	0.00	0.00	0.00
88	1.006	-3.268	0.00	0.00	0.00	0.00
89	0.997	-5.501	0.00	0.00	26.00	4.93
90	1.028	-6.562	0.00	0.00	26.00	4.93
91	1.001	-3.521	0.00	0.00	0.00	0.00
92	0.972	-8.007	0.00	0.00	50.80	15.99
93	0.977	-9.069	0.00	0.00	62.99	11.26
94	0.986	-3.676	0.00	0.00	0.00	0.00
95	1.001	-3.592	0.00	0.00	0.00	0.00
96	0.962	-7.982	0.00	0.00	48.00	12.05
97	0.978	-7.810	0.00	0.00	48.00	12.05

98	1.008	-0.548	0.00	0.00	0.00	0.00
99	1.002	-2.455	0.00	0.00	22.38	3.53
100	1.002	-2.455	0.00	0.00	22.38	3.53
101	1.003	-1.067	0.00	0.00	0.00	0.00
102	0.984	-6.733	0.00	0.00	64.85	8.10
103	0.984	-6.733	0.00	0.00	64.85	8.10
104	0.984	-6.733	0.00	0.00	64.85	8.10
105	0.960	-2.801	0.00	0.00	0.00	0.00
106	0.950	-5.326	0.00	0.00	26.75	5.13
107	0.950	-5.326	0.00	0.00	26.75	5.13
108	0.950	-5.326	0.00	0.00	26.75	5.13
109	0.987	-4.768	0.00	0.00	0.00	0.00
110	0.961	-10.506	0.00	0.00	63.15	11.83
111	0.961	-10.506	0.00	0.00	63.15	11.83
112	1.006	-0.370	0.00	0.00	0.00	0.00
113	1.042	-3.640	0.00	0.00	0.00	0.00
114	1.030	-7.282	0.00	0.00	45.72	5.13
115	1.031	-7.313	0.00	0.00	45.72	5.13
116	1.031	-7.313	0.00	0.00	45.72	5.13
117	1.000	3.032	0.00	0.00	0.00	0.00
118	1.021	-0.120	0.00	0.00	0.00	0.00
119	1.006	-2.921	0.00	0.00	33.47	8.29
120	1.007	-2.829	0.00	0.00	32.39	7.70
121	1.013	-0.859	0.00	0.00	0.00	0.00
122	1.001	-4.046	0.00	0.00	37.85	5.77
123	1.001	-4.046	0.00	0.00	37.85	5.77
124	0.987	-3.553	0.00	0.00	0.00	0.00
125	0.974	-8.889	0.00	0.00	59.37	4.44
126	0.982	-5.924	0.00	0.00	59.37	4.44
127	0.969	-0.630	0.00	0.00	0.00	0.00
128	0.993	-2.504	0.00	0.00	0.00	0.00
129	1.005	-3.176	0.00	0.00	0.00	0.00
130	0.969	-0.630	0.00	0.00	0.00	0.00
131	0.957	-8.343	0.00	0.00	64.53	18.35
132	0.994	-6.460	0.00	0.00	55.59	7.40
133	0.994	-6.460	0.00	0.00	55.59	7.40
134	0.957	-8.343	0.00	0.00	64.53	18.35
135	1.044	-3.605	0.00	0.00	0.00	0.00
136	1.026	-6.737	0.00	0.00	39.41	10.15
137	1.026	-6.737	0.00	0.00	39.41	10.15
138	1.044	-3.605	0.00	0.00	0.00	0.00
139	1.018	-0.523	0.00	0.00	0.00	0.00
140	1.002	-3.611	0.00	0.00	37.00	8.33
141	1.003	-3.642	0.00	0.00	37.00	8.33
142	1.002	-3.611	0.00	0.00	37.00	8.33
143	1.041	-3.472	0.00	0.00	0.00	0.00
144	1.028	-7.010	0.00	0.00	27.70	3.75
145	1.034	-5.688	0.00	0.00	27.70	3.75
146	1.034	-5.688	0.00	0.00	27.70	3.75
147	1.041	-3.248	0.00	0.00	0.00	0.00
148	1.038	-6.247	0.00	0.00	37.53	0.89
149	1.038	-6.247	0.00	0.00	37.53	0.89
150	1.031	-4.979	0.00	0.00	0.00	0.00
151	1.002	-10.482	0.00	0.00	66.04	14.81
152	1.002	-10.482	0.00	0.00	66.04	14.81
153	1.002	-10.482	0.00	0.00	66.04	14.81
154	1.044	-3.509	0.00	0.00	0.00	0.00
155	1.018	-7.964	0.00	0.00	55.06	14.22
156	0.973	-1.174	0.00	0.00	0.00	0.00
157	0.961	-3.905	0.00	0.00	23.40	4.67
158	0.964	-3.322	0.00	0.00	23.40	4.67
159	0.993	-3.594	0.00	0.00	0.00	0.00
160	0.974	-7.776	0.00	0.00	47.00	9.86
161	0.974	-7.776	0.00	0.00	47.00	9.86
162	1.042	-3.677	0.00	0.00	0.00	0.00

163	1.029	-6.538	0.00	0.00	36.00	7.12
164	1.029	-6.565	0.00	0.00	36.00	7.12
165	1.019	-8.305	0.00	0.00	36.00	7.12
166	1.019	-0.445	0.00	0.00	0.00	0.00
167	1.011	-2.149	0.00	0.00	20.40	4.71
168	1.011	-2.149	0.00	0.00	20.40	4.71
169	1.030	-5.077	0.00	0.00	0.00	0.00
170	1.001	-9.828	0.00	0.00	57.00	15.88
171	0.986	-4.867	0.00	0.00	0.00	0.00
172	0.955	-10.075	0.00	0.00	57.00	15.88
173	0.984	-4.214	0.00	0.00	0.00	0.00
174	0.986	-4.866	0.00	0.00	0.00	0.00
175	0.972	-7.336	0.00	0.00	35.00	5.48
176	0.972	-7.336	0.00	0.00	35.00	5.48
177	0.966	-8.983	0.00	0.00	23.00	4.93
178	0.966	-8.983	0.00	0.00	23.00	4.93
179	0.986	-3.609	0.00	0.00	0.00	0.00
180	0.977	-8.180	0.00	0.00	51.00	3.29
181	0.977	-8.180	0.00	0.00	51.00	3.29
182	0.977	-8.180	0.00	0.00	51.00	3.29
183	0.977	-8.180	0.00	0.00	51.00	3.29
184	0.986	-3.610	0.00	0.00	0.00	0.00
185	0.980	0.237	0.00	0.00	0.00	0.00
186	1.045	-3.481	0.00	0.00	0.00	0.00
187	1.031	-7.201	0.00	0.00	46.50	6.57
188	1.031	-7.201	0.00	0.00	46.50	6.57
189	1.002	2.771	0.00	0.00	0.00	0.00
190	1.038	-2.707	0.00	0.00	0.00	0.00
191	1.002	2.771	0.00	0.00	0.00	0.00
192	1.002	2.771	0.00	0.00	0.00	0.00
193	0.987	-4.768	0.00	0.00	0.00	0.00
194	0.997	-3.556	0.00	0.00	0.00	0.00
195	0.949	-5.453	0.00	0.00	42.75	7.70
196	0.968	-4.090	0.00	0.00	0.00	0.00
197	0.968	-4.090	0.00	0.00	0.00	0.00
198	0.969	-4.112	0.00	0.00	0.00	0.00
199	0.969	-4.112	0.00	0.00	0.00	0.00
200	1.014	5.580	23.00	5.34	0.00	0.00
201	0.983	5.780	23.00	-4.75	0.00	0.00
202	0.981	4.321	11.00	-3.97	0.00	0.00
203	1.003	9.300	101.00	-4.51	0.00	0.00
204	1.005	6.939	94.00	-1.39	0.00	0.00
206	1.014	5.546	146.00	38.23	0.00	0.00
207	1.013	6.482	146.00	30.26	0.00	0.00
208	1.013	6.482	146.00	30.26	0.00	0.00
209	1.006	9.157	155.00	-21.95	0.00	0.00
210	1.141	8.399	152.00	256.00	0.00	0.00
211	1.004	9.079	152.00	-26.31	0.00	0.00
212	0.993	6.173	50.00	0.30	0.00	0.00
213	1.002	4.878	128.00	42.69	0.00	0.00
214	1.010	5.102	150.00	61.93	0.00	0.00
215	1.012	3.581	128.00	23.95	0.00	0.00
216	1.012	3.581	128.00	23.95	0.00	0.00
217	1.013	3.840	150.00	28.88	0.00	0.00
218	1.012	3.211	128.00	20.85	0.00	0.00
219	1.012	3.211	128.00	20.85	0.00	0.00
220	1.013	3.470	150.00	25.26	0.00	0.00
221	1.004	2.979	88.00	6.05	0.00	0.00
222	0.984	4.773	33.00	-7.61	0.00	0.00
223	0.984	4.740	33.00	-7.68	0.00	0.00
224	0.984	4.740	33.00	-7.68	0.00	0.00
225	0.998	6.102	64.00	-2.26	0.00	0.00
205	1.005	-0.370	-8.85	-3.25	21.46	0.00
		TOTAL:	3864.49	880.33	3821.58	672.35

|==============================BRANCH INFORMATION=============================|

BRNCH	FROM BUS	T0 BUS	REAL FROM BUS (MW)	REACTIVE INJ (MVAR)	REAL TO BUS (MW)	REACTIVE INJ (MVAR)	REAL (MW)	REACTIVE LOSS (MVAR)
1	1	71	638.42	199.76	-635.69	-196.34	2.72	3.43
2	1	189	95.73	-42.81	-95.67	24.77	0.06	-18.04
3	2	71	300.00	261.42	-299.16	-277.08	0.84	-15.66
4	3	117	299.19	-61.47	-296.40	-2.97	2.79	-64.44
5	4	36	56.83	-7.56	-56.70	7.39	0.12	-0.17
6	4	200	-22.93	-3.72	23.00	5.34	0.07	1.63
7	4	201	-22.92	6.46	23.00	-4.75	0.08	1.71
8	4	202	-10.98	4.54	11.00	-3.97	0.02	0.57
9	5	6	41.48	-3.14	-41.45	4.36	0.02	1.22
10	5	6	41.48	-3.14	-41.45	4.36	0.02	1.22
11	5	27	-84.68	-30.00	84.72	15.62	0.04	-14.38
12	6	7	0.00	-0.00	-0.00	0.00	0.00	0.00
13	6	28	2.75	3.88	-2.74	-5.43	0.00	-1.55
14	6	29	44.82	10.58	-44.46	-11.36	0.36	-0.77
15	6	48	15.58	9.28	-15.50	-11.53	0.08	-2.25
16	6	61	21.48	3.36	-21.37	-5.67	0.11	-2.31
17	8	9	32.58	7.48	-32.51	-5.33	0.07	2.15
18	8	10	0.00	0.00	0.00	0.00	0.00	0.00
19	8	11	0.00	0.00	0.00	0.00	0.00	0.00
20	8	51	74.14	-0.52	-73.73	0.97	0.41	0.45
21	8	57	-180.09	-26.00	180.11	26.14	0.02	0.15
22	8	105	73.37	18.95	-72.02	-17.03	1.36	1.92
23	12	13	32.53	6.75	-32.50	-5.07	0.03	1.68
24	12	14	32.53	6.75	-32.50	-5.07	0.03	1.68
25	12	15	21.49	6.76	-21.42	-9.47	0.06	-2.70
26	12	18	23.76	1.79	-23.68	-3.10	0.08	-1.31
27	12	28	-31.43	-10.25	31.69	8.39	0.26	-1.85
28	12	63	-78.89	-12.02	78.90	12.05	0.02	0.03
29	15	16	57.10	14.87	-57.00	-9.48	0.10	5.39
30	15	17	57.10	14.87	-57.00	-9.48	0.10	5.39
31	15	18	-11.76	-7.17	11.78	6.11	0.02	-1.07
32	15	39	1.02	-3.13	-1.02	-0.13	0.00	-3.26
33	15	57	-82.04	-10.18	82.51	11.40	0.47	1.22
34	18	19	38.40	9.14	-38.26	-5.33	0.14	3.81
35	18	20	38.30	7.68	-38.26	-5.33	0.04	2.35
36	18	21	38.33	7.66	-38.26	-5.33	0.07	2.33
37	18	51	-38.75	4.39	38.90	-4.94	0.15	-0.55
38	18	51	-38.75	4.39	38.90	-4.94	0.15	-0.55
39	18	58	-25.21	-16.03	25.24	15.06	0.03	-0.97
40	18	121	-0.42	-20.58	0.55	16.81	0.13	-3.77
41	22	23	37.13	7.91	-37.00	-4.38	0.13	3.53
42	22	24	12.37	2.80	-12.35	-1.51	0.02	1.29
43	22	25	-17.40	-1.47	17.42	0.32	0.02	-1.15
44	22	29	-32.10	-9.37	32.25	8.39	0.15	-0.98
45	25	26	15.27	0.84	-15.24	-0.00	0.03	0.84
46	25	36	-32.69	-1.19	32.86	-1.17	0.17	-2.37
47	27	28	72.18	3.91	-72.14	-1.46	0.04	2.45
48	27	31	-109.17	-63.02	109.40	11.91	0.23	-51.11
49	27	60	-161.26	-83.07	161.54	33.05	0.28	-50.01
50	27	71	211.55	55.18	-210.45	-145.89	1.10	-90.71
51	27	203	-100.81	15.08	101.00	-4.51	0.19	10.57
52	28	41	68.95	23.35	-68.83	-23.26	0.11	0.08
53	28	58	40.52	14.66	-40.35	-16.71	0.17	-2.06
54	28	204	-93.84	10.49	94.00	-1.39	0.16	9.10
55	28	205	30.33	4.21	-30.31	-3.25	0.02	0.96
56	29	30	12.21	2.93	-12.19	-2.37	0.02	0.56
57	31	32	0.00	0.00	0.00	0.00	0.00	0.00
58	31	33	0.00	0.00	0.00	0.00	0.00	0.00
59	31	60	-109.40	-12.16	109.40	11.01	0.00	-1.15
60	34	35	42.86	11.08	-42.67	-5.92	0.19	5.16

61	34	43	-42.86	-11.20	43.05	10.40	0.20	-0.80
62	36	37	10.52	2.37	-10.50	-1.92	0.02	0.45
63	36	38	10.52	2.37	-10.50	-1.92	0.02	0.45
64	36	48	2.81	-11.11	-2.80	9.46	0.02	-1.65
65	39	40	1.02	0.00	-1.02	-0.00	0.00	0.00
66	41	42	19.84	3.73	-19.81	-2.96	0.02	0.77
67	41	42	19.84	3.73	-19.81	-2.96	0.02	0.77
68	41	63	29.16	15.64	-29.07	-17.23	0.09	-1.59
69	43	44	13.23	0.45	-13.21	-0.00	0.02	0.45
70	43	54	-56.29	-4.70	57.26	4.85	0.97	0.15
71	43	196	0.01	-6.27	-0.00	2.77	0.01	-3.51
72	45	46	0.00	0.00	0.00	0.00	0.00	0.00
73	45	47	0.00	0.00	0.00	0.00	0.00	0.00
74	45	58	-0.00	-0.08	0.00	0.00	0.00	-0.07
75	45	58	-0.00	-0.08	0.00	0.00	0.00	-0.07
76	48	49	9.15	0.87	-9.14	-0.57	0.01	0.30
77	48	50	9.15	1.15	-9.14	-0.57	0.01	0.58
78	51	52	6.51	1.52	-6.50	-1.21	0.01	0.31
79	51	53	6.51	1.42	-6.50	-1.21	0.01	0.21
80	51	54	57.64	5.04	-57.26	-5.02	0.38	0.02
81	51	57	-74.72	0.91	75.16	-0.39	0.43	0.52
82	54	55	-0.00	0.00	0.00	-0.00	0.00	0.00
83	54	56	0.00	0.00	0.00	0.00	0.00	0.00
84	57	156	99.54	26.77	-98.33	-23.24	1.21	3.53
85	57	206	-145.80	-28.16	146.00	38.23	0.20	10.07
86	57	207	-145.76	-17.98	146.00	30.26	0.24	12.28
87	57	208	-145.76	-17.98	146.00	30.26	0.24	12.28
88	58	59	15.12	1.53	-15.11	-1.18	0.01	0.35
89	60	117	187.05	100.43	-186.50	-153.46	0.56	-53.03
90	60	209	-154.79	35.11	155.00	-21.95	0.21	13.16
91	60	210	-151.41	-218.98	152.00	256.00	0.59	37.03
92	60	211	-151.79	39.15	152.00	-26.31	0.21	12.84
93	61	62	10.68	2.80	-10.67	-2.37	0.01	0.43
94	61	62	10.68	2.80	-10.67	-2.37	0.01	0.43
95	63	64	0.00	0.00	0.00	0.00	0.00	0.00
96	63	65	0.00	0.00	0.00	0.00	0.00	0.00
97	63	212	-49.83	4.91	50.00	0.30	0.17	5.21
98	66	105	-42.81	-9.85	42.83	9.81	0.02	-0.04
99	66	195	21.41	4.85	-21.37	-3.85	0.03	1.00
100	66	195	21.41	4.85	-21.37	-3.85	0.03	1.00
101	67	69	62.13	22.09	-62.00	-15.34	0.13	6.75
102	67	171	-31.06	-11.10	31.07	7.93	0.00	-3.16
103	67	171	-31.06	-11.10	31.07	7.93	0.00	-3.16
104	68	70	62.20	22.09	-62.00	-15.34	0.20	6.75
105	68	173	-62.20	-22.19	62.23	11.87	0.02	-10.32
106	71	72	103.12	-71.62	-103.01	77.82	0.11	6.20
107	71	73	128.66	-130.87	-128.38	147.67	0.28	16.80
108	71	73	162.96	-166.10	-162.58	187.39	0.38	21.30
109	71	86	398.84	229.67	-398.20	-236.00	0.65	-6.33
110	71	185	305.44	132.82	-305.37	-135.09	0.07	-2.27
111	72	74	16.13	2.19	-16.12	-1.80	0.01	0.39
112	72	128	48.46	46.92	-48.20	-46.86	0.26	0.06
113	72	128	48.46	46.92	-48.20	-46.86	0.26	0.06
114	73	75	16.13	2.16	-16.12	-1.80	0.01	0.36
115	73	113	53.06	12.50	-52.95	-12.87	0.11	-0.38
116	73	147	29.45	45.14	-29.42	-45.38	0.03	-0.24
117	73	147	29.45	45.14	-29.42	-45.38	0.03	-0.24
118	73	186	99.66	11.65	-99.60	-11.49	0.06	0.16
119	73	186	99.66	11.65	-99.60	-11.49	0.06	0.16
120	76	77	69.23	23.38	-69.09	-15.99	0.14	7.39
121	76	135	-34.61	-11.75	34.62	9.54	0.00	-2.21
122	76	135	-34.61	-11.75	34.62	9.54	0.00	-2.21
123	78	79	60.31	19.36	-60.20	-13.31	0.11	6.05
124	78	80	60.31	19.36	-60.20	-13.31	0.11	6.05
125	78	81	60.31	19.36	-60.20	-13.31	0.11	6.05

126	78	85	-90.47	-29.20	90.49	29.28	0.02	0.07
127	78	85	-90.47	-29.20	90.49	29.28	0.02	0.07
128	82	84	34.28	-33.89	-34.25	35.68	0.03	1.79
129	82	84	34.28	-33.89	-34.25	35.68	0.03	1.79
130	82	127	207.50	112.21	-207.24	-121.54	0.26	-9.33
131	82	213	-127.80	-30.59	128.00	42.69	0.20	12.10
132	82	214	-149.74	-46.43	150.00	61.93	0.26	15.50
133	83	124	130.14	22.01	-129.45	-18.03	0.69	3.99
134	83	128	86.86	1.06	-86.46	-0.23	0.40	0.83
135	83	128	86.86	1.06	-86.46	-0.23	0.40	0.83
136	83	179	101.54	16.71	-100.99	-14.28	0.55	2.44
137	83	215	-127.81	-12.90	128.00	23.95	0.19	11.04
138	83	216	-127.81	-12.90	128.00	23.95	0.19	11.04
139	83	217	-149.77	-15.23	150.00	28.88	0.23	13.65
140	84	85	237.70	-3.15	-237.58	3.82	0.12	0.67
141	84	85	237.70	-3.15	-237.58	3.82	0.12	0.67
142	84	218	-127.82	-9.91	128.00	20.85	0.18	10.94
143	84	219	-127.82	-9.91	128.00	20.85	0.18	10.94
144	84	220	-149.77	-11.74	150.00	25.26	0.23	13.52
145	85	129	90.19	-36.10	-89.70	37.37	0.49	1.27
146	85	129	90.19	-36.10	-89.70	37.37	0.49	1.27
147	85	159	100.83	2.31	-100.16	-0.46	0.67	1.85
148	85	159	100.83	2.31	-100.16	-0.46	0.67	1.85
149	85	221	-87.87	1.27	88.00	6.05	0.13	7.32
150	86	87	144.23	-129.55	-143.91	148.68	0.32	19.13
151	86	88	98.59	-69.02	-98.47	76.39	0.12	7.37
152	86	127	126.31	62.63	-126.27	-71.25	0.04	-8.62
153	87	90	26.02	5.93	-26.00	-4.93	0.02	1.00
154	87	150	128.09	41.19	-127.81	-40.20	0.29	0.99
155	87	150	128.09	41.19	-127.81	-40.20	0.29	0.99
156	87	186	-119.99	-26.21	120.47	27.73	0.48	1.51
157	88	89	26.02	5.99	-26.00	-4.93	0.02	1.06
158	88	91	105.54	66.12	-105.39	-65.59	0.16	0.53
159	88	129	-11.13	7.99	11.14	-8.52	0.01	-0.52
160	88	129	-11.13	7.99	11.14	-8.52	0.01	-0.52
161	91	92	50.88	20.52	-50.80	-15.99	0.08	4.53
162	91	93	63.11	17.72	-62.99	-11.26	0.12	6.46
163	91	95	48.08	11.26	-48.07	-16.02	0.01	-4.76
164	91	129	-71.85	-23.78	71.96	23.90	0.11	0.12
165	91	194	15.16	39.66	-15.13	-39.89	0.03	-0.22
166	94	96	48.12	16.01	-48.00	-12.05	0.12	3.96
167	94	179	-48.12	-16.10	48.13	11.91	0.01	-4.20
168	95	97	48.07	15.91	-48.00	-12.05	0.07	3.86
169	98	99	22.39	4.30	-22.38	-3.53	0.01	0.77
170	98	100	22.39	4.30	-22.38	-3.53	0.01	0.77
171	98	101	86.63	35.19	-86.51	-34.76	0.12	0.42
172	98	112	-53.93	52.92	53.97	-52.88	0.04	0.04
173	98	118	-38.74	-48.46	38.86	48.18	0.11	-0.28
174	98	118	-38.74	-48.46	38.86	48.18	0.11	-0.28
175	101	102	64.97	14.75	-64.85	-8.10	0.12	6.65
176	101	103	64.97	14.75	-64.85	-8.10	0.12	6.65
177	101	104	64.97	14.75	-64.85	-8.10	0.12	6.65
178	101	112	-108.41	-9.79	108.58	10.59	0.17	0.80
179	105	106	26.77	6.37	-26.75	-5.13	0.02	1.24
180	105	107	26.77	6.37	-26.75	-5.13	0.02	1.24
181	105	108	26.77	6.37	-26.75	-5.13	0.02	1.24
182	105	156	-51.14	-12.19	51.48	11.62	0.34	-0.57
183	109	110	63.28	18.56	-63.15	-11.83	0.13	6.73
184	109	111	63.28	18.56	-63.15	-11.83	0.13	6.73
185	109	129	-171.24	-64.59	172.49	69.83	1.26	5.25
186	109	159	-120.74	-11.94	121.28	13.79	0.54	1.85
187	109	171	30.85	5.54	-30.83	-5.68	0.02	-0.14
188	109	171	30.85	5.54	-30.83	-5.68	0.02	-0.14
189	109	171	57.59	21.00	-57.58	-26.28	0.01	-5.27
190	109	174	46.14	7.17	-46.13	-13.62	0.01	-6.45

191	109	193	0.00	-0.07	0.00	0.00	0.00	-0.07
192	112	222	-32.90	10.77	33.00	-7.61	0.10	3.16
193	112	223	-32.90	10.82	33.00	-7.68	0.10	3.14
194	112	224	-32.90	10.82	33.00	-7.68	0.10	3.14
195	112	225	-63.87	9.54	64.00	-2.26	0.13	7.28
196	113	114	45.81	8.11	-45.72	-5.13	0.09	2.98
197	113	115	45.78	8.13	-45.72	-5.13	0.06	3.00
198	113	116	45.78	8.13	-45.72	-5.13	0.06	3.00
199	113	143	-105.45	15.90	105.48	-21.44	0.03	-5.54
200	113	162	21.03	-27.74	-21.03	21.75	0.00	-5.99
201	117	118	116.23	-42.25	-116.10	49.59	0.12	7.34
202	117	118	116.23	-42.25	-116.10	49.59	0.12	7.34
203	117	118	116.23	-42.25	-116.10	49.59	0.12	7.34
204	117	189	110.09	-56.51	-110.04	45.41	0.06	-11.10
205	118	119	33.50	10.06	-33.47	-8.29	0.03	1.77
206	118	120	32.42	9.35	-32.39	-7.70	0.03	1.65
207	118	121	38.29	15.34	-38.19	-16.47	0.10	-1.14
208	118	121	38.29	15.34	-38.19	-16.47	0.10	-1.14
209	118	139	55.64	15.64	-55.58	-15.88	0.06	-0.24
210	118	139	55.64	15.64	-55.58	-15.88	0.06	-0.24
211	118	166	20.43	4.11	-20.41	-5.47	0.02	-1.35
212	118	166	20.43	4.11	-20.41	-5.47	0.02	-1.35
213	121	122	37.92	7.96	-37.85	-5.77	0.07	2.19
214	121	123	37.92	7.96	-37.85	-5.77	0.07	2.19
215	124	125	59.48	10.07	-59.37	-4.44	0.11	5.63
216	124	126	59.42	6.93	-59.37	-4.44	0.05	2.49
217	124	179	10.56	0.87	-10.56	-1.29	0.00	-0.42
218	127	128	64.79	-48.71	-64.73	52.07	0.06	3.36
219	127	128	64.79	-48.71	-64.73	52.07	0.06	3.36
220	127	129	89.32	-71.69	-89.21	78.37	0.11	6.67
221	127	129	89.32	-71.69	-89.21	78.37	0.11	6.67
222	127	130	0.00	0.00	0.00	0.00	0.00	0.00
223	128	131	64.67	25.75	-64.53	-18.35	0.14	7.40
224	128	134	64.67	25.75	-64.53	-18.35	0.14	7.40
225	128	179	137.27	20.54	-136.69	-18.36	0.58	2.18
226	128	179	137.27	20.54	-136.69	-18.36	0.58	2.18
227	129	132	55.65	10.68	-55.59	-7.40	0.06	3.28
228	129	133	55.65	10.68	-55.59	-7.40	0.06	3.28
229	135	136	39.48	12.50	-39.41	-10.15	0.07	2.35
230	135	137	39.48	12.50	-39.41	-10.15	0.07	2.35
231	135	138	0.00	0.00	-0.00	-0.00	0.00	0.00
232	135	186	-70.21	-20.39	70.22	13.71	0.02	-6.68
233	135	186	-77.98	-23.96	78.00	12.77	0.02	-11.19
234	139	140	37.06	10.47	-37.00	-8.33	0.06	2.14
235	139	141	37.04	10.49	-37.00	-8.33	0.04	2.16
236	139	142	37.06	10.47	-37.00	-8.33	0.06	2.14
237	143	144	27.76	5.52	-27.70	-3.75	0.06	1.77
238	143	145	27.72	4.85	-27.70	-3.75	0.02	1.10
239	143	146	27.72	4.85	-27.70	-3.75	0.02	1.10
240	143	147	-188.68	5.85	188.75	-9.55	0.07	-3.70
241	147	148	37.57	2.86	-37.53	-0.89	0.04	1.97
242	147	149	37.57	2.86	-37.53	-0.89	0.04	1.97
243	147	190	-102.52	47.18	102.66	-46.55	0.14	0.62
244	147	190	-102.52	47.18	102.66	-46.55	0.14	0.62
245	150	151	66.17	21.68	-66.04	-14.81	0.13	6.87
246	150	152	66.17	21.68	-66.04	-14.81	0.13	6.87
247	150	153	66.17	21.68	-66.04	-14.81	0.13	6.87
248	150	169	57.11	15.01	-57.10	-21.26	0.01	-6.25
249	154	155	55.15	18.92	-55.06	-14.22	0.09	4.70
250	154	186	-55.15	-19.04	55.16	19.03	0.01	-0.01
251	156	157	23.44	5.85	-23.40	-4.67	0.04	1.18
252	156	158	23.42	5.59	-23.40	-4.67	0.02	0.92
253	159	160	47.07	13.52	-47.00	-9.86	0.07	3.66
254	159	161	47.07	13.52	-47.00	-9.86	0.07	3.66
255	159	194	-15.09	-40.12	15.13	39.89	0.04	-0.24

256	162	163	36.06	9.02	-36.00	-7.12	0.06	1.90
257	162	164	36.04	9.04	-36.00	-7.12	0.04	1.92
258	162	165	36.11	10.23	-36.00	-7.12	0.11	3.11
259	162	186	-87.17	-50.41	87.21	41.91	0.04	-8.50
260	166	167	20.41	5.36	-20.40	-4.71	0.01	0.65
261	166	168	20.41	5.36	-20.40	-4.71	0.01	0.65
262	169	170	57.10	21.14	-57.00	-15.88	0.10	5.26
263	171	172	57.11	21.67	-57.00	-15.88	0.11	5.79
264	173	175	35.06	7.47	-35.00	-5.48	0.06	1.99
265	173	176	35.06	7.47	-35.00	-5.48	0.06	1.99
266	173	179	-132.35	-27.00	132.48	14.58	0.14	-12.43
267	174	177	23.06	6.71	-23.00	-4.93	0.06	1.78
268	174	178	23.06	6.71	-23.00	-4.93	0.06	1.78
269	179	180	51.08	7.42	-51.00	-3.29	0.08	4.13
270	179	181	51.08	7.42	-51.00	-3.29	0.08	4.13
271	179	182	51.08	7.42	-51.00	-3.29	0.08	4.13
272	179	183	51.08	7.42	-51.00	-3.29	0.08	4.13
273	179	184	0.00	-4.26	0.00	0.00	0.00	-4.26
274	185	186	136.13	-130.13	-135.83	147.87	0.30	17.73
275	185	186	136.13	-130.13	-135.83	147.87	0.30	17.73
276	186	187	46.56	9.69	-46.50	-6.57	0.06	3.12
277	186	188	46.56	9.69	-46.50	-6.57	0.06	3.12
278	189	190	205.70	-70.49	-205.33	93.11	0.38	22.62
279	189	191	0.00	0.00	0.00	0.00	0.00	0.00
280	189	192	0.00	0.00	0.00	0.00	0.00	0.00
281	196	197	0.00	0.00	0.00	0.00	0.00	0.00
282	196	198	0.00	-2.78	0.00	-0.06	0.00	-2.83
283	198	199	0.00	0.00	0.00	0.00	0.00	0.00
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						Total:	43.29	215.72

E. SOLUTION FOR THE CHANGE CASE OF THE 225-BUS SYSTEM

REPORT OF SYSTEM SUMMARY

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MAXIMUM POWER MISMATCH           : 0.0000303020 pu.
ITERATIONS                       : 3
SOLUTION TIME                    : 1.077 sec.
TOTAL TIME                       : 9.534 sec.
BUSES                            : 225
GENERATOR BUS                    : 196
LOAD BUS                         : 28
SWING BUS                        : 1
BRANCHES                         : 283
SHUNTS                           : 78
SHUNT INJECTIONS(MW)             : -9.3
SHUNT INJECTIONS(MWAR)           : -14.3
TRANSFORMERS                     : 163
TOTAL REAL GEN CAPACITY(MW)      : 3864.49
TOTAL REACTIVE GEN CAPACITY(MVAR): 880.33
TOTAL REAL POWER LOSSES(MW)      : 43.29
TOTAL REACTIVE POWER LOSSES(MVAR): 215.72
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|==========================BUS INFORMATION==========================|

BUS	VOLTAGE		GENERATION		LOAD	
	VOLTS (pu)	ANGLE (deg)	REAL (MW)	REACTIVE (MVAR)	REAL (MW)	REACTIVE (MVAR)
1	1.000	3.130	734.15	156.95	0.00	0.00
2	1.000	1.423	300.00	261.42	0.00	0.00
3	1.000	8.467	299.19	-61.47	0.00	0.00
4	0.997	1.712	0.00	0.00	0.00	0.00
5	1.010	3.117	0.00	0.00	0.00	0.00
6	1.012	1.439	0.00	0.00	0.00	0.00
7	1.012	1.439	0.00	0.00	0.00	0.00
8	0.997	1.749	0.00	0.00	0.00	0.00
9	0.983	-1.872	0.00	0.00	32.51	5.33
10	0.997	1.749	0.00	0.00	0.00	0.00
11	0.997	1.749	0.00	0.00	0.00	0.00
12	0.994	0.133	0.00	0.00	0.00	0.00
13	0.984	-2.727	0.00	0.00	32.50	5.07
14	0.984	-2.727	0.00	0.00	32.50	5.07
15	0.986	-0.680	0.00	0.00	0.00	0.00
16	0.966	-5.838	0.00	0.00	57.00	9.48
17	0.966	-5.838	0.00	0.00	57.00	9.48
18	0.990	-0.488	0.00	0.00	0.00	0.00
19	0.969	-5.949	0.00	0.00	38.26	5.33
20	0.979	-3.892	0.00	0.00	38.26	5.33
21	0.978	-3.862	0.00	0.00	38.26	5.33
22	0.990	-0.605	0.00	0.00	0.00	0.00
23	0.971	-5.876	0.00	0.00	37.00	4.38
24	0.971	-6.389	0.00	0.00	12.35	1.51
25	0.991	-0.309	0.00	0.00	0.00	0.00
26	0.988	-3.443	0.00	0.00	15.24	0.00
27	1.011	3.351	0.00	0.00	0.00	0.00
28	1.009	1.407	0.00	0.00	0.00	0.00
29	0.998	0.132	0.00	0.00	0.00	0.00
30	0.987	-2.343	0.00	0.00	12.19	2.37
31	1.020	4.413	0.00	0.00	0.00	0.00
32	1.020	4.413	0.00	0.00	0.00	0.00

33	1.020	4.413	0.00	0.00	0.00	0.00
34	0.954	-5.110	0.00	0.00	0.00	0.00
35	0.928	-11.713	0.00	0.00	42.67	5.92
36	0.996	1.114	0.00	0.00	0.00	0.00
37	0.986	-1.219	0.00	0.00	10.50	1.92
38	0.986	-1.219	0.00	0.00	10.50	1.92
39	0.987	-0.741	0.00	0.00	0.00	0.00
40	0.987	-0.885	0.00	0.00	1.02	0.00
41	1.005	0.911	0.00	0.00	0.00	0.00
42	0.997	-1.249	0.00	0.00	39.63	5.92
43	0.963	-3.994	0.00	0.00	0.00	0.00
44	0.961	-5.955	0.00	0.00	13.21	0.00
45	0.995	-0.142	0.00	0.00	0.00	0.00
46	0.995	-0.142	0.00	0.00	0.00	0.00
47	0.995	-0.142	0.00	0.00	0.00	0.00
48	1.001	0.942	0.00	0.00	0.00	0.00
49	0.997	-0.897	0.00	0.00	9.14	0.57
50	0.994	-2.675	0.00	0.00	9.14	0.57
51	0.992	0.217	0.00	0.00	0.00	0.00
52	0.982	-2.404	0.00	0.00	6.50	1.21
53	0.984	-1.578	0.00	0.00	6.50	1.21
54	0.984	-0.952	0.00	0.00	0.00	0.00
55	0.984	-0.952	0.00	0.00	0.00	0.00
56	0.984	-0.952	0.00	0.00	0.00	0.00
57	0.998	1.805	0.00	0.00	0.00	0.00
58	0.995	-0.142	0.00	0.00	0.00	0.00
59	0.992	-1.463	0.00	0.00	15.11	1.18
60	1.020	4.437	0.00	0.00	0.00	0.00
61	1.003	0.577	0.00	0.00	0.00	0.00
62	0.993	-1.563	0.00	0.00	21.34	4.74
63	0.995	0.205	0.00	0.00	0.00	0.00
64	0.995	0.205	0.00	0.00	0.00	0.00
65	0.995	0.205	0.00	0.00	0.00	0.00
66	0.959	-2.890	0.00	0.00	0.00	0.00
67	0.986	-4.893	0.00	0.00	0.00	0.00
68	0.982	-4.430	0.00	0.00	0.00	0.00
69	0.955	-10.566	0.00	0.00	62.00	15.34
70	0.950	-10.086	0.00	0.00	62.00	15.34
71	0.981	0.378	0.00	0.00	0.00	0.00
72	1.009	-1.910	0.00	0.00	0.00	0.00
73	1.046	-3.131	0.00	0.00	0.00	0.00
74	1.005	-3.280	0.00	0.00	16.12	1.80
75	1.043	-4.405	0.00	0.00	16.12	1.80
76	1.044	-3.625	0.00	0.00	0.00	0.00
77	1.013	-9.255	0.00	0.00	69.09	15.99
78	1.000	-1.861	0.00	0.00	0.00	0.00
79	0.973	-7.192	0.00	0.00	60.20	13.31
80	0.973	-7.192	0.00	0.00	60.20	13.31
81	0.973	-7.192	0.00	0.00	60.20	13.31
82	0.975	-0.104	0.00	0.00	0.00	0.00
83	0.998	-1.251	0.00	0.00	0.00	0.00
84	1.001	-1.606	0.00	0.00	0.00	0.00
85	1.000	-1.782	0.00	0.00	0.00	0.00
86	0.971	-0.458	0.00	0.00	0.00	0.00
87	1.036	-4.461	0.00	0.00	0.00	0.00
88	1.006	-3.268	0.00	0.00	0.00	0.00
89	0.997	-5.501	0.00	0.00	26.00	4.93
90	1.028	-6.562	0.00	0.00	26.00	4.93
91	1.001	-3.521	0.00	0.00	0.00	0.00
92	0.972	-8.007	0.00	0.00	50.80	15.99
93	0.977	-9.069	0.00	0.00	62.99	11.26
94	0.986	-3.676	0.00	0.00	0.00	0.00
95	1.001	-3.592	0.00	0.00	0.00	0.00
96	0.962	-7.982	0.00	0.00	48.00	12.05
97	0.978	-7.810	0.00	0.00	48.00	12.05

98	1.008	-0.548	0.00	0.00	0.00	0.00
99	1.002	-2.455	0.00	0.00	22.38	3.53
100	1.002	-2.455	0.00	0.00	22.38	3.53
101	1.003	-1.067	0.00	0.00	0.00	0.00
102	0.984	-6.733	0.00	0.00	64.85	8.10
103	0.984	-6.733	0.00	0.00	64.85	8.10
104	0.984	-6.733	0.00	0.00	64.85	8.10
105	0.960	-2.801	0.00	0.00	0.00	0.00
106	0.950	-5.326	0.00	0.00	26.75	5.13
107	0.950	-5.326	0.00	0.00	26.75	5.13
108	0.950	-5.326	0.00	0.00	26.75	5.13
109	0.987	-4.768	0.00	0.00	0.00	0.00
110	0.961	-10.506	0.00	0.00	63.15	11.83
111	0.961	-10.506	0.00	0.00	63.15	11.83
112	1.006	-0.370	0.00	0.00	0.00	0.00
113	1.042	-3.640	0.00	0.00	0.00	0.00
114	1.030	-7.282	0.00	0.00	45.72	5.13
115	1.031	-7.313	0.00	0.00	45.72	5.13
116	1.031	-7.313	0.00	0.00	45.72	5.13
117	1.000	3.032	0.00	0.00	0.00	0.00
118	1.021	-0.120	0.00	0.00	0.00	0.00
119	1.006	-2.921	0.00	0.00	33.47	8.29
120	1.007	-2.829	0.00	0.00	32.39	7.70
121	1.013	-0.859	0.00	0.00	0.00	0.00
122	1.001	-4.046	0.00	0.00	37.85	5.77
123	1.001	-4.046	0.00	0.00	37.85	5.77
124	0.987	-3.553	0.00	0.00	0.00	0.00
125	0.974	-8.889	0.00	0.00	59.37	4.44
126	0.982	-5.924	0.00	0.00	59.37	4.44
127	0.969	-0.630	0.00	0.00	0.00	0.00
128	0.993	-2.504	0.00	0.00	0.00	0.00
129	1.005	-3.176	0.00	0.00	0.00	0.00
130	0.969	-0.630	0.00	0.00	0.00	0.00
131	0.957	-8.343	0.00	0.00	64.53	18.35
132	0.994	-6.460	0.00	0.00	55.59	7.40
133	0.994	-6.460	0.00	0.00	55.59	7.40
134	0.957	-8.343	0.00	0.00	64.53	18.35
135	1.044	-3.605	0.00	0.00	0.00	0.00
136	1.026	-6.737	0.00	0.00	39.41	10.15
137	1.026	-6.737	0.00	0.00	39.41	10.15
138	1.044	-3.605	0.00	0.00	0.00	0.00
139	1.018	-0.523	0.00	0.00	0.00	0.00
140	1.002	-3.611	0.00	0.00	37.00	8.33
141	1.003	-3.642	0.00	0.00	37.00	8.33
142	1.002	-3.611	0.00	0.00	37.00	8.33
143	1.041	-3.472	0.00	0.00	0.00	0.00
144	1.028	-7.010	0.00	0.00	27.70	3.75
145	1.034	-5.688	0.00	0.00	27.70	3.75
146	1.034	-5.688	0.00	0.00	27.70	3.75
147	1.041	-3.248	0.00	0.00	0.00	0.00
148	1.038	-6.247	0.00	0.00	37.53	0.89
149	1.038	-6.247	0.00	0.00	37.53	0.89
150	1.031	-4.979	0.00	0.00	0.00	0.00
151	1.002	-10.482	0.00	0.00	66.04	14.81
152	1.002	-10.482	0.00	0.00	66.04	14.81
153	1.002	-10.482	0.00	0.00	66.04	14.81
154	1.044	-3.509	0.00	0.00	0.00	0.00
155	1.018	-7.964	0.00	0.00	55.06	14.22
156	0.973	-1.174	0.00	0.00	0.00	0.00
157	0.961	-3.905	0.00	0.00	23.40	4.67
158	0.964	-3.322	0.00	0.00	23.40	4.67
159	0.993	-3.594	0.00	0.00	0.00	0.00
160	0.974	-7.776	0.00	0.00	47.00	9.86
161	0.974	-7.776	0.00	0.00	47.00	9.86
162	1.042	-3.677	0.00	0.00	0.00	0.00

163	1.029	-6.538	0.00	0.00	36.00	7.12
164	1.029	-6.565	0.00	0.00	36.00	7.12
165	1.019	-8.305	0.00	0.00	36.00	7.12
166	1.019	-0.445	0.00	0.00	0.00	0.00
167	1.011	-2.149	0.00	0.00	20.40	4.71
168	1.011	-2.149	0.00	0.00	20.40	4.71
169	1.030	-5.077	0.00	0.00	0.00	0.00
170	1.001	-9.828	0.00	0.00	57.00	15.88
171	0.986	-4.867	0.00	0.00	0.00	0.00
172	0.955	-10.075	0.00	0.00	57.00	15.88
173	0.984	-4.214	0.00	0.00	0.00	0.00
174	0.986	-4.866	0.00	0.00	0.00	0.00
175	0.972	-7.336	0.00	0.00	35.00	5.48
176	0.972	-7.336	0.00	0.00	35.00	5.48
177	0.966	-8.983	0.00	0.00	23.00	4.93
178	0.966	-8.983	0.00	0.00	23.00	4.93
179	0.986	-3.609	0.00	0.00	0.00	0.00
180	0.977	-8.180	0.00	0.00	51.00	3.29
181	0.977	-8.180	0.00	0.00	51.00	3.29
182	0.977	-8.180	0.00	0.00	51.00	3.29
183	0.977	-8.180	0.00	0.00	51.00	3.29
184	0.986	-3.610	0.00	0.00	0.00	0.00
185	0.980	0.237	0.00	0.00	0.00	0.00
186	1.045	-3.481	0.00	0.00	0.00	0.00
187	1.031	-7.201	0.00	0.00	46.50	6.57
188	1.031	-7.201	0.00	0.00	46.50	6.57
189	1.002	2.771	0.00	0.00	0.00	0.00
190	1.038	-2.707	0.00	0.00	0.00	0.00
191	1.002	2.771	0.00	0.00	0.00	0.00
192	1.002	2.771	0.00	0.00	0.00	0.00
193	0.987	-4.768	0.00	0.00	0.00	0.00
194	0.997	-3.556	0.00	0.00	0.00	0.00
195	0.949	-5.453	0.00	0.00	42.75	7.70
196	0.968	-4.090	0.00	0.00	0.00	0.00
197	0.968	-4.090	0.00	0.00	0.00	0.00
198	0.969	-4.112	0.00	0.00	0.00	0.00
199	0.969	-4.112	0.00	0.00	0.00	0.00
200	1.014	5.580	23.00	5.34	0.00	0.00
201	0.983	5.780	23.00	-4.75	0.00	0.00
202	0.981	4.321	11.00	-3.97	0.00	0.00
203	1.003	9.300	101.00	-4.51	0.00	0.00
204	1.005	6.939	94.00	-1.39	0.00	0.00
206	1.014	5.546	146.00	38.23	0.00	0.00
207	1.013	6.482	146.00	30.26	0.00	0.00
208	1.013	6.482	146.00	30.26	0.00	0.00
209	1.006	9.157	155.00	-21.95	0.00	0.00
210	1.141	8.399	152.00	256.00	0.00	0.00
211	1.004	9.079	152.00	-26.31	0.00	0.00
212	0.993	6.173	50.00	0.30	0.00	0.00
213	1.002	4.878	128.00	42.69	0.00	0.00
214	1.010	5.102	150.00	61.93	0.00	0.00
215	1.012	3.581	128.00	23.95	0.00	0.00
216	1.012	3.581	128.00	23.95	0.00	0.00
217	1.013	3.840	150.00	28.88	0.00	0.00
218	1.012	3.211	128.00	20.85	0.00	0.00
219	1.012	3.211	128.00	20.85	0.00	0.00
220	1.013	3.470	150.00	25.26	0.00	0.00
221	1.004	2.979	88.00	6.05	0.00	0.00
222	0.984	4.773	33.00	-7.61	0.00	0.00
223	0.984	4.740	33.00	-7.68	0.00	0.00
224	0.984	4.740	33.00	-7.68	0.00	0.00
225	0.998	6.102	64.00	-2.26	0.00	0.00
205	1.005	-0.370	-8.85	-3.25	21.46	0.00
		TOTAL:	3864.49	880.33	3821.58	672.35

|===============================BRANCH INFORMATION==============================|

BRNCH	FROM BUS	T0 BUS	REAL FROM BUS (MW)	REACTIVE INJ (MVAR)	REAL TO BUS (MW)	REACTIVE INJ (MVAR)	REAL LOSS (MW)	REACTIVE LOSS (MVAR)
1	1	71	638.42	199.76	-635.69	-196.34	2.72	3.43
2	1	189	95.73	-42.81	-95.67	24.77	0.06	-18.04
3	2	71	300.00	261.42	-299.16	-277.08	0.84	-15.66
4	3	117	299.19	-61.47	-296.40	-2.97	2.79	-64.44
5	4	36	56.83	-7.56	-56.70	7.39	0.12	-0.17
6	4	200	-22.93	-3.72	23.00	5.34	0.07	1.63
7	4	201	-22.92	6.46	23.00	-4.75	0.08	1.71
8	4	202	-10.98	4.54	11.00	-3.97	0.02	0.57
9	5	6	41.48	-3.14	-41.45	4.36	0.02	1.22
10	5	6	41.48	-3.14	-41.45	4.36	0.02	1.22
11	5	27	-84.68	-30.00	84.72	15.62	0.04	-14.38
12	6	7	0.00	-0.00	-0.00	0.00	0.00	0.00
13	6	28	2.75	3.88	-2.74	-5.43	0.00	-1.55
14	6	29	44.82	10.58	-44.46	-11.36	0.36	-0.77
15	6	48	15.58	9.28	-15.50	-11.53	0.08	-2.25
16	6	61	21.48	3.36	-21.37	-5.67	0.11	-2.31
17	8	9	32.58	7.48	-32.51	-5.33	0.07	2.15
18	8	10	0.00	0.00	0.00	0.00	0.00	0.00
19	8	11	0.00	0.00	0.00	0.00	0.00	0.00
20	8	51	74.14	-0.52	-73.73	0.97	0.41	0.45
21	8	57	-180.09	-26.00	180.11	26.14	0.02	0.15
22	8	105	73.37	18.95	-72.02	-17.03	1.36	1.92
23	12	13	32.53	6.75	-32.50	-5.07	0.03	1.68
24	12	14	32.53	6.75	-32.50	-5.07	0.03	1.68
25	12	15	21.49	6.76	-21.42	-9.47	0.06	-2.70
26	12	18	23.76	1.79	-23.68	-3.10	0.08	-1.31
27	12	28	-31.43	-10.25	31.69	8.39	0.26	-1.85
28	12	63	-78.89	-12.02	78.90	12.05	0.02	0.03
29	15	16	57.10	14.87	-57.00	-9.48	0.10	5.39
30	15	17	57.10	14.87	-57.00	-9.48	0.10	5.39
31	15	18	-11.76	-7.17	11.78	6.11	0.02	-1.07
32	15	39	1.02	-3.13	-1.02	-0.13	0.00	-3.26
33	15	57	-82.04	-10.18	82.51	11.40	0.47	1.22
34	18	19	38.40	9.14	-38.26	-5.33	0.14	3.81
35	18	20	38.30	7.68	-38.26	-5.33	0.04	2.35
36	18	21	38.33	7.66	-38.26	-5.33	0.07	2.33
37	18	51	-38.75	4.39	38.90	-4.94	0.15	-0.55
38	18	51	-38.75	4.39	38.90	-4.94	0.15	-0.55
39	18	58	-25.21	-16.03	25.24	15.06	0.03	-0.97
40	18	121	-0.42	-20.58	0.55	16.81	0.13	-3.77
41	22	23	37.13	7.91	-37.00	-4.38	0.13	3.53
42	22	24	12.37	2.80	-12.35	-1.51	0.02	1.29
43	22	25	-17.40	-1.47	17.42	0.32	0.02	-1.15
44	22	29	-32.10	-9.37	32.25	8.39	0.15	-0.98
45	25	26	15.27	0.84	-15.24	-0.00	0.03	0.84
46	25	36	-32.69	-1.19	32.86	-1.17	0.17	-2.37
47	27	28	72.18	3.91	-72.14	-1.46	0.04	2.45
48	27	31	-109.17	-63.02	109.40	11.91	0.23	-51.11
49	27	60	-161.26	-83.07	161.54	33.05	0.28	-50.01
50	27	71	211.55	55.18	-210.45	-145.89	1.10	-90.71
51	27	203	-100.81	15.08	101.00	-4.51	0.19	10.57
52	28	41	68.95	23.35	-68.83	-23.26	0.11	0.08
53	28	58	40.52	14.66	-40.35	-16.71	0.17	-2.06
54	28	204	-93.84	10.49	94.00	-1.39	0.16	9.10
55	28	205	30.33	4.21	-30.31	-3.25	0.02	0.96
56	29	30	12.21	2.93	-12.19	-2.37	0.02	0.56
57	31	32	0.00	0.00	0.00	0.00	0.00	0.00
58	31	33	0.00	0.00	0.00	0.00	0.00	0.00

59	31	60	-109.40	-12.16	109.40	11.01	0.00	-1.15
60	34	35	42.86	11.08	-42.67	-5.92	0.19	5.16
61	34	43	-42.86	-11.20	43.05	10.40	0.20	-0.80
62	36	37	10.52	2.37	-10.50	-1.92	0.02	0.45
63	36	38	10.52	2.37	-10.50	-1.92	0.02	0.45
64	36	48	2.81	-11.11	-2.80	9.46	0.02	-1.65
65	39	40	1.02	0.00	-1.02	-0.00	0.00	0.00
66	41	42	19.84	3.73	-19.81	-2.96	0.02	0.77
67	41	42	19.84	3.73	-19.81	-2.96	0.02	0.77
68	41	63	29.16	15.64	-29.07	-17.23	0.09	-1.59
69	43	44	13.23	0.45	-13.21	-0.00	0.02	0.45
70	43	54	-56.29	-4.70	57.26	4.85	0.97	0.15
71	43	196	0.01	-6.27	-0.00	2.77	0.01	-3.51
72	45	46	0.00	0.00	0.00	0.00	0.00	0.00
73	45	47	0.00	0.00	0.00	0.00	0.00	0.00
74	45	58	-0.00	-0.08	0.00	0.00	0.00	-0.07
75	45	58	-0.00	-0.08	0.00	0.00	0.00	-0.07
76	48	49	9.15	0.87	-9.14	-0.57	0.01	0.30
77	48	50	9.15	1.15	-9.14	-0.57	0.01	0.58
78	51	52	6.51	1.52	-6.50	-1.21	0.01	0.31
79	51	53	6.51	1.42	-6.50	-1.21	0.01	0.21
80	51	54	57.64	5.04	-57.26	-5.02	0.38	0.02
81	51	57	-74.72	0.91	75.16	-0.39	0.43	0.52
82	54	55	-0.00	0.00	0.00	-0.00	0.00	0.00
83	54	56	0.00	0.00	0.00	0.00	0.00	0.00
84	57	156	99.54	26.77	-98.33	-23.24	1.21	3.53
85	57	206	-145.80	-28.16	146.00	38.23	0.20	10.07
86	57	207	-145.76	-17.98	146.00	30.26	0.24	12.28
87	57	208	-145.76	-17.98	146.00	30.26	0.24	12.28
88	58	59	15.12	1.53	-15.11	-1.18	0.01	0.35
89	60	117	187.05	100.43	-186.50	-153.46	0.56	-53.03
90	60	209	-154.79	35.11	155.00	-21.95	0.21	13.16
91	60	210	-151.41	-218.98	152.00	256.00	0.59	37.03
92	60	211	-151.79	39.15	152.00	-26.31	0.21	12.84
93	61	62	10.68	2.80	-10.67	-2.37	0.01	0.43
94	61	62	10.68	2.80	-10.67	-2.37	0.01	0.43
95	63	64	0.00	0.00	0.00	0.00	0.00	0.00
96	63	65	0.00	0.00	0.00	0.00	0.00	0.00
97	63	212	-49.83	4.91	50.00	0.30	0.17	5.21
98	66	105	-42.81	-9.85	42.83	9.81	0.02	-0.04
99	66	195	21.41	4.85	-21.37	-3.85	0.03	1.00
100	66	195	21.41	4.85	-21.37	-3.85	0.03	1.00
101	67	69	62.13	22.09	-62.00	-15.34	0.13	6.75
102	67	171	-31.06	-11.10	31.07	7.93	0.00	-3.16
103	67	171	-31.06	-11.10	31.07	7.93	0.00	-3.16
104	68	70	62.20	22.09	-62.00	-15.34	0.20	6.75
105	68	173	-62.20	-22.19	62.23	11.87	0.02	-10.32
106	71	72	103.12	-71.62	-103.01	77.82	0.11	6.20
107	71	73	128.66	-130.87	-128.38	147.67	0.28	16.80
108	71	73	162.96	-166.10	-162.58	187.39	0.38	21.30
109	71	86	398.84	229.67	-398.20	-236.00	0.65	-6.33
110	71	185	305.44	132.82	-305.37	-135.09	0.07	-2.27
111	72	74	16.13	2.19	-16.12	-1.80	0.01	0.39
112	72	128	48.46	46.92	-48.20	-46.86	0.26	0.06
113	72	128	48.46	46.92	-48.20	-46.86	0.26	0.06
114	73	75	16.13	2.16	-16.12	-1.80	0.01	0.36
115	73	113	53.06	12.50	-52.95	-12.87	0.11	-0.38
116	73	147	29.45	45.14	-29.42	-45.38	0.03	-0.24
117	73	147	29.45	45.14	-29.42	-45.38	0.03	-0.24
118	73	186	99.66	11.65	-99.60	-11.49	0.06	0.16
119	73	186	99.66	11.65	-99.60	-11.49	0.06	0.16
120	76	77	69.23	23.38	-69.09	-15.99	0.14	7.39
121	76	135	-34.61	-11.75	34.62	9.54	0.00	-2.21
122	76	135	-34.61	-11.75	34.62	9.54	0.00	-2.21
123	78	79	60.31	19.36	-60.20	-13.31	0.11	6.05

124	78	80	60.31	19.36	-60.20	-13.31	0.11	6.05
125	78	81	60.31	19.36	-60.20	-13.31	0.11	6.05
126	78	85	-90.47	-29.20	90.49	29.28	0.02	0.07
127	78	85	-90.47	-29.20	90.49	29.28	0.02	0.07
128	82	84	34.28	-33.89	-34.25	35.68	0.03	1.79
129	82	84	34.28	-33.89	-34.25	35.68	0.03	1.79
130	82	127	207.50	112.21	-207.24	-121.54	0.26	-9.33
131	82	213	-127.80	-30.59	128.00	42.69	0.20	12.10
132	82	214	-149.74	-46.43	150.00	61.93	0.26	15.50
133	83	124	130.14	22.01	-129.45	-18.03	0.69	3.99
134	83	128	86.86	1.06	-86.46	-0.23	0.40	0.83
135	83	128	86.86	1.06	-86.46	-0.23	0.40	0.83
136	83	179	101.54	16.71	-100.99	-14.28	0.55	2.44
137	83	215	-127.81	-12.90	128.00	23.95	0.19	11.04
138	83	216	-127.81	-12.90	128.00	23.95	0.19	11.04
139	83	217	-149.77	-15.23	150.00	28.88	0.23	13.65
140	84	85	237.70	-3.15	-237.58	3.82	0.12	0.67
141	84	85	237.70	-3.15	-237.58	3.82	0.12	0.67
142	84	218	-127.82	-9.91	128.00	20.85	0.18	10.94
143	84	219	-127.82	-9.91	128.00	20.85	0.18	10.94
144	84	220	-149.77	-11.74	150.00	25.26	0.23	13.52
145	85	129	90.19	-36.10	-89.70	37.37	0.49	1.27
146	85	129	90.19	-36.10	-89.70	37.37	0.49	1.27
147	85	159	100.83	2.31	-100.16	-0.46	0.67	1.85
148	85	159	100.83	2.31	-100.16	-0.46	0.67	1.85
149	85	221	-87.87	1.27	88.00	6.05	0.13	7.32
150	86	87	144.23	-129.55	-143.91	148.68	0.32	19.13
151	86	88	98.59	-69.02	-98.47	76.39	0.12	7.37
152	86	127	126.31	62.63	-126.27	-71.25	0.04	-8.62
153	87	90	26.02	5.93	-26.00	-4.93	0.02	1.00
154	87	150	128.09	41.19	-127.81	-40.20	0.29	0.99
155	87	150	128.09	41.19	-127.81	-40.20	0.29	0.99
156	87	186	-119.99	-26.21	120.47	27.73	0.48	1.51
157	88	89	26.02	5.99	-26.00	-4.93	0.02	1.06
158	88	91	105.54	66.12	-105.39	-65.59	0.16	0.53
159	88	129	-11.13	7.99	11.14	-8.52	0.01	-0.52
160	88	129	-11.13	7.99	11.14	-8.52	0.01	-0.52
161	91	92	50.88	20.52	-50.80	-15.99	0.08	4.53
162	91	93	63.11	17.72	-62.99	-11.26	0.12	6.46
163	91	95	48.08	11.26	-48.07	-16.02	0.01	-4.76
164	91	129	-71.85	-23.78	71.96	23.90	0.11	0.12
165	91	194	15.16	39.66	-15.13	-39.89	0.03	-0.22
166	94	96	48.12	16.01	-48.00	-12.05	0.12	3.96
167	94	179	-48.12	-16.10	48.13	11.91	0.01	-4.20
168	95	97	48.07	15.91	-48.00	-12.05	0.07	3.86
169	98	99	22.39	4.30	-22.38	-3.53	0.01	0.77
170	98	100	22.39	4.30	-22.38	-3.53	0.01	0.77
171	98	101	86.63	35.19	-86.51	-34.76	0.12	0.42
172	98	112	-53.93	52.92	53.97	-52.88	0.04	0.04
173	98	118	-38.74	-48.46	38.86	48.18	0.11	-0.28
174	98	118	-38.74	-48.46	38.86	48.18	0.11	-0.28
175	101	102	64.97	14.75	-64.85	-8.10	0.12	6.65
176	101	103	64.97	14.75	-64.85	-8.10	0.12	6.65
177	101	104	64.97	14.75	-64.85	-8.10	0.12	6.65
178	101	112	-108.41	-9.79	108.58	10.59	0.17	0.80
179	105	106	26.77	6.37	-26.75	-5.13	0.02	1.24
180	105	107	26.77	6.37	-26.75	-5.13	0.02	1.24
181	105	108	26.77	6.37	-26.75	-5.13	0.02	1.24
182	105	156	-51.14	-12.19	51.48	11.62	0.34	-0.57
183	109	110	63.28	18.56	-63.15	-11.83	0.13	6.73
184	109	111	63.28	18.56	-63.15	-11.83	0.13	6.73
185	109	129	-171.24	-64.59	172.49	69.83	1.26	5.25
186	109	159	-120.74	-11.94	121.28	13.79	0.54	1.85
187	109	171	30.85	5.54	-30.83	-5.68	0.02	-0.14
188	109	171	30.85	5.54	-30.83	-5.68	0.02	-0.14

189	109	171	57.59	21.00	-57.58	-26.28	0.01	-5.27
190	109	174	46.14	7.17	-46.13	-13.62	0.01	-6.45
191	109	193	0.00	-0.07	0.00	0.00	0.00	-0.07
192	112	222	-32.90	10.77	33.00	-7.61	0.10	3.16
193	112	223	-32.90	10.82	33.00	-7.68	0.10	3.14
194	112	224	-32.90	10.82	33.00	-7.68	0.10	3.14
195	112	225	-63.87	9.54	64.00	-2.26	0.13	7.28
196	113	114	45.81	8.11	-45.72	-5.13	0.09	2.98
197	113	115	45.78	8.13	-45.72	-5.13	0.06	3.00
198	113	116	45.78	8.13	-45.72	-5.13	0.06	3.00
199	113	143	-105.45	15.90	105.48	-21.44	0.03	-5.54
200	113	162	21.03	-27.74	-21.03	21.75	0.00	-5.99
201	117	118	116.23	-42.25	-116.10	49.59	0.12	7.34
202	117	118	116.23	-42.25	-116.10	49.59	0.12	7.34
203	117	118	116.23	-42.25	-116.10	49.59	0.12	7.34
204	117	189	110.09	-56.51	-110.04	45.41	0.06	-11.10
205	118	119	33.50	10.06	-33.47	-8.29	0.03	1.77
206	118	120	32.42	9.35	-32.39	-7.70	0.03	1.65
207	118	121	38.29	15.34	-38.19	-16.47	0.10	-1.14
208	118	121	38.29	15.34	-38.19	-16.47	0.10	-1.14
209	118	139	55.64	15.64	-55.58	-15.88	0.06	-0.24
210	118	139	55.64	15.64	-55.58	-15.88	0.06	-0.24
211	118	166	20.43	4.11	-20.41	-5.47	0.02	-1.35
212	118	166	20.43	4.11	-20.41	-5.47	0.02	-1.35
213	121	122	37.92	7.96	-37.85	-5.77	0.07	2.19
214	121	123	37.92	7.96	-37.85	-5.77	0.07	2.19
215	124	125	59.48	10.07	-59.37	-4.44	0.11	5.63
216	124	126	59.42	6.93	-59.37	-4.44	0.05	2.49
217	124	179	10.56	0.87	-10.56	-1.29	0.00	-0.42
218	127	128	64.79	-48.71	-64.73	52.07	0.06	3.36
219	127	128	64.79	-48.71	-64.73	52.07	0.06	3.36
220	127	129	89.32	-71.69	-89.21	78.37	0.11	6.67
221	127	129	89.32	-71.69	-89.21	78.37	0.11	6.67
222	127	130	0.00	0.00	0.00	0.00	0.00	0.00
223	128	131	64.67	25.75	-64.53	-18.35	0.14	7.40
224	128	134	64.67	25.75	-64.53	-18.35	0.14	7.40
225	128	179	137.27	20.54	-136.69	-18.36	0.58	2.18
226	128	179	137.27	20.54	-136.69	-18.36	0.58	2.18
227	129	132	55.65	10.68	-55.59	-7.40	0.06	3.28
228	129	133	55.65	10.68	-55.59	-7.40	0.06	3.28
229	135	136	39.48	12.50	-39.41	-10.15	0.07	2.35
230	135	137	39.48	12.50	-39.41	-10.15	0.07	2.35
231	135	138	0.00	0.00	-0.00	-0.00	0.00	0.00
232	135	186	-70.21	-20.39	70.22	13.71	0.02	-6.68
233	135	186	-77.98	-23.96	78.00	12.77	0.02	-11.19
234	139	140	37.06	10.47	-37.00	-8.33	0.06	2.14
235	139	141	37.04	10.49	-37.00	-8.33	0.04	2.16
236	139	142	37.06	10.47	-37.00	-8.33	0.06	2.14
237	143	144	27.76	5.52	-27.70	-3.75	0.06	1.77
238	143	145	27.72	4.85	-27.70	-3.75	0.02	1.10
239	143	146	27.72	4.85	-27.70	-3.75	0.02	1.10
240	143	147	-188.68	5.85	188.75	-9.55	0.07	-3.70
241	147	148	37.57	2.86	-37.53	-0.89	0.04	1.97
242	147	149	37.57	2.86	-37.53	-0.89	0.04	1.97
243	147	190	-102.52	47.18	102.66	-46.55	0.14	0.62
244	147	190	-102.52	47.18	102.66	-46.55	0.14	0.62
245	150	151	66.17	21.68	-66.04	-14.81	0.13	6.87
246	150	152	66.17	21.68	-66.04	-14.81	0.13	6.87
247	150	153	66.17	21.68	-66.04	-14.81	0.13	6.87
248	150	169	57.11	15.01	-57.10	-21.26	0.01	-6.25
249	154	155	55.15	18.92	-55.06	-14.22	0.09	4.70
250	154	186	-55.15	-19.04	55.16	19.03	0.01	-0.01
251	156	157	23.44	5.85	-23.40	-4.67	0.04	1.18
252	156	158	23.42	5.59	-23.40	-4.67	0.02	0.92
253	159	160	47.07	13.52	-47.00	-9.86	0.07	3.66

254	159	161	47.07	13.52	-47.00	-9.86	0.07	3.66
255	159	194	-15.09	-40.12	15.13	39.89	0.04	-0.24
256	162	163	36.06	9.02	-36.00	-7.12	0.06	1.90
257	162	164	36.04	9.04	-36.00	-7.12	0.04	1.92
258	162	165	36.11	10.23	-36.00	-7.12	0.11	3.11
259	162	186	-87.17	-50.41	87.21	41.91	0.04	-8.50
260	166	167	20.41	5.36	-20.40	-4.71	0.01	0.65
261	166	168	20.41	5.36	-20.40	-4.71	0.01	0.65
262	169	170	57.10	21.14	-57.00	-15.88	0.10	5.26
263	171	172	57.11	21.67	-57.00	-15.88	0.11	5.79
264	173	175	35.06	7.47	-35.00	-5.48	0.06	1.99
265	173	176	35.06	7.47	-35.00	-5.48	0.06	1.99
266	173	179	-132.35	-27.00	132.48	14.58	0.14	-12.43
267	174	177	23.06	6.71	-23.00	-4.93	0.06	1.78
268	174	178	23.06	6.71	-23.00	-4.93	0.06	1.78
269	179	180	51.08	7.42	-51.00	-3.29	0.08	4.13
270	179	181	51.08	7.42	-51.00	-3.29	0.08	4.13
271	179	182	51.08	7.42	-51.00	-3.29	0.08	4.13
272	179	183	51.08	7.42	-51.00	-3.29	0.08	4.13
273	179	184	0.00	-4.26	0.00	0.00	0.00	-4.26
274	185	186	136.13	-130.13	-135.83	147.87	0.30	17.73
275	185	186	136.13	-130.13	-135.83	147.87	0.30	17.73
276	186	187	46.56	9.69	-46.50	-6.57	0.06	3.12
277	186	188	46.56	9.69	-46.50	-6.57	0.06	3.12
278	189	190	205.70	-70.49	-205.33	93.11	0.38	22.62
279	189	191	0.00	0.00	0.00	0.00	0.00	0.00
280	189	192	0.00	0.00	0.00	0.00	0.00	0.00
281	196	197	0.00	0.00	0.00	0.00	0.00	0.00
282	196	198	0.00	-2.78	0.00	-0.06	0.00	-2.83
283	198	199	0.00	0.00	0.00	0.00	0.00	0.00
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						Total:	43.29	215.72

F. NO LIMIT SOLUTION FOR CHANGE CASE OF THE 225-BUS SYSTEM

REPORT OF SYSTEM SUMMARY

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MAXIMUM POWER MISMATCH            : 0.0000248063 pu.
ITERATIONS                        : 2
SOLUTION TIME                     : 3.948 sec.
TOTAL TIME                        : 10.877 sec.
BUSES                             : 225
GENERATOR BUS                     : 196
LOAD BUS                          : 28
SWING BUS                         : 1
BRANCHES                          : 283
SHUNTS                            : 78
SHUNT INJECTIONS(MW)              : -9.3
SHUNT INJECTIONS(MWAR)            : -14.2
TRANSFORMERS                      : 163
TOTAL REAL GEN CAPACITY(MW)       : 3964.26
TOTAL REACTIVE GEN CAPACITY(MVAR): 875.26
TOTAL REAL POWER LOSSES(MW)       : 43.06
TOTAL REACTIVE POWER LOSSES(MVAR): 210.98
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|===========================BUS INFORMATION===========================|

BUS	VOLTAGE VOLTS (pu)	ANGLE (deg)	GENERATION REAL (MW)	REACTIVE (MVAR)	LOAD REAL (MW)	REACTIVE (MVAR)
1	1.000	3.158	734.15	224.12	0.00	0.00
2	1.000	1.738	300.00	279.39	0.00	0.00
3	1.000	8.333	299.19	-43.91	0.00	0.00
4	0.993	1.727	0.00	0.00	0.00	0.00
5	0.999	3.223	0.00	0.00	0.00	0.00
6	1.004	1.511	0.00	0.00	0.00	0.00
7	1.004	1.511	0.00	0.00	0.00	0.00
8	0.996	1.688	0.00	0.00	0.00	0.00
9	0.982	-1.943	0.00	0.00	32.51	5.33
10	0.996	1.688	0.00	0.00	0.00	0.00
11	0.996	1.688	0.00	0.00	0.00	0.00
12	0.991	0.111	0.00	0.00	0.00	0.00
13	0.981	-2.771	0.00	0.00	32.50	5.07
14	0.981	-2.771	0.00	0.00	32.50	5.07
15	0.984	-0.734	0.00	0.00	0.00	0.00
16	0.963	-5.921	0.00	0.00	57.00	9.48
17	0.963	-5.921	0.00	0.00	57.00	9.48
18	0.987	-0.540	0.00	0.00	0.00	0.00
19	0.966	-6.035	0.00	0.00	38.26	5.33
20	0.976	-3.964	0.00	0.00	38.26	5.33
21	0.975	-3.934	0.00	0.00	38.26	5.33
22	0.983	-0.588	0.00	0.00	0.00	0.00
23	0.965	-5.929	0.00	0.00	37.00	4.38
24	0.964	-6.450	0.00	0.00	12.35	1.51
25	0.985	-0.293	0.00	0.00	0.00	0.00
26	0.982	-3.466	0.00	0.00	15.24	0.00
27	1.000	3.464	0.00	0.00	0.00	0.00
28	1.004	1.436	0.00	0.00	0.00	0.00
29	0.991	0.171	0.00	0.00	0.00	0.00
30	0.980	-2.340	0.00	0.00	12.19	2.37
31	1.004	4.507	0.00	0.00	0.00	0.00
32	1.004	4.507	0.00	0.00	0.00	0.00

33	1.004	4.507	0.00	0.00	0.00	0.00
34	0.951	-5.193	0.00	0.00	0.00	0.00
35	0.925	-11.831	0.00	0.00	42.67	5.92
36	0.991	1.131	0.00	0.00	0.00	0.00
37	0.982	-1.225	0.00	0.00	10.50	1.92
38	0.982	-1.225	0.00	0.00	10.50	1.92
39	0.985	-0.796	0.00	0.00	0.00	0.00
40	0.985	-0.940	0.00	0.00	1.02	0.00
41	1.000	0.926	0.00	0.00	0.00	0.00
42	0.992	-1.256	0.00	0.00	39.63	5.92
43	0.960	-4.071	0.00	0.00	0.00	0.00
44	0.959	-6.042	0.00	0.00	13.21	0.00
45	0.991	-0.174	0.00	0.00	0.00	0.00
46	0.991	-0.174	0.00	0.00	0.00	0.00
47	0.991	-0.174	0.00	0.00	0.00	0.00
48	0.995	0.978	0.00	0.00	0.00	0.00
49	0.991	-0.883	0.00	0.00	9.14	0.57
50	0.988	-2.683	0.00	0.00	9.14	0.57
51	0.990	0.158	0.00	0.00	0.00	0.00
52	0.980	-2.475	0.00	0.00	6.50	1.21
53	0.982	-1.645	0.00	0.00	6.50	1.21
54	0.982	-1.015	0.00	0.00	0.00	0.00
55	0.982	-1.015	0.00	0.00	0.00	0.00
56	0.982	-1.015	0.00	0.00	0.00	0.00
57	0.996	1.743	0.00	0.00	0.00	0.00
58	0.991	-0.174	0.00	0.00	0.00	0.00
59	0.989	-1.505	0.00	0.00	15.11	1.18
60	1.004	4.531	0.00	0.00	0.00	0.00
61	0.996	0.636	0.00	0.00	0.00	0.00
62	0.985	-1.538	0.00	0.00	21.34	4.74
63	0.991	0.184	0.00	0.00	0.00	0.00
64	0.991	0.184	0.00	0.00	0.00	0.00
65	0.991	0.184	0.00	0.00	0.00	0.00
66	0.958	-2.965	0.00	0.00	0.00	0.00
67	0.985	-4.394	0.00	0.00	0.00	0.00
68	0.981	-2.925	0.00	0.00	0.00	0.00
69	0.954	-10.076	0.00	0.00	62.00	15.34
70	0.949	-8.603	0.00	0.00	62.00	15.34
71	0.980	0.698	0.00	0.00	0.00	0.00
72	1.006	-0.825	0.00	0.00	0.00	0.00
73	1.044	-2.883	0.00	0.00	0.00	0.00
74	1.003	-2.202	0.00	0.00	16.12	1.80
75	1.041	-4.161	0.00	0.00	16.12	1.80
76	1.042	-3.370	0.00	0.00	0.00	0.00
77	1.011	-9.017	0.00	0.00	69.09	15.99
78	0.999	-1.357	0.00	0.00	0.00	0.00
79	0.972	-6.694	0.00	0.00	60.20	13.31
80	0.972	-6.694	0.00	0.00	60.20	13.31
81	0.972	-6.694	0.00	0.00	60.20	13.31
82	0.975	0.419	0.00	0.00	0.00	0.00
83	0.997	0.638	0.00	0.00	0.00	0.00
84	1.000	-1.102	0.00	0.00	0.00	0.00
85	1.000	-1.278	0.00	0.00	0.00	0.00
86	0.970	-0.017	0.00	0.00	0.00	0.00
87	1.035	-4.163	0.00	0.00	0.00	0.00
88	1.005	-2.772	0.00	0.00	0.00	0.00
89	0.996	-5.009	0.00	0.00	26.00	4.93
90	1.026	-6.269	0.00	0.00	26.00	4.93
91	1.001	-3.023	0.00	0.00	0.00	0.00
92	0.971	-7.516	0.00	0.00	50.80	15.99
93	0.977	-8.579	0.00	0.00	62.99	11.26
94	0.984	-2.168	0.00	0.00	0.00	0.00
95	1.000	-3.094	0.00	0.00	0.00	0.00
96	0.960	-6.490	0.00	0.00	48.00	12.05
97	0.977	-7.318	0.00	0.00	48.00	12.05

98	1.004	-0.710	0.00	0.00	0.00	0.00
99	0.998	-2.633	0.00	0.00	22.38	3.53
100	0.998	-2.633	0.00	0.00	22.38	3.53
101	0.999	-1.234	0.00	0.00	0.00	0.00
102	0.980	-6.947	0.00	0.00	64.85	8.10
103	0.980	-6.947	0.00	0.00	64.85	8.10
104	0.980	-6.947	0.00	0.00	64.85	8.10
105	0.958	-2.875	0.00	0.00	0.00	0.00
106	0.949	-5.408	0.00	0.00	26.75	5.13
107	0.949	-5.408	0.00	0.00	26.75	5.13
108	0.949	-5.408	0.00	0.00	26.75	5.13
109	0.986	-4.269	0.00	0.00	0.00	0.00
110	0.961	-10.015	0.00	0.00	63.15	11.83
111	0.961	-10.015	0.00	0.00	63.15	11.83
112	1.002	-0.533	0.00	0.00	0.00	0.00
113	1.040	-3.403	0.00	0.00	0.00	0.00
114	1.028	-7.056	0.00	0.00	45.72	5.13
115	1.029	-7.088	0.00	0.00	45.72	5.13
116	1.029	-7.088	0.00	0.00	45.72	5.13
117	0.994	2.899	0.00	0.00	0.00	0.00
118	1.016	-0.272	0.00	0.00	0.00	0.00
119	1.001	-3.101	0.00	0.00	33.47	8.29
120	1.002	-3.008	0.00	0.00	32.39	7.70
121	1.008	-1.004	0.00	0.00	0.00	0.00
122	0.996	-4.220	0.00	0.00	37.85	5.77
123	0.996	-4.220	0.00	0.00	37.85	5.77
124	0.985	-1.958	0.00	0.00	0.00	0.00
125	0.972	-7.314	0.00	0.00	59.37	4.44
126	0.980	-4.338	0.00	0.00	59.37	4.44
127	0.968	-0.105	0.00	0.00	0.00	0.00
128	0.991	-1.124	0.00	0.00	0.00	0.00
129	1.004	-2.675	0.00	0.00	0.00	0.00
130	0.968	-0.105	0.00	0.00	0.00	0.00
131	0.955	-6.989	0.00	0.00	64.53	18.35
132	0.994	-5.963	0.00	0.00	55.59	7.40
133	0.994	-5.963	0.00	0.00	55.59	7.40
134	0.955	-6.989	0.00	0.00	64.53	18.35
135	1.042	-3.350	0.00	0.00	0.00	0.00
136	1.024	-6.491	0.00	0.00	39.41	10.15
137	1.024	-6.491	0.00	0.00	39.41	10.15
138	1.042	-3.350	0.00	0.00	0.00	0.00
139	1.013	-0.680	0.00	0.00	0.00	0.00
140	0.997	-3.798	0.00	0.00	37.00	8.33
141	0.998	-3.829	0.00	0.00	37.00	8.33
142	0.997	-3.798	0.00	0.00	37.00	8.33
143	1.040	-3.243	0.00	0.00	0.00	0.00
144	1.026	-6.793	0.00	0.00	27.70	3.75
145	1.033	-5.466	0.00	0.00	27.70	3.75
146	1.033	-5.466	0.00	0.00	27.70	3.75
147	1.040	-3.025	0.00	0.00	0.00	0.00
148	1.036	-6.033	0.00	0.00	37.53	0.89
149	1.036	-6.033	0.00	0.00	37.53	0.89
150	1.030	-4.682	0.00	0.00	0.00	0.00
151	1.001	-10.201	0.00	0.00	66.04	14.81
152	1.001	-10.201	0.00	0.00	66.04	14.81
153	1.001	-10.201	0.00	0.00	66.04	14.81
154	1.043	-3.254	0.00	0.00	0.00	0.00
155	1.017	-7.722	0.00	0.00	55.06	14.22
156	0.971	-1.243	0.00	0.00	0.00	0.00
157	0.959	-3.982	0.00	0.00	23.40	4.67
158	0.963	-3.398	0.00	0.00	23.40	4.67
159	0.993	-3.094	0.00	0.00	0.00	0.00
160	0.973	-7.282	0.00	0.00	47.00	9.86
161	0.973	-7.282	0.00	0.00	47.00	9.86
162	1.041	-3.433	0.00	0.00	0.00	0.00

163	1.027	-6.302	0.00	0.00	36.00	7.12
164	1.028	-6.330	0.00	0.00	36.00	7.12
165	1.017	-8.075	0.00	0.00	36.00	7.12
166	1.014	-0.601	0.00	0.00	0.00	0.00
167	1.006	-2.321	0.00	0.00	20.40	4.71
168	1.006	-2.321	0.00	0.00	20.40	4.71
169	1.029	-4.780	0.00	0.00	0.00	0.00
170	1.000	-9.545	0.00	0.00	57.00	15.88
171	0.985	-4.368	0.00	0.00	0.00	0.00
172	0.954	-9.584	0.00	0.00	57.00	15.88
173	0.982	-2.708	0.00	0.00	0.00	0.00
174	0.985	-4.367	0.00	0.00	0.00	0.00
175	0.970	-5.842	0.00	0.00	35.00	5.48
176	0.970	-5.842	0.00	0.00	35.00	5.48
177	0.965	-8.490	0.00	0.00	23.00	4.93
178	0.965	-8.490	0.00	0.00	23.00	4.93
179	0.985	-2.101	0.00	0.00	0.00	0.00
180	0.975	-6.689	0.00	0.00	51.00	3.29
181	0.975	-6.689	0.00	0.00	51.00	3.29
182	0.975	-6.689	0.00	0.00	51.00	3.29
183	0.975	-6.689	0.00	0.00	51.00	3.29
184	0.985	-2.101	0.00	0.00	0.00	0.00
185	0.979	0.554	0.00	0.00	0.00	0.00
186	1.043	-3.226	0.00	0.00	0.00	0.00
187	1.030	-6.957	0.00	0.00	46.50	6.57
188	1.030	-6.957	0.00	0.00	46.50	6.57
189	0.998	2.579	0.00	0.00	100.00	0.00
190	1.037	-2.520	0.00	0.00	0.00	0.00
191	0.998	2.579	0.00	0.00	0.00	0.00
192	0.998	2.579	0.00	0.00	0.00	0.00
193	0.986	-4.269	0.00	0.00	0.00	0.00
194	0.997	-3.057	0.00	0.00	0.00	0.00
195	0.947	-5.535	0.00	0.00	42.75	7.70
196	0.965	-4.167	0.00	0.00	0.00	0.00
197	0.965	-4.167	0.00	0.00	0.00	0.00
198	0.967	-4.189	0.00	0.00	0.00	0.00
199	0.967	-4.189	0.00	0.00	0.00	0.00
200	1.014	5.600	23.00	6.75	0.00	0.00
201	0.983	5.801	23.00	-3.38	0.00	0.00
202	0.982	4.338	11.00	-2.95	0.00	0.00
203	1.003	9.467	101.00	6.06	0.00	0.00
204	1.005	6.991	94.00	3.75	0.00	0.00
206	1.014	5.488	146.00	41.18	0.00	0.00
207	1.013	6.425	146.00	32.62	0.00	0.00
208	1.013	6.425	146.00	32.62	0.00	0.00
209	1.006	9.312	155.00	7.89	0.00	0.00
210	1.016	9.164	152.00	26.15	0.00	0.00
211	1.004	9.232	152.00	3.45	0.00	0.00
212	0.993	6.168	50.00	2.10	0.00	0.00
213	1.002	5.404	128.00	43.80	0.00	0.00
214	1.010	5.628	150.00	63.18	0.00	0.00
215	1.012	9.284	228.00	36.15	0.00	0.00
216	1.012	5.476	128.00	26.03	0.00	0.00
217	1.013	5.735	150.00	31.20	0.00	0.00
218	1.012	3.718	128.00	21.60	0.00	0.00
219	1.012	3.718	128.00	21.60	0.00	0.00
220	1.013	3.977	150.00	26.10	0.00	0.00
221	1.004	3.485	88.00	6.59	0.00	0.00
222	0.984	4.623	33.00	-6.18	0.00	0.00
223	0.984	4.590	33.00	-6.24	0.00	0.00
224	0.984	4.590	33.00	-6.24	0.00	0.00
225	0.998	5.961	64.00	-0.07	0.00	0.00
205	1.005	-0.370	-9.08	1.89	21.46	0.00
		TOTAL:	3964.26	875.26	3921.58	672.35

|==============================BRANCH INFORMATION=============================|

BRNCH	FROM BUS	T0 BUS	REAL FROM BUS (MW)	REACTIVE INJ (MVAR)	REAL TO BUS (MW)	REACTIVE INJ (MVAR)	REAL LOSS (MW)	REACTIVE LOSS (MVAR)
1	1	71	573.39	217.17	-571.09	-219.08	2.30	-1.92
2	1	189	160.76	6.95	-160.60	-23.92	0.16	-16.97
3	2	71	300.00	279.39	-299.10	-294.36	0.90	-14.97
4	3	117	299.19	-43.91	-296.41	-20.08	2.78	-63.99
5	4	36	56.83	-3.74	-56.70	3.57	0.12	-0.17
6	4	200	-22.92	-5.08	23.00	6.75	0.08	1.68
7	4	201	-22.92	5.06	23.00	-3.38	0.08	1.67
8	4	202	-10.98	3.48	11.00	-2.95	0.02	0.54
9	5	6	41.51	-7.13	-41.48	8.41	0.02	1.28
10	5	6	41.51	-7.13	-41.48	8.41	0.02	1.28
11	5	27	-84.73	-21.16	84.76	7.09	0.04	-14.08
12	6	7	0.00	0.00	0.00	0.00	0.00	0.00
13	6	28	2.80	-1.31	-2.80	-0.22	0.00	-1.53
14	6	29	44.84	9.29	-44.47	-10.03	0.37	-0.74
15	6	48	15.55	6.97	-15.48	-9.21	0.07	-2.24
16	6	61	21.48	3.42	-21.37	-5.68	0.11	-2.26
17	8	9	32.58	7.49	-32.51	-5.33	0.07	2.16
18	8	10	0.00	0.00	0.00	0.00	0.00	0.00
19	8	11	0.00	-0.00	-0.00	0.00	0.00	0.00
20	8	51	74.25	1.90	-73.84	-1.43	0.42	0.47
21	8	57	-180.20	-28.45	180.22	28.60	0.02	0.15
22	8	105	73.38	18.98	-72.02	-17.03	1.36	1.95
23	12	13	32.53	6.77	-32.50	-5.07	0.03	1.70
24	12	14	32.53	6.77	-32.50	-5.07	0.03	1.70
25	12	15	21.90	5.19	-21.84	-7.88	0.06	-2.69
26	12	18	24.16	0.04	-24.07	-1.33	0.09	-1.29
27	12	28	-31.61	-8.03	31.86	6.19	0.26	-1.84
28	12	63	-79.51	-10.93	79.53	10.97	0.02	0.03
29	15	16	57.10	14.91	-57.00	-9.48	0.10	5.43
30	15	17	57.10	14.91	-57.00	-9.48	0.10	5.43
31	15	18	-11.59	-6.37	11.61	5.30	0.02	-1.07
32	15	39	1.02	-3.11	-1.02	-0.13	0.00	-3.24
33	15	57	-81.80	-12.66	82.27	13.91	0.47	1.25
34	18	19	38.40	9.17	-38.26	-5.33	0.14	3.84
35	18	20	38.30	7.69	-38.26	-5.33	0.04	2.36
36	18	21	38.33	7.68	-38.26	-5.33	0.07	2.35
37	18	51	-38.86	2.07	39.00	-2.61	0.15	-0.54
38	18	51	-38.86	2.07	39.00	-2.61	0.15	-0.54
39	18	58	-26.02	-13.38	26.05	12.41	0.03	-0.97
40	18	121	1.17	-19.60	-1.05	15.83	0.12	-3.77
41	22	23	37.13	7.96	-37.00	-4.38	0.13	3.58
42	22	24	12.37	2.82	-12.35	-1.51	0.02	1.31
43	22	25	-17.39	-2.88	17.41	1.75	0.02	-1.13
44	22	29	-32.12	-8.03	32.27	7.06	0.15	-0.97
45	25	26	15.27	0.85	-15.24	-0.00	0.03	0.85
46	25	36	-32.67	-2.63	32.85	0.31	0.17	-2.32
47	27	28	73.94	-7.75	-73.90	10.40	0.04	2.65
48	27	31	-101.80	-34.77	101.98	-15.39	0.18	-50.16
49	27	60	-151.09	-41.17	151.31	-8.12	0.23	-49.29
50	27	71	192.18	17.28	-191.35	-110.16	0.83	-92.88
51	27	203	-100.81	4.53	101.00	6.06	0.19	10.58
52	28	41	69.57	20.50	-69.46	-20.40	0.12	0.09
53	28	58	41.34	12.04	-41.17	-14.06	0.17	-2.02
54	28	204	-93.84	5.36	94.00	3.75	0.16	9.11
55	28	205	30.56	-0.93	-30.54	1.89	0.02	0.96
56	29	30	12.21	2.93	-12.19	-2.37	0.02	0.56
57	31	32	0.00	0.00	0.00	0.00	0.00	0.00
58	31	33	0.00	0.00	0.00	0.00	0.00	0.00

59	31	60	-101.98	15.15	101.99	-16.27	0.00	-1.12
60	34	35	42.86	11.11	-42.67	-5.92	0.19	5.19
61	34	43	-42.86	-11.23	43.06	10.45	0.20	-0.78
62	36	37	10.52	2.37	-10.50	-1.92	0.02	0.45
63	36	38	10.52	2.37	-10.50	-1.92	0.02	0.45
64	36	48	2.83	-8.79	-2.81	7.13	0.01	-1.65
65	39	40	1.02	0.00	-1.02	0.00	0.00	0.00
66	41	42	19.84	3.74	-19.81	-2.96	0.02	0.78
67	41	42	19.84	3.74	-19.81	-2.96	0.02	0.78
68	41	63	29.78	12.76	-29.70	-14.35	0.08	-1.59
69	43	44	13.23	0.46	-13.21	0.00	0.02	0.46
70	43	54	-56.29	-4.78	57.27	4.96	0.98	0.18
71	43	196	0.01	-6.24	-0.00	2.75	0.01	-3.49
72	45	46	0.00	0.00	0.00	0.00	0.00	0.00
73	45	47	0.00	0.00	0.00	0.00	0.00	0.00
74	45	58	-0.00	-0.08	0.00	0.00	0.00	-0.07
75	45	58	-0.00	-0.08	0.00	0.00	0.00	-0.07
76	48	49	9.15	0.87	-9.14	-0.57	0.01	0.30
77	48	50	9.15	1.16	-9.14	-0.57	0.01	0.59
78	51	52	6.51	1.52	-6.50	-1.21	0.01	0.31
79	51	53	6.51	1.43	-6.50	-1.21	0.01	0.22
80	51	54	57.65	5.15	-57.27	-5.12	0.38	0.03
81	51	57	-74.83	-1.47	75.27	2.00	0.44	0.54
82	54	55	0.00	0.00	0.00	0.00	0.00	0.00
83	54	56	0.00	0.00	0.00	0.00	0.00	0.00
84	57	156	99.55	26.83	-98.33	-23.27	1.22	3.55
85	57	206	-145.80	-31.01	146.00	41.18	0.20	10.17
86	57	207	-145.76	-20.26	146.00	32.62	0.24	12.36
87	57	208	-145.76	-20.26	146.00	32.62	0.24	12.36
88	58	59	15.12	1.53	-15.11	-1.18	0.01	0.35
89	60	117	205.09	23.73	-204.60	-76.26	0.49	-52.53
90	60	209	-154.79	5.05	155.00	7.89	0.21	12.94
91	60	210	-151.80	-13.62	152.00	26.15	0.20	12.53
92	60	211	-151.80	9.02	152.00	3.45	0.20	12.47
93	61	62	10.68	2.80	-10.67	-2.37	0.01	0.43
94	61	62	10.68	2.80	-10.67	-2.37	0.01	0.43
95	63	64	0.00	0.00	0.00	0.00	0.00	0.00
96	63	65	0.00	0.00	0.00	0.00	0.00	0.00
97	63	212	-49.83	3.12	50.00	2.10	0.17	5.22
98	66	105	-42.81	-9.86	42.83	9.82	0.02	-0.04
99	66	195	21.41	4.86	-21.37	-3.85	0.03	1.01
100	66	195	21.41	4.86	-21.37	-3.85	0.03	1.01
101	67	69	62.13	22.10	-62.00	-15.34	0.13	6.76
102	67	171	-31.06	-11.10	31.07	7.94	0.00	-3.16
103	67	171	-31.06	-11.10	31.07	7.94	0.00	-3.16
104	68	70	62.21	22.12	-62.00	-15.34	0.21	6.78
105	68	173	-62.21	-22.22	62.23	11.94	0.02	-10.28
106	71	72	68.02	-68.84	-67.95	72.54	0.07	3.69
107	71	73	130.99	-129.69	-130.71	146.68	0.28	16.99
108	71	73	165.91	-164.61	-165.53	186.14	0.38	21.54
109	71	86	342.58	228.21	-342.05	-236.11	0.52	-7.90
110	71	185	309.64	134.25	-309.57	-136.49	0.07	-2.24
111	72	74	16.13	2.19	-16.12	-1.80	0.01	0.39
112	72	128	29.75	49.31	-29.57	-49.57	0.19	-0.26
113	72	128	29.75	49.31	-29.57	-49.57	0.19	-0.26
114	73	75	16.13	2.17	-16.12	-1.80	0.01	0.37
115	73	113	53.98	12.58	-53.86	-12.94	0.11	-0.36
116	73	147	34.36	45.68	-34.33	-45.88	0.04	-0.20
117	73	147	34.36	45.68	-34.33	-45.88	0.04	-0.20
118	73	186	97.16	11.54	-97.11	-11.41	0.06	0.13
119	73	186	97.16	11.54	-97.11	-11.41	0.06	0.13
120	76	77	69.23	23.40	-69.09	-15.99	0.14	7.41
121	76	135	-34.61	-11.76	34.62	9.56	0.00	-2.21
122	76	135	-34.61	-11.76	34.62	9.56	0.00	-2.21
123	78	79	60.31	19.37	-60.20	-13.31	0.11	6.06

124	78	80	60.31	19.37	-60.20	-13.31	0.11	6.06
125	78	81	60.31	19.37	-60.20	-13.31	0.11	6.06
126	78	85	-90.47	-29.21	90.49	29.29	0.02	0.07
127	78	85	-90.47	-29.21	90.49	29.29	0.02	0.07
128	82	84	34.67	-34.19	-34.64	36.02	0.03	1.83
129	82	84	34.67	-34.19	-34.64	36.02	0.03	1.83
130	82	127	206.71	115.07	-206.45	-124.36	0.26	-9.29
131	82	213	-127.80	-31.64	128.00	43.80	0.20	12.16
132	82	214	-149.74	-47.59	150.00	63.18	0.26	15.59
133	83	124	145.96	21.95	-145.09	-16.58	0.87	5.37
134	83	128	120.93	-2.39	-120.15	5.01	0.77	2.62
135	83	128	120.93	-2.39	-120.15	5.01	0.77	2.62
136	83	179	117.19	16.50	-116.46	-12.64	0.73	3.86
137	83	215	-227.42	-1.45	228.00	36.15	0.58	34.71
138	83	216	-127.81	-14.92	128.00	26.03	0.19	11.11
139	83	217	-149.77	-17.47	150.00	31.20	0.23	13.73
140	84	85	238.09	-2.37	-237.98	3.04	0.12	0.67
141	84	85	238.09	-2.37	-237.98	3.04	0.12	0.67
142	84	218	-127.82	-10.64	128.00	21.60	0.18	10.96
143	84	219	-127.82	-10.64	128.00	21.60	0.18	10.96
144	84	220	-149.77	-12.55	150.00	26.10	0.23	13.54
145	85	129	90.42	-35.41	-89.92	36.68	0.49	1.27
146	85	129	90.42	-35.41	-89.92	36.68	0.49	1.27
147	85	159	101.00	2.64	-100.33	-0.78	0.67	1.86
148	85	159	101.00	2.64	-100.33	-0.78	0.67	1.86
149	85	221	-87.87	0.74	88.00	6.59	0.13	7.33
150	86	87	149.11	-128.28	-148.78	148.01	0.33	19.73
151	86	88	96.47	-69.52	-96.35	76.73	0.12	7.21
152	86	127	67.10	62.67	-67.08	-71.55	0.02	-8.89
153	87	90	26.02	5.93	-26.00	-4.93	0.02	1.00
154	87	150	128.09	41.24	-127.81	-40.25	0.29	1.00
155	87	150	128.09	41.24	-127.81	-40.25	0.29	1.00
156	87	186	-114.65	-26.20	115.08	27.53	0.44	1.33
157	88	89	26.02	5.99	-26.00	-4.93	0.02	1.06
158	88	91	104.69	65.77	-104.54	-65.24	0.15	0.52
159	88	129	-11.85	7.86	11.86	-8.38	0.01	-0.52
160	88	129	-11.85	7.86	11.86	-8.38	0.01	-0.52
161	91	92	50.88	20.52	-50.80	-15.99	0.08	4.53
162	91	93	63.11	17.73	-62.99	-11.26	0.12	6.47
163	91	95	48.08	11.27	-48.07	-16.02	0.01	-4.75
164	91	129	-72.39	-23.77	72.50	23.90	0.11	0.13
165	91	194	14.86	39.28	-14.83	-39.50	0.03	-0.22
166	94	96	48.12	16.02	-48.00	-12.05	0.12	3.97
167	94	179	-48.12	-16.12	48.13	11.94	0.01	-4.18
168	95	97	48.07	15.91	-48.00	-12.05	0.07	3.86
169	98	99	22.39	4.31	-22.38	-3.53	0.01	0.78
170	98	100	22.39	4.31	-22.38	-3.53	0.01	0.78
171	98	101	86.63	34.05	-86.51	-33.63	0.12	0.43
172	98	112	-53.93	47.55	53.96	-47.54	0.03	0.02
173	98	118	-38.74	-45.22	38.85	44.89	0.10	-0.33
174	98	118	-38.74	-45.22	38.85	44.89	0.10	-0.33
175	101	102	64.97	14.80	-64.85	-8.10	0.12	6.70
176	101	103	64.97	14.80	-64.85	-8.10	0.12	6.70
177	101	104	64.97	14.80	-64.85	-8.10	0.12	6.70
178	101	112	-108.42	-11.10	108.59	11.91	0.17	0.81
179	105	106	26.77	6.37	-26.75	-5.13	0.02	1.24
180	105	107	26.77	6.37	-26.75	-5.13	0.02	1.24
181	105	108	26.77	6.37	-26.75	-5.13	0.02	1.24
182	105	156	-51.14	-12.20	51.48	11.64	0.34	-0.56
183	109	110	63.28	18.57	-63.15	-11.83	0.13	6.74
184	109	111	63.28	18.57	-63.15	-11.83	0.13	6.74
185	109	129	-171.21	-64.41	172.47	69.67	1.26	5.25
186	109	159	-120.76	-12.18	121.30	14.03	0.54	1.85
187	109	171	30.85	5.55	-30.83	-5.69	0.02	-0.13
188	109	171	30.85	5.55	-30.83	-5.69	0.02	-0.13

189	109	171	57.59	21.02	-57.58	-26.29	0.01	-5.27
190	109	174	46.14	7.18	-46.13	-13.62	0.01	-6.44
191	109	193	0.00	-0.07	0.00	-0.00	0.00	-0.07
192	112	222	-32.90	9.29	33.00	-6.18	0.10	3.11
193	112	223	-32.90	9.33	33.00	-6.24	0.10	3.09
194	112	224	-32.90	9.33	33.00	-6.24	0.10	3.09
195	112	225	-63.87	7.34	64.00	-0.07	0.13	7.27
196	113	114	45.81	8.12	-45.72	-5.13	0.09	2.99
197	113	115	45.78	8.14	-45.72	-5.13	0.06	3.01
198	113	116	45.78	8.14	-45.72	-5.13	0.06	3.01
199	113	143	-99.95	16.45	99.98	-22.00	0.03	-5.55
200	113	162	16.45	-28.26	-16.45	22.28	0.00	-5.98
201	117	118	115.73	-43.49	-115.61	50.91	0.12	7.42
202	117	118	115.73	-43.49	-115.61	50.91	0.12	7.42
203	117	118	115.73	-43.49	-115.61	50.91	0.12	7.42
204	117	189	129.83	-108.86	-129.72	98.39	0.11	-10.47
205	118	119	33.50	10.08	-33.47	-8.29	0.03	1.79
206	118	120	32.42	9.36	-32.39	-7.70	0.03	1.66
207	118	121	37.49	14.86	-37.39	-16.00	0.10	-1.14
208	118	121	37.49	14.86	-37.39	-16.00	0.10	-1.14
209	118	139	55.64	15.68	-55.59	-15.91	0.06	-0.23
210	118	139	55.64	15.68	-55.59	-15.91	0.06	-0.23
211	118	166	20.43	4.13	-20.41	-5.47	0.02	-1.34
212	118	166	20.43	4.13	-20.41	-5.47	0.02	-1.34
213	121	122	37.92	7.98	-37.85	-5.77	0.07	2.21
214	121	123	37.92	7.98	-37.85	-5.77	0.07	2.21
215	124	125	59.48	10.10	-59.37	-4.44	0.11	5.66
216	124	126	59.42	6.93	-59.37	-4.44	0.05	2.49
217	124	179	26.20	-0.61	-26.19	0.25	0.01	-0.36
218	127	128	34.81	-46.50	-34.78	48.23	0.03	1.73
219	127	128	34.81	-46.50	-34.78	48.23	0.03	1.73
220	127	129	90.03	-71.97	-89.92	78.75	0.11	6.77
221	127	129	90.03	-71.97	-89.92	78.75	0.11	6.77
222	127	130	0.00	0.00	0.00	0.00	0.00	0.00
223	128	131	64.67	25.78	-64.53	-18.35	0.14	7.43
224	128	134	64.67	25.78	-64.53	-18.35	0.14	7.43
225	128	179	121.60	21.69	-121.13	-20.07	0.46	1.61
226	128	179	121.60	21.69	-121.13	-20.07	0.46	1.61
227	129	132	55.65	10.69	-55.59	-7.40	0.06	3.29
228	129	133	55.65	10.69	-55.59	-7.40	0.06	3.29
229	135	136	39.48	12.51	-39.41	-10.15	0.07	2.36
230	135	137	39.48	12.51	-39.41	-10.15	0.07	2.36
231	135	138	0.00	0.00	0.00	0.00	0.00	0.00
232	135	186	-70.21	-20.41	70.22	13.76	0.02	-6.66
233	135	186	-77.99	-23.98	78.00	12.83	0.02	-11.15
234	139	140	37.07	10.49	-37.00	-8.33	0.07	2.16
235	139	141	37.04	10.51	-37.00	-8.33	0.04	2.18
236	139	142	37.07	10.49	-37.00	-8.33	0.07	2.16
237	143	144	27.76	5.53	-27.70	-3.75	0.06	1.78
238	143	145	27.72	4.85	-27.70	-3.75	0.02	1.10
239	143	146	27.72	4.85	-27.70	-3.75	0.02	1.10
240	143	147	-183.19	6.40	183.25	-10.12	0.07	-3.72
241	147	148	37.57	2.87	-37.53	-0.89	0.04	1.98
242	147	149	37.57	2.87	-37.53	-0.89	0.04	1.98
243	147	190	-94.87	47.96	94.99	-47.46	0.12	0.50
244	147	190	-94.87	47.96	94.99	-47.46	0.12	0.50
245	150	151	66.17	21.70	-66.04	-14.81	0.13	6.89
246	150	152	66.17	21.70	-66.04	-14.81	0.13	6.89
247	150	153	66.17	21.70	-66.04	-14.81	0.13	6.89
248	150	169	57.11	15.05	-57.10	-21.27	0.01	-6.23
249	154	155	55.15	18.93	-55.06	-14.22	0.09	4.71
250	154	186	-55.15	-19.05	55.16	19.05	0.01	-0.01
251	156	157	23.44	5.85	-23.40	-4.67	0.04	1.18
252	156	158	23.42	5.60	-23.40	-4.67	0.02	0.93
253	159	160	47.07	13.53	-47.00	-9.86	0.07	3.67

254	159	161	47.07	13.53	-47.00	-9.86	0.07	3.67
255	159	194	-14.79	-39.74	14.83	39.50	0.04	-0.24
256	162	163	36.06	9.03	-36.00	-7.12	0.06	1.91
257	162	164	36.04	9.04	-36.00	-7.12	0.04	1.92
258	162	165	36.11	10.24	-36.00	-7.12	0.11	3.12
259	162	186	-91.76	-50.96	91.80	42.53	0.04	-8.43
260	166	167	20.41	5.36	-20.40	-4.71	0.01	0.65
261	166	168	20.41	5.36	-20.40	-4.71	0.01	0.65
262	169	170	57.10	21.16	-57.00	-15.88	0.10	5.28
263	171	172	57.11	21.67	-57.00	-15.88	0.11	5.79
264	173	175	35.06	7.47	-35.00	-5.48	0.06	1.99
265	173	176	35.06	7.47	-35.00	-5.48	0.06	1.99
266	173	179	-132.35	-27.08	132.49	14.71	0.14	-12.37
267	174	177	23.06	6.71	-23.00	-4.93	0.06	1.78
268	174	178	23.06	6.71	-23.00	-4.93	0.06	1.78
269	179	180	51.08	7.43	-51.00	-3.29	0.08	4.14
270	179	181	51.08	7.43	-51.00	-3.29	0.08	4.14
271	179	182	51.08	7.43	-51.00	-3.29	0.08	4.14
272	179	183	51.08	7.43	-51.00	-3.29	0.08	4.14
273	179	184	0.00	-4.25	0.00	-0.00	0.00	-4.25
274	185	186	138.05	-129.04	-137.75	146.94	0.30	17.90
275	185	186	138.05	-129.04	-137.75	146.94	0.30	17.90
276	186	187	46.56	9.70	-46.50	-6.57	0.06	3.13
277	186	188	46.56	9.70	-46.50	-6.57	0.06	3.13
278	189	190	190.32	-74.77	-189.98	94.91	0.34	20.15
279	189	191	0.00	0.00	0.00	0.00	0.00	0.00
280	189	192	0.00	0.00	0.00	0.00	0.00	0.00
281	196	197	0.00	0.00	0.00	0.00	0.00	0.00
282	196	198	0.00	-2.76	0.00	-0.06	0.00	-2.82
283	198	199	0.00	0.00	0.00	0.00	0.00	0.00
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						Total:	43.06	210.98

REFERENCES

Publications

B. Stott, 1974. *Review of load-flow calculation methods*. Proceedings of IEEE, **Vol. 62, No.7,** pp.916-929.

Dunlop. R.D, Gutman. R., & Marchenko. P.P, 1979. *Analytical development of loadability characteristics for EHV and UHV transmission lines.* IEEE Transactions on power Apparatus and Systems, **Vol 98. No.2**, pp. 606-617.

F.L. Alvarado, 1999. *Solving power flow problems with a Matlab implementation of the power system applications data dictionary.* Proceedings of the 32nd Hawaii International Conference on System Sciences. **Vol.30, No.3**, pp.243–254.

Garver.L.L, Van Horne. P.R & K. A. Wirgau, 1979. *Load supplying capability of generation-transmission networks*. IEEE Transactions on Power Apparatus and Systems. **Vol. PAS-98, No.3,** pp. 957- 962.

Landgren. G.L & Anderson. S. W, 1973. *Simultaneous power interchanges capability analysis.* IEEE Transactions on Power Apparatus and Systems, **Vol. PAS-92, No.6,** pp. 1973-1986

Landgren. G.L, Terhune.H.L, & Angel.R.K, 1972. *Transmission interchange capability - analysis by computer.* IEEE Transactions on Power Apparatus and Systems, **Vol. PAS-91, No. 6,** pp. 2405- 2414

Mamandur. K.R.C, Berg. G.J, 1982. *Automatic adjustment of generator voltages in Newton-Raphson method of power-flow solutions.* IEEE Transactions on Power Apparatus and Systems. **Vol. Pas-101, No.6,** pp.916-929.

Sauer, W., 1997. Technical Challenges of Computing Available Transfer Capability (ATC) in Electric Power Systems. *Proceedings of the Thirtieth Annual Hawaii International Conference on System Sciences, Hawaii,* **Vol V**, pp. 559-593.

Sauer. P. W, 1981. *On the formulation of power distribution factors for linear load flow methods.* IEEE Transactions on Power Apparatus and Systems. **Vol. PAS-100, No.2,** pp. 764-770.

Shaaban.M, Ni.Yixin, Wu, Felix.F, 2000. Transfer Capability Computations in Deregulated Power Systems. *Proceedings of the 33rd Hawaii International Conference on System Sciences***. Vol. Pas-101, No.6,** pp.916-929.

St. Clair.H.P, 1953. *Practical concepts in capability and performance of transmission lines.* AIEE Transactions, **Vol 72. Part III**, pp.1152-1157.

Stott. B & Marinho. J.L, 1979. *Linear programming for power system network security application.* IEEE Transactions on Power Apparatus and Systems. **Vol. PAS-98,** pp. 837-848

Books

Ajjarapu. V, 2006. *Computational techniques for voltage stability assessment and control.* New York: Springer.

Anderson. P.M, Fouad. A.A, 2008. *Power system control and stability.* 2nd edition. India PVT: John Viley & Sons, Inc.

Arrillaga.J, Arnold.C.P, 1990. *Computer Analysis of Power System*. England: John Wiley & Sons, Inc

Crow.M, 2003. *Computational Methods for Electric Power Systems.* USA: CRC Press

Cutsem.T.V & Vournas.C, 1998. Voltage stability of electric power systems, New York: Springer.

Chow. J.H (Ed.), Wu. F.F (Ed), Mamoh. J.A (Ed), 2005. Applied Mathematics for Restructured Electric Power Systems, Optimization, Control, and Computational Inteligence.USA: Springer.

Gross.C, 1979. *Power System Analyis.* Canada: John Wiley & Sons, Inc.

Glover.J, Sarma.M., Overbye. T, 2008. *Power System Analysis and Design*. 4th Edition. USA: Thomson.

Grainger. J. & Stevenson. W, 1994. *Power System Analysis*. International Edition. Singapore: McGraw-Hill.

Heydt.G, 1986. *Computer Analysis Methods for Power Systems.* New York: Macmillian Publishing Company

İliç. M & Zaborsky. J, 2000. *Dynamics and control of large electric power systems.* Canada: John Wiley & Sons, Inc.

Kundur.P, 1993. *Power system stability and control,* New York: McGraw-Hill.

Miler.R.H, Malinowski.J.H, 1993. *Power system operation*. 3rd edition. New York: McGraw-Hill.

Natarajan.R, 2002. *Computer Aided Power System Analysis.* New York and Basel: Marcel Deccer, Inc.

Yamayee. Z & Bala. J,1994. *Electromechanical Energy Devices and Power Systems.* Canada: John Wiley & Sons, Inc.

Taylor. C.W, 1994, *Electric power system stability,* New York: McGraw-Hill.

Electronic Sources and Reports

Dabson, I., Greene, S., Rajaraman, R., Christensen, L., DeMarco, C., Alvarado, F., Glaviç, M., Zhang, J., Zimmerman, R., 2001, Electric Power Transfer Capability: Concepts, Application, Sensitivity and Uncertainty, Power Systems Engineering Research Center, PSERC Publication 01-34, http://www.pserc.cornell.edu/tcc. [citied 12 April].

National program on technology enhanced learning, Indian Institute of Technology & Indian institute of Science, http://nptel.iitm.ac.in. [citied 2 May]

Transmission Transfer Capability Task Force, *"Transmission Transfer Capability",* North American Electric Reliability Council, Princeton, New Jersey, May 1995.

Transmission Transfer Capability Task Force, "Available *Transfer Capability Definitions and Determination",* North American Electric Reliability Council, Princeton, New Jersey, June 1996**.**

Zimmerman, R., Murillo-Sánchez, C., Gan, D., MATPOWER, A MATLAB™ Power System Simulation Package, Version 3.2, 2007, Power Systems Engineering Research Center (PSERC), School of Electrical Engineering, Cornell University, Ithaca, NY, http://www.pserc.cornell.edu/matpower [citied 12 April].

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