Mansoura Engineering Journal

Volume 16 | Issue 2 Article 11

8-8-2021

On Line Algorithm for Line Overload Alleviation.

K. Yassin
National Energy Control Center Egypt., Electrical Authority.

E. Abd-Raboh
Faculty of Engineering., El-Mansoura University., Mansoura., Egypt.

E. Towfik
Mechanical and Electrical Department., Ministry of Works and Water Sources.

Recommended Citation

Yassin, K.; Abd-Raboh, E.; and Towfik, E. (2021) "On Line Algorithm for Line Overload Alleviation.," *Mansoura Engineering Journal*: Vol. 16 : Iss. 2 , Article 11.
Available at: https://doi.org/10.21608/bfemu.2021.187969

On line algorithm for line overloads alleviation

ازالة التحميل الزائد على الخطوط الكهربائية

K. Yassin
National Energy
Control Center
Egypt. Elect. Authority

E. Abd-Rabon
Faculty of Engineering
Mansoura University
Egypt

E. Towfik
Mech. and elect. depart.
Ministry of works and
water sources

الخلاصة:

ان مسألة الحفاظ على أمان الشبكات الكهربية في مواجهة أي حدث طارئ ليمثل اهمية قصوى في مجال تشغيل الأنظمة الكهربية. لذا فقد دأب الكثيرون على دراسة وبحث الطرق المختلفة في هذا المجال محاولين إيجاد أنسب الطرق التي يمكن العمل بها في مراكز التحكم في الطاقة لإزالة التحميل الزائد على الخطوط الكهربائية. ويعد هذا البحث واحداً من هذه الأبحاث حيث يقدم طريقة سريعة تحدد قيم القدرات المنقولة على أي من الخطوط نتيجة لخروج خط آخر دون اللجوء إلى حسابات سريان القدرة في كل حالة. كما يقدم البحث أيضاً طريقتين يمكن استخدام إي منهما لإزالة التحميل الزائد على الخطوط وذلك إما عن طريق فتح أحد الخطوط أو تشغيل المحطات بنظام القضبان المنفصلة، وقد تأكد نجاح هاتين الطريقتين من خلال تطبيقات أجريت على الشبكة جهد ٢٢٠ ك.ف. بمصر الشمالية.

هذا وقد أجريت مقارنة بين هاتين الطريقتين والطريقة التي تعتمد على اعادة توزيع التوليد. وتبين أن الطريقة المقترحة تؤمن التشغيل دون المساس باقتصاديات التشغيل اذا ما قورنت بطريقة اعادة توزيع التوليد.

وقد وضح أيضاً أن الطريقة المقترحة يمكن أن تستخدم كأساس لبناء قاعدة معلومات لنظام الذكاء الصناعي لتشغيل نظم القوى الكهربية.

Abstract

This paper presents an algorithm to be used in an energy control center to alleviate transmission lines overloads.
The algorithm utilizes the concept of line outage distribution factors derived from the network admittance matrix. Two options are available for the dispatcher to alleviate line overloads, either by line switching or busbar splitting.
The method is applied to the 220 Kv network of Northern Egypt power system. The results achived proves the efficiency of such algorithm. Morover, a comparison is carried out between the proposed algorithm in this paper and the generation shift approach.

1. Introduction:

One of the major problems in electrical networks is to guarantee the security if an unexpected event occurs. Particularly, if one or several overloads appear on transmission lines, a corrective action must be quickly taken before the reaction of the automatic protections.

* To remove overloads, two actions can be taken:

a. The first one, a correction of the injections through the variation of the generation pattern is to be considered.
The generation shift method represents this action [1]. Such shifts are generally in conflict with the carefully determined economic dispatch of generation which has taken into account many factors, such as generator limits, transmission penalties, incremental costs and system security. Any deviation from this dispatch will result in increased production cost.

b. The second is a modification of the network topology through line switching or busbar splitting leaving the injections (generation pattern) unchanged. This action affects neither the Customers nor the cost of the operation and thus is particularly interesting.
In many situations, line switching will not greatly change the transmission penalty factors and therefore can be undertaken without seriously affecting the economic dispatch.
It would be convenient for system dispatchers to have a fast easy to operate computer program to alleviate line overloads.
The literature survery lindicated that there are three main approachs used to determine the line to be switched to releive the overloads:

1. Z matrix approach [2], [3] :

The method uses Z matrix representation to determine whether a line switching would reduce or aggravate an overload condition. If a line between buses P, Q is overloaded in the base Case, then to check the effect of switching the line between buses R, S, the quantity $|Z_{PR} - Z_{QR}| - |\bar{Z}_{PR} - \bar{Z}_{QR}|$ is computed. If it is positive, then the overload will be reduced by switching the line R. S where Z_{PR}, Z_{QR} are the Z matrix elements of the base case and $\bar{Z}_{PR}, \bar{Z}_{QR}$ are the matrix elements after switching the line R. S.

2. Current injection approach [4], [5] :

The method uses the concept of simulating the line to be switched by current injections. such current injection is distributed among other lines of the network. The distribution of this current injection depends on the matrix of node branch distribution factors derived from the Z matrix of the base case and the branch currents in the overloaded case .

3. Line outage distribution factors [6] :

The line to be switched (R-S) to releive the overload on line (P-Q) is choosen according to the distribution of the flow on line (R.S) in the overloaded case among other lines using the line outage distribution factors derived from the Z matrix of the base case. The line outage distribution factors d(L,K) reflect the change of the MW flow on line L if line K is outaged .

The goals of this research was to develop a fast algorithm which could be used in a real time energy control ceter to remove the overloads on transmission lines .

The following sections describe the algorithm developed, its implementation on the 220 KV network of Northern Egypt power system and finally, the conclusions and recommendations .

2. Problem formulation :

2.1 General :

A global network topology is defined by the position of each line, each injection and each coupler. Where one or several overloads appear on the network, the problem will be to modify the network topology to remove such overloads within the limits imposed by all the constraints .

Topology modifications in this paper consist of either line switching or busbar splitting .

2.2 Methodology :

The research described in this paper deals only with the MW overloading of transmission lines . The process of relieving such overloads begins with developing a tool to reduce the power flow on an overloaded line by a switching action. The line outage distribution factors (DF) are used to express the flow modification on line L due to the outage of line K as follows :

$$P_L = P_L^o + DF(L,K) \times P_K^o \quad \ldots\ldots\ldots (1)$$

where :
- P_L : flow on line L after the outage of line K
- P_L^o : initial flow on line L
- $DF(L,K)$: line outage distribution factor
- P_K^o : initial flow on line K

The line outage distribution factors are computed [7] from the network topology after inverting the admittance matrix as following :

$$DF(L,K) = \frac{x_K \,[X_{in} - X_{jn} - X_{im} + X_{jm}]}{x_l \,[x_K - (X_{nn} + X_{mm} - 2X_{nm})]} \quad \ldots (2)$$

where :
- $DF(L,K)$: line outage distribution factors giving the change in flow on line L when line K is outaged
- x_K, x_l : the individual line reactances for lines K, L respectively .
- n, m : Sending and recieving buses for line K .
- i, j : Sending and recieving buses for line L .
- X : Elements of the bus reactance matrix .

2.3 Step-by-step procedure :

The above developed methodolgy is implemented as depicted in the block diagram (fig. 1) as follows :

- The network topology and system state (generation and loads at different buses) are read by the program .
- Build the network admittance matrix and invert it to ob tain the Z matrix .
- Compute line outage distribution factors by equation (2) and store them for further analysis .
- Compute base case load flow and check whether there is any overloads in the base case or not . If overloads do exist, take necessary action to relieve such overloads, otherwise start to implement the outage list to check their effect and necessary corrective action to be taken .
- The corrective actions adopted in the current work are divided into :

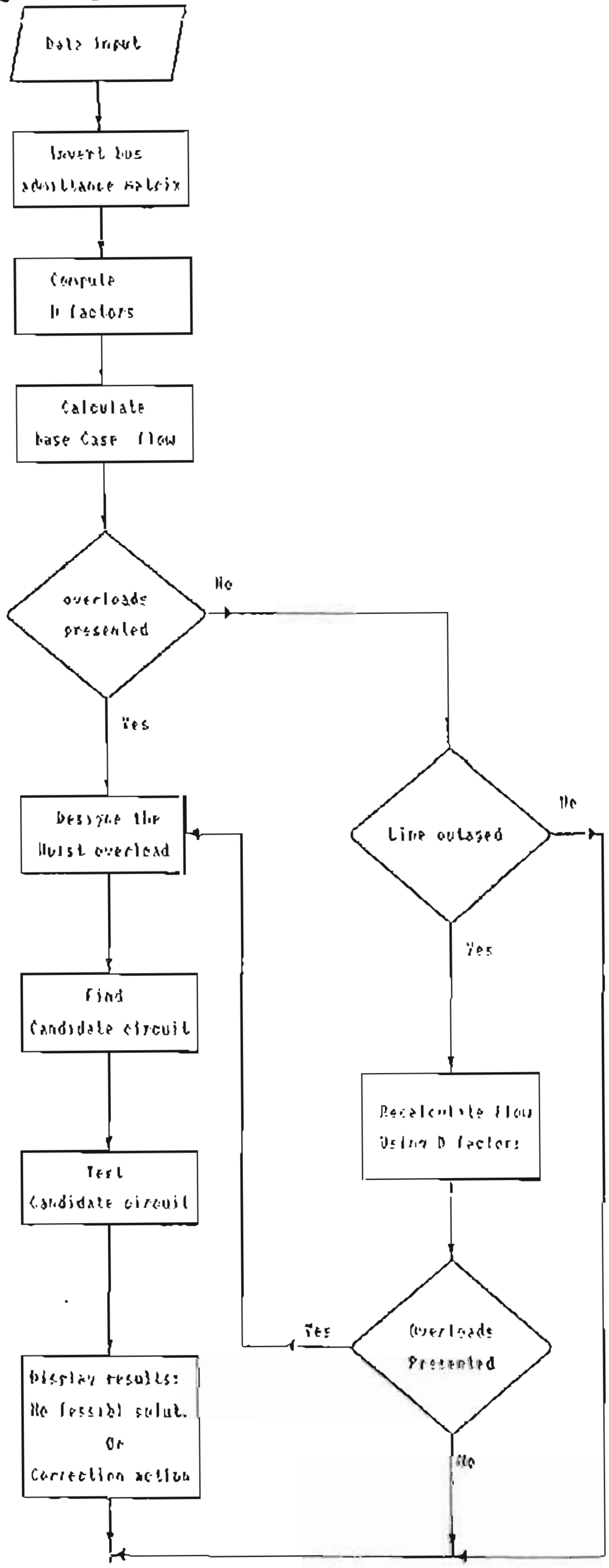

Fig. (1) : Block diagram of network switching program

2.3.1 Line switching action :

If the flow on line L exceeds the max limit P_L^{max}

$$P_L > P_L^{max} \quad (3)$$

Then, the elements on the row of such line in the line outage distribution factors matrix are the candidates to be screened one at a time as shown in fig (2) untill the overload is removed, then using equation (1), the new flow on line L is computed , this flow is compared with the maximum limit using equation (3). If the flow is within limit, the effect of the removal of the K^{th} line on the loading of the remaining line is checked. If no overloads are detected on the remaining lines, then the removal of the K^{th} line would be the corrective action necessary in this case.

If none of the candidates screened led to the removal of the overloads without causing new overloads, then the candidate circuits that led to the reduction of the overloads to the permissible levels shall be considered using the following criteria :

$$B_L = |P_L^{\circ}| - P_L^{max} \quad (4)$$

$$B_V = |P_V| - P_V^{max} \quad (5)$$

Where : P_V = flow on line V after the outage of line K.
B_L = the value of the old overload on line L which was removed by switching line K.
B_V = the value of the new overload on line V due to switching line K.

Then, the candidate circuits which make $B_V > B_L$ are rejected.

2.3.2 busbar splitting action :

The switching algorithm is easily extended to the case where a breaker operation splits a bus. To do this, each breaker which is to be a candidate for corrective switching is represented as a zero impedance circuit made up of two circuits in series having equal but opposite reactances. This is shown schematically in fig. (3). The reasulting network has one additional node and two additional circuits for each breaker. The algorithm described previously will treat the two circuits mading up the zero impedance link in the same way as other circuits in the network. Therefore selecion of either circuit representing the breaker itself as a corrective switching action. A special note needs to be made concerning the use of a series combination such as shown in fig (3). When building the reactance matrix of the network the diagonal term corresponding to the added bus will be zero. This will cause trouble in factorization routines unless one guarantees that no pivot occurs on this bus until after one fill-in term has been made at the diagonal term.

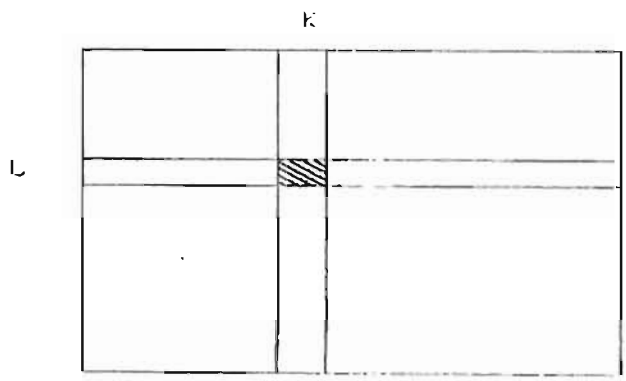

Fig. (2) : The K th case for line switching action.

Fig. (3) : Representation of bus splitting circuit breaker

3. Test results:

An application on the 220 kv network of the Northern Egypt power system is carried out. The test system consists of 42 buses and 54 lines Fig. (4) shows a single line diagram of the base case data are presented in reference [8].

Case (1)

In this case, the loads at bus 28,bus 4 and the great part of load at bus 25 are fed from the generation at bus 5 through circuits 10 and 11 causing overloads on these circuits by 129 and 114 percent of its ratings respectively. The program produced the following corrective action to remove these overloads by either opening line 29 (bus 30 to bus 33) or opening circuit breaker at bus 33.

Case (2)

In this case, due to the concentration of generation at bus 5, the circuits 10 and 11 were overloaded by 140 and 130 percent of its ratings respectively.
The algorithm succeeded to remove these overloads by opening the circuit breaker at bus 3 as shown in table (1) while the overloads were not removed by the line switching action, since opening line 14 worsened the overload on line 5 as shown in table (2).
The generation shift method (9) removed the overlods on circuit 10 and 11 as shown in table (3) on the expense of deviating from the economic dispatch of generation.

4. Conclusions:

The developed program in this paper is fast enough to be used in a real time system as part of corrective action. Test results show the advantages and disavantages of line switching, busbar splitting and the generation shifting corrective actions.
The results show that the switching action (specialy busbar splitting) are highly efficient as corrective actions.
The best chances of removing overloads with corrective actions appear when only a single circuit is overloaded.
The results also show that the generation shifting action is the proper one when the overloads are due to generation concentration in certain areas, while the switching actions are the proper when the overloads are due to line outages.
The algorithm developed can be easily used to build a knowledge base for an expert system.

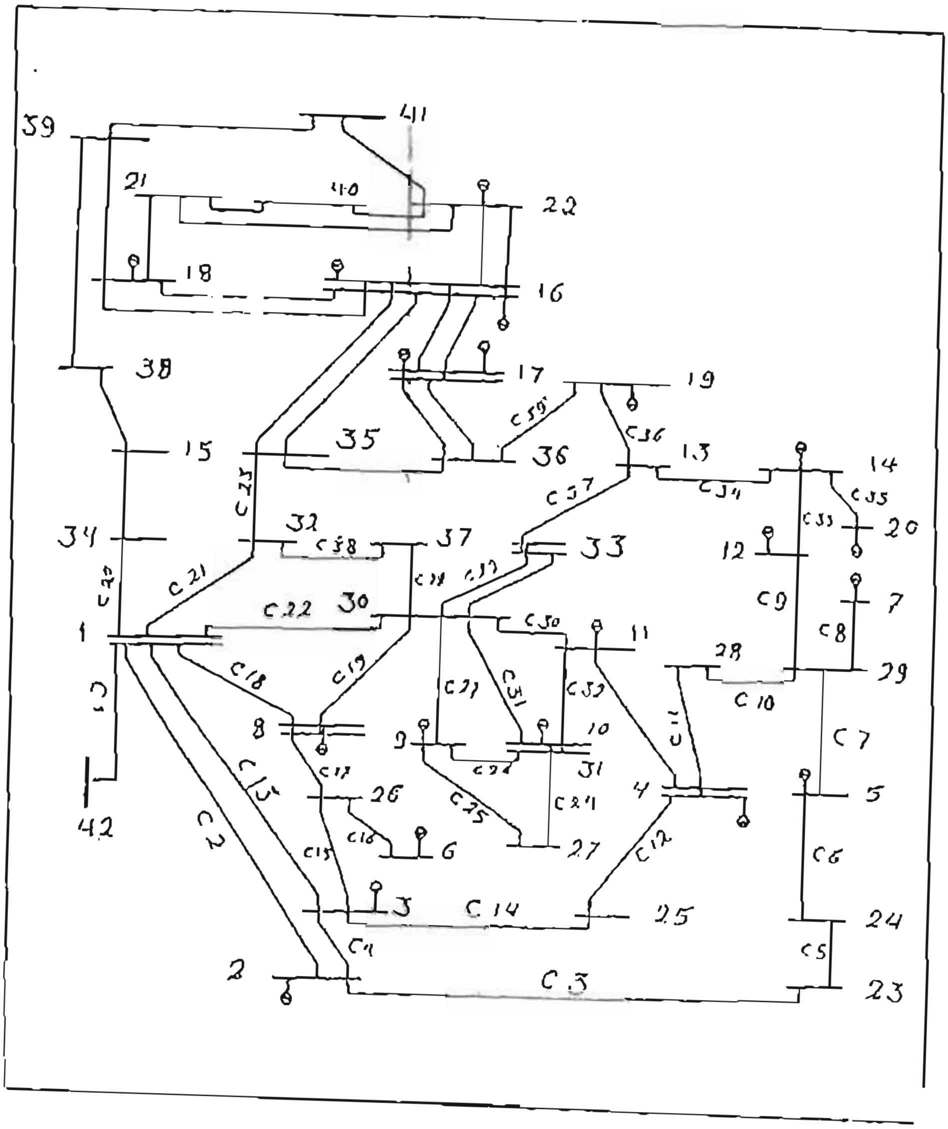

Fig. (4) : Northern Egypt 220 kv network