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Computer Based Optimum Load Shedding Controller Using Unconstrained Minimization Technique (Case Study)

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Abstract: In this paper, the computerized controller for studying load shedding has been designed and implemented. This controller is designed based on the problem of minimizing load shedding during emergency conditions. The studied problem is formulated as a nonlinear static optimization problem subject to operational and equipment constraints. Suitable adjustments of control of generation rescheduling and control of phase shifting transformers before load shedding is determined and recommended.
SUMT, solution algorithm adopting sequential unconstrained minimization technique is given. Results of application of the proposed technique to a 5 and 20-node network are presented. An overload relief policy is proposed to minimize load shedding.the proposed computerized technique have been presented in this paper.Applications to be IEEE – 5 and 20 bus system are presented to validate the applicability of the proposed technique to any system of any size.

Keywords: SUMT, Load Shedding, Power System, Minimization Technique, Sequential Unconstrained, computerized technique

I. INTRODUCTION

The main function of power system is to supply electricity to all consumers. However, when the system is in an unstable condition, only a certain amount of electricity can be supplied. Thus, in many cases part of the system load needs to be shed in order to make sure the system is stable and able to provide power to critical loads.

Various methods have been used to determine the amount of load to be shed. For instance, traditional load shedding has been applied in where it sheds a fixed amount load with decreasing frequency [1, 2]. Some methods proposed a load curtailment procedure where it considers violation vector with current capacity and also voltage drops [3]. HARRISON presented a control method to prevent voltage instability using a dynamic model of load shedding [1].

Several techniques have been proposed for the adjustment of phase angles of phase shifting transformers to alleviate line overloads. The displacement technique proposed in reference [4,5] is an iterative method. The convergence of such an iterative procedure depends highly on the proper selection of the acceleration factor.

In this paper, the optimization problem is formulated as a nonlinear static optimization problem. The SUMT (sequential un-constrained minimization technique) [5-6] is used for solving the problem. The technique uses the problem constraints and the original objective function to form unconstrained objective function which is minimized by an appropriate unconstrained, multivariable technique based on McCormick's modification of the Fletcher - Powell method [13].

The optimization problem formulation introduced in this paper includes adjustment of phase shiftingtransformers,economic shift in load shedding and generation.

In this paper a fast method for determining the location and quantity of the load to be shed in order to avoid risk of voltage instability is presented. The method defines clearly the bus where load shedding should make.

II. PROBLEM STATEMENT

Adjustments of phase angle of phase shifters have the effect of changing system state variables (V,δ) to regulate real power flow. Any change of state variables will result in change of system losses. Optimum phase shifters operation is defined as adjusting the available phase shifters to satisfy the following objectives.
-Elimination I minimization of system overloading.
-Minimization of transmission losses.
Figure (1) shows the model used to simulate the presence of a phase shifter in network element i-j.

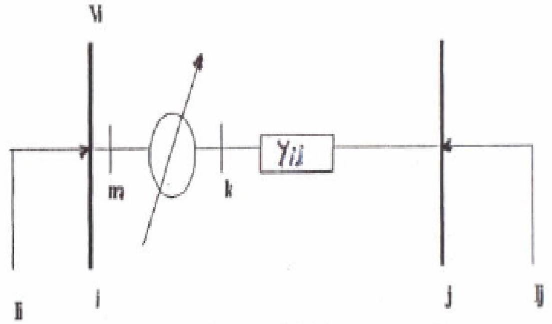

Fig. (1): Phase Shifting Transformer Simulation.

The terminal voltages Vi, Vk are related by:

$$\frac{V_i}{V_k} = a_k + Jb_k \qquad (1)$$

The complex turns ratio for a specified angular displacement is given by:

$$a_k + Jb_k = \cos\emptyset_{ij} + J\emptyset_{ij} \qquad (2)$$

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Transformation ratio of current and voltage is:

$$\frac{I_{im}}{I_{kj}} = \frac{V_k^*}{V_{mi}^*} - \frac{1}{a_k - Jb_k} \quad (3)$$

Since

$$I_{kj} = (V_k - V_j)y_{ij} \quad (4)$$

Then

$$I_{im} = (V_k - V_j)\frac{y_{ij}}{a_k - Jb_k} \quad (5)$$

Substituting for Vk from equation (1) and for ak and bk from equation (2).

$$I_{im} = |V_i - V_j(\cos\emptyset_{ij} + J\sin\emptyset_{ij})| * (g_{ij} + Jb_{ij}) = I_i \quad (6)$$

The active and reactive conjugate of complex power injected at node I is given by:

$$P_i - JQ_i = V_i^* I_i = V_i^* |V_i - V_j(\cos\emptyset_{ij} + J\sin\emptyset_{ij})| * (g_{ij} + Jb_{ij}) \quad (7)$$

Substituting the values of

$$v_i = |v_i|e^{\delta_i}, v_j = |v_j|e^{\delta_j}, \quad \delta_{ij} = \delta_i - \delta_j$$

In equation (7) and separating the real and imaginary parts, we get:

$$P_i = g_{ij}\{|v_i|^2 - |v_i||v_j|\cos(\delta_{ij} - \emptyset_{ij})\} - |b_{ij}|\{|v_i||v_j|\sin(\delta_{ij} - \emptyset_{ij})\} \quad (8)$$

Similarly at node j

$$P_j = g_{ij}\{|v_j|^2 - |v_i||v_j|\cos(\delta_{ij} - \emptyset_{ij})\} + |b_{ij}|\{|v_i||v_j|\sin(\delta_{ij} - \emptyset_{ij})\} \quad (9)$$

The total losses in a line ij are given by the sum of the real power entering at the two ends of the line.

$$P_L = P_i + P_j = g_{ij}\{|v_i|^2 + |v_j|^2 - 2|v_i||v_j|\cos(\delta_{ij} - \emptyset_{ij})\} \quad (10)$$

III. OBJECTIVE FUNCTION

The objective is to alleviate line overloads with an overall minimal adjustment to the control variables. Hence, to minimize the overall adjustments, it is ideal to penalize the adjustments (positive or negative) to the control variable. The general objective function must include terms representing the losses. the generation costs, and the active and reactive load shedding [(ΔLp)i and [(ΔLq)i] each of them with the appropriate weighting factor. The following general objective function' is used.

F =
$W_{ij} \sum_{i=1}^{N} \sum_{j=i+1}^{N} (P_{loss})_{ij}$ +
αii=1mHi+i−1NβiΔLpi,ΔLqi (11)

F=F1+F2+F3
Where:
W_{ij}, αi and βi are weighting factors.

The objective function in this investigation is proposed consisting of three main parts which can be represented as described. The first part in the objectives function which represented as:

$$F_i = W_{ij} \sum_{i=1}^{N} \sum_{j=i+1}^{N} (P_{loss})_{ij}$$

(for the purpose of minimizing total transmission losses). From equation (10):

$$F_i = W_{ij} \sum_{i=1}^{N} \sum_{j=1+1}^{N} g_{ij} \begin{Bmatrix} (|V_i|^2 + |V_j|^2) - \\ 2|V_i||V_j|\cos(\delta_i - \delta_j - \emptyset_{ij}) \end{Bmatrix}$$

$$F_1 = f(V_i, \delta_i, \emptyset_{ij})$$

The second term in the objective function is function of total operation cost represented by F_2 as follows:

$$F_2 = \alpha_i \sum_{i=1}^{m} H_i$$

The standard economic dispatch objective equal to the sum of the fuel costs which depends only on the active powers P_{Gk} thus,

$$F_2 H(P_{Gi}) = f(P_{G1}, P_{G2}, \ldots\ldots, P_{Gm} \quad (13)$$

The selection of the production cost function $H(P_{Gi})$ depends on two factors namely the accuracy with which this function has to represent the actual fuel costs of thermal unit and the speed with which the associated dispatch problems can be solved. In this paper the quadratic production cost function [6] is considered.

$$H(P_{Gi}) = \sum_{k=1}^{m} A_i (P_{Gi})^2 + B_i P_{Gi} + C_i \quad (14)$$

Where A_i, B_i, and C_i are constants.

The last part of the objective function is the load shedding minimization function represented by (F3). Various different forms of the cost function $f\{(\Delta Lp)_i, (\Delta Lq)_i\}$ may be suitable for optimization [6], corresponding to the requirements and operating policies of various utility companies. However, the cost function may be greatly simplified without much loss. This can be achieved if only the real power demands $(Lp)_i$ are considered as problem variables, and the reactive demands $(Lq)_i$ are assumed linearly dependent on $(lp)_i$, i.e., the power factor of the loads are assumed to be known and constant du ring the emergency.

$$(L_q)_i - \gamma(L_p)_i = 0 \quad (15)$$

In this paper, F3 is considered to be a quadratic function of the unsatisfied real demand (Lp)Di – (Lp)i, therefore:

$$F3\{((L_p)_i^D), ((L_p)_i)\} = \beta_i \sum_{i=1}^{N} \{((L_p)_i^D) - ((L_p)_i)\} \quad (16)$$

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IV. SOLUTION ALGORITHM CONSTRAINTS

The control variables (Φij),(P_Gi),and (ΔPL)i have their upper and lower permissible limits. Any change to this control variable has the effect of changing the system voltage profiles and the system losses. Thus, the operator's control on these control variables is indirectly limited by network performance constraints, i.e. line flows constraints, stability constraints, permissible limits of the voltages at the different buses and reactive power rating of the generators the constraints on the objective function (F) formulated in equation (11) can be stated as follows.

(a) Inequality constraints:-

$$|P_{ij}| \le |P_{ijmax}| \quad (17)$$

Where:

$$P_{ij} = |V_i|^2|Y_{ij}|cos\theta_{ij} - |V_i||V_j||Y_{ij}| * cos(\delta_i - \delta_i - \emptyset_{ij}) \quad (18)$$

$$(P_{Gi})_{min} \le P_{Gi} \le (P_{Gi})_{max} \quad (19)$$

$$(Q_{Gi})_{min} \le Q_{Gi} \le (Q_{Gi})_{max} \quad (20)$$

$$|V_{imin}| \le |V_i| \le |V_{imax}| \quad (21)$$

$|\delta_i - \delta_j| \le a_{ij}$ (stability constraint in terms of voltage angle across lines) (22)

$$(\Delta Lp)_i \le (Lp)_i initial \quad (23)$$

$$(\Delta Lp)_i \ge 0 \quad (24)$$

$$|\emptyset_{ijmin}| \le |\emptyset_{ij}| \le |\emptyset_{ijmax}| \quad (25)$$

$$P_i = \sum_{j=1}^{N} |V_i|\,|V_j||Y_{ij}|cos(\delta_i - \delta_j + \theta_{ij} - \emptyset_{ij}) \quad (26)$$

$$Q_i = \sum_{j=1}^{N} |V_i|\,|V_j||Y_{ij}|sin(\delta_i - \delta_j + \theta_{ij} - \emptyset_{ij}) \quad (27)$$

i=1,2,3,………………, N-1

where N= number of nodes

$$(\Delta L_q)_i - \gamma(\Delta L_p)_i = 0 \quad (28)$$

V. SEQUENTIAL UNCONSTRAINED MINIMIZATION TECHNIQUE (SUMT) .[13]

This method finds the minimum of multivariable, nonlinear inequality and equality constraints.

Minimize $(X_1, X_2,...,...,X_n)$ (29)

Subject to:

$G_k (X_1, X_2,....X_n) \ge 0$, k=1,2,....,M (30)

Where M is the number of inequality constraints.

$H_k(X_1, X_2, ….,X_n) = 0$, k=M+1, M+2, …. M+Z (31)

Where z is the number of equality constraints.

The algorithm proceeds as follows:

1. The problem constraints and the original objective function are used to form unconstrained objective function in the form:

$$F' = F + r_k + \sum_{k=1}^{M} f(G_k) + \frac{1}{r_k}\sum_{k=M+1}^{M+z} f(H_k) \quad (32)$$

Where:

r_k is a positive constant

$f(Gk)$ is a function of the inequality constraints and its value tends to infinity as the constraint boundary is approached.

$f(Hk)$ is a function of the equality constraints.

2. As the algorithm progresses Γ_k reevaluated to form monotonically decreasing sequence $r_1 > r_2$ …………………. $> r_k$.

3. As the r_k becomes small, under suitable condition F' approaches F and then the problem is installed.

TABLE (1) VALUES OF (TIJ)MAX AND (PIJ)MAX (20-NODE STUDIED SYSTEM)

Branch i-j	(τij)max	(Pij)max
1-2	0.12	5.0
2-3	0.09	1.0
2-4	0.09	2.0
2-11	0.08	0.8
2-13	0.08	1.3
3-4	0.09	2.0
3-13	0.09	2.0
4-5	0.18	1.8
4-6	0.09	1.9
4-7	0.11	1.9
5-15	0.11	1.7
6-7	0.07	0.5
6-8	0.18	2.2
7-9	0.07	0.8
8-15	0.09	2.0
9-10	0.18	1.2
9-11	0.08	1.3
9-13	0.08	1.0
10-16	0.08	1.0
11-12	0.18	2.0
12-14	0.08	2.1
12-17	0.06	1.0
13-14	0.172	2.5
14-20	0.06	1.0
15-16	0.08	1.0
17-18	0.05	1.2
18-19	0.08	1.0
19-20	0.08	0.9

TABLE (2) VALUES OF $(TIJ)_{MAX}$ (5-NODE STUDIED SYSTEM)

Branch (i-j)	(τij)max
1-2	0.11
1-3	0.10
2-3	0.09
2-4	0.09
2-5	0.09
3-4	0.09
3-5	0.09

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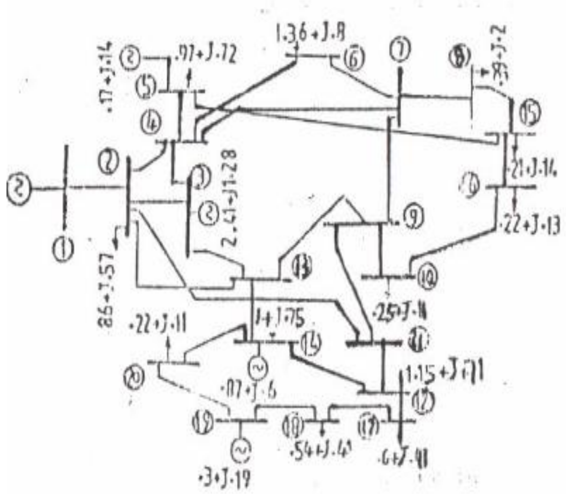

Fig. (2) Selected power system

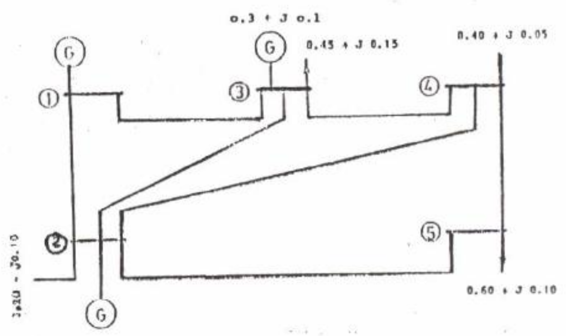

Fig. (3) Single Line Diagram of the Case Study

VI. SOLUTION ALGORITHM

1- An initial AC load flow is required for the considered emergency condition to determine constraint violation.

2-The optimization problem is solved in three steps:-
In the first step the adjustment of the angular displacement of phase shifting transformers ($\Delta\emptyset_{ij}$) is only considered, i.e., in equation (11) Wij=l, $\propto_i$=0, β_i=0. In the second step the optimum generation shifts are determined, i.e., Wij=0, $\propto_i$=1, β_i=0. In the last step the optimum load shedding is calculated, Wij=0, $\propto_i$=0, $\beta_i = 1$. Each step is followed by an AC power flow. If there is no constraint violation, the optimization process is stopped.

3-ln each step, the optimization technique (SUMT) is performed as follows:
a) A modified, objective function is formulated using equation (32).
b) Select a starting point (feasible or non-feasible). In this analysis the post fault conditions f(X1) are considered as the starting point.

c) Select initial value of rk as the value of r1 In practice, a value ofr1, which gives the value of F'=(X1,r1) approximately equal to1.1 to2.0 times the values of f(x1) has been found to be quite satisfactory in achieving quick convergence [14].

d) Estimate the sub-optimal solution.
e) Select anew value rk. The subsequent values of rk have to be chosen such that:
rk+1 <rk (33)

The values of rk are chosen according to the relation:
$r_{k+1} = Cr_k$ (34)
Where C < 1. The value of C can be taken as 0.1 or 0.2 or 0.3, ……,etc, (the accuracy of the solution is increased as the value of C is decreased but the number of iterations to final convergence are increased).
f) Repeat the procedure until the final convergence is satisfied.
4- An AC load flow with the new schedule of the system calculated in step 3 is used to determine the final conditions of the system

VII. SELECTED SYSTEMS FOR STUDY

Two different practical systems are selected; the first is 20-nodes network
(Fig.2) and the second is 5-node network, Fig.3. Tables 1 and 2 give the values of the maximum phase angle differences tolerated ($(\tau_{ij})max$) for the two networks. These constraints can be obtained rather laboriously from experiments performed with available transient stability programs, or preferably from direct stability analysis [6].

VIII. RESULTS AND DISCUSSION

a- 20-Node network
The emergency condition is considered as tripping branch (3-4) at both ends. Table (3) shows the overloaded branches in this case.

TABLE(3) OVERLOADED BRANCHES AFTER TRIPPING BRANCH [3-4]

Overload branch i-j	Pij (P.U.)	Pii Max (P.U.)	%loading
3 - 2	1.2049	1.0	120.490
2 – 4	2.7416	2.0	137.080
2 -11	1.0505	0.8	131.310
3 - 9	1.2821	1.0	128.210

By applying the proposed technique with starting point of r_k=l.0 and c=0. l. The following results are obtained.

Step_(l) Optimum phase-shifting transformer adjustments. Table (2) shows the optimum-phase shifting transformers angular setting to minimize system overloading (after16 iteration).

TABLE (4) PHASE SHIFTING TRANSFORMERS

Phase shifting transformer i-j	Angular setting $\emptyset_{ij}$ (degrees)
4-5	-2.0
7-8	-10.0
9-10	-14.0
13-14	-14.0

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After phase-shifting transformers adjustment the transmission losses ($\sum \Delta PL$) increased by 3.0285%o and the followinglines are found to be still overloaded.

TABLE (5) OVERLOAD BRANCHES AFTER PHASE-SHIFTING TRANSFORMERS

Overloaded branches i-j	Pij (P.U.)	Pij Max (P.U.)	% loading
2-4	2.8970	2.0	144.8505

Step (2): Economic shift in generation to minimize system overloading.

Table (6) shows the generation schedules and the system operating cost in $/hr. in the initial (optimum cost) state and in the modified schedule state (after 13 iterations).

TABLE (6) OPTIMUM GENERATION RESCHEDULING

	Generation (p.u.)					
	P1	P3	P5	P14	P19	Cost $/hr
Initial value	4.76	2. 4	0.17	0.87	0.3	3141.992
After rescheduling	3.71	2. 4	2.17	0.87	0.3	3384.872

After generation rescheduling, the total operating costs increased by 7.73%and the following lines arc found still overloaded.

TABLE (7) OVERLOADED BRANCHES IN THE

Overload branch i-j	Pij (P.U.)	Pii Max (P.U.)	%loading
2-4	2.0503	2.0	102.519

Step (3) Optimum load shedding to remove system overloading.
Table (8) shows the optimum load shedding to remove system overloading (after 1l iterations).

TABLE (8) OPTIMUM LOAD SHEDDING

Bus Code (I)	Load Shedding (p.u.)
5	0.01387+j0.01029

The total transmission losses after the threesteps increased by 4.8752%.

The problem is solved to determine the optimum load shedding as the only control variable to remove system overloading, i.e.in equation (1l) Wij=0, αi=0, βi=1. The following results are obtained to remove overloading (after 21 iterations).

TABLE (9) OPTIMUM LOAD SHEDDING IN

Bus Code (i)	Load Shedding (P.U.)
5	0.2367+j0.1757
8	0.116+j0.0595
10	0.124+j0.0717

The total transmission losses in the system increased by 4.6251%.The obtained results illustrated in Tables 8 and 9 clear that the system overloading is removed with minimum load shedding by applying the proposed technique (2.9 % of the value obtained when the load shedding is considered ns the only control variable).

b- 5-node network
The emergency condition is considered as tripping branch (2-4) at both ends.
Table(10) shows the overloaded branches in this case.

TABLE (10)

OVERLOADED BRANCHES AFTER TRIPPING BRANCH (2-4)

Overload branch i-j	Pij (P.U.)	Pii Max (P.U.)	% loading
1-3	0.4766	0.399	119.456

Applying the proposed technique with starting point of rk= l.0, and c=0.l, the over-loading is removed completely in step (l).After 6 iterations, optimum phase shifting transformer angular setting given in Table (11) is obtained.

TABLE(11) PHASE SHIFTING TRANSFORMERS SETTING TO REMOVE OVERLOADING

Phase shifting transformer i-j	Angular setting $\emptyset_{ij}$ (degrees)
1-2	-20

After phase-shifting transformers adjustment the total transformission losses increased by 5.432%.
The problem is solved to determine the optimum load shedding as the only control variable to remove overloading i.e.,Wij = 0, βi=1.0 in equation (11). Table (12) shows the obtained results in the case (after 8 iterations). Total transmission losses in the system increased by 4.872%.

TABLE (12) OPTIMUM LOAD SHEDDING TO REMOVE SYSTEM OVERLOADING

Bus Code (i)	Load Shedding (P.U.)
3	0.1348+j0.0425

Comparing the results given in Tables 11 and 12, it is clear that the system overloading is removed by applying the proposed technique without any load shedding.

IX. COMPUTERIZED TECHNIQUE DESIGN

The main futures of the designed computerized technique can be stated as follows:
1- Determination of the feeder that will be disconnected in case of the main feeder disconnection.
2- Automatic Tripping of all relative circuit breakers.
3- Automating reclosing in case of services back coming.
4- Redistribution of the disconnected feeder or transformer loads to the working one.

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Suggested Program Advantages

1- Applicable for different substation ratings
2- Applicable for different feeder ratings
3- Possibility to identify and change the feeders supply the high priority loads.
5- Allows increasing the number of working feeders as well as number of transformers.

Computerized ControllerAssumptions:

The maximum allowed load of each feeder is 278 A
If the preload of any feeder less than 85% of the peak load, the feeder is allowed to be over loaded up to 450 A. This overload condition can continued up to one hour.

if the preload of any feeder is more than 85% of the peak load, the overload period reduced by a certain ratio. Each 5% reduction of the load causes 10 minutes less in overload period. For example: if the preload is 90%, the time period will be 50 minutes, where if the preload is 95 %, the time period will be 40 minutes and so on.

The following table (13) illustrates the input data. Such data represent the actual loads and rating of the distribution network feeders.

TABLE(13) ACTUAL DATA INPUTTED TO THE COMPUTERIZED CONTROLLER

GRID STATION	VOLTAGE (KV)	FEEDER ID	MAX LOAD (Amp)	PRIORITY
NAHDAH (NHD)	13.8	2	204.48	10
NAHDAH (NHD)	13.8	3	195.84	14
NAHDAH (NHD)	13.8	4	119.52	17
NAHDAH (NHD)	13.8	5	205.92	30
NAHDAH (NHD)	13.8	6	203.04	18
NAHDAH (NHD)	13.8	9	0.00	26
NAHDAH (NHD)	13.8	10	167.04	27
NAHDAH (NHD)	13.8	11	184.32	1
NAHDAH (NHD)	13.8	13	141.12	11
NAHDAH (NHD)	13.8	14	326.88	28
NAHDAH (NHD)	13.8	15	250.56	6
NAHDAH (NHD)	13.8	16	220.32	12
NAHDAH (NHD)	13.8	17	218.88	16
NAHDAH (NHD)	13.8	18	244.80	29
NAHDAH (NHD)	13.8	19	295.20	2
NAHDAH (NHD)	13.8	20	299.52	13
NAHDAH (NHD)	13.8	21	321.12	15
NAHDAH (NHD)	13.8	22	129.60	7
NAHDAH (NHD)	13.8	25	146.88	25
NAHDAH (NHD)	13.8	26	138.24	8
NAHDAH (NHD)	13.8	28	200.16	19
NAHDAH (NHD)	13.8	32	249.12	20
NAHDAH (NHD)	13.8	34	197.28	3
NAHDAH (NHD)	13.8	35	244.80	24
NAHDAH (NHD)	13.8	36	264.96	9
NAHDAH (NHD)	13.8	37	125.28	23
NAHDAH (NHD)	13.8	38	168.48	4
NAHDAH (NHD)	13.8	39	145.44	21
NAHDAH (NHD)	13.8	40	264.96	22
NAHDAH (NHD)	13.8	41	201.60	5

NOTES:
1) FEEDER LOAD IS YEARLY MAX ABSOLUTE.
2) GRID STATION MAX LOAD IS 143 MVA OUT OF 120 MVA.
3) 13.8KV FEEDER (CABLE) IS ADJUSTED ON 278A AFTER THAT IT WILL TRIP.
4) EACH LOAD MORE THAN (278 A) MEANS DOUBLE CABLE IS CONNECTED ON BREAKER.
5) TRANSFORMER CAN CARRY (120%) OF ITS RATING.
6) 13.8 KV CABLE IS 185 mm2 AND IT CAN CARRY UP TO 290 A.

X. COMPUTERIZED TECHNIQUE IMPLEMENTATION

The following figures, Fig. (4) to Fig. ( ) indicates the computerized controller output against different operating conditions.

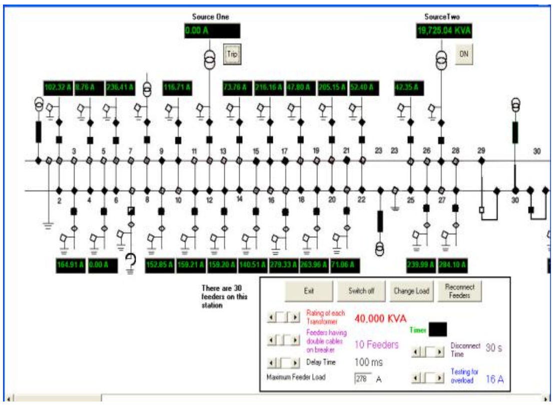

Fig. (4) Controller User Interface

If the user select, or other reason causes to disconnect one of the sources, the loads will redistributed to the other source according to the priority order. The message of "All feeders have transferred to source 3 because source one is disconnected", and the user have to click ok button as shown in the following Fig. (5)

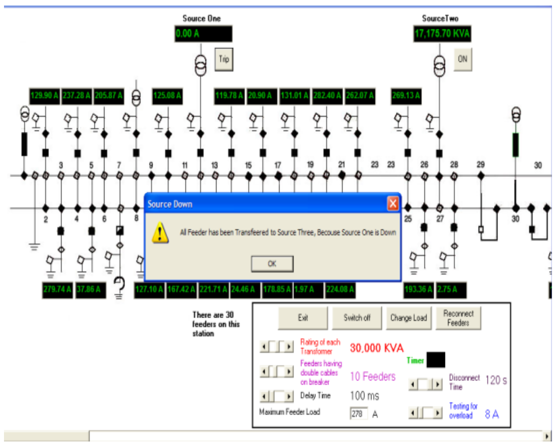

Fig.(5)

Then the message of "source one is disconnected and source three is overloaded, the loads of low priority will be disconnected" is indicated as shown I the following Fig. (6).

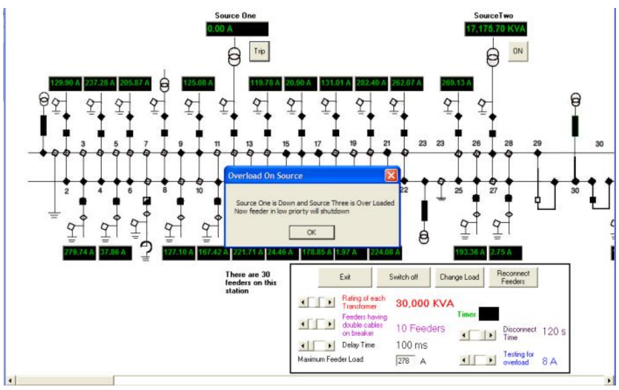

Fig.(6)

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After that the system illustrate a short report indicates list of the feeders that have been disconnected and their priority and loads as shown in Fig(7).

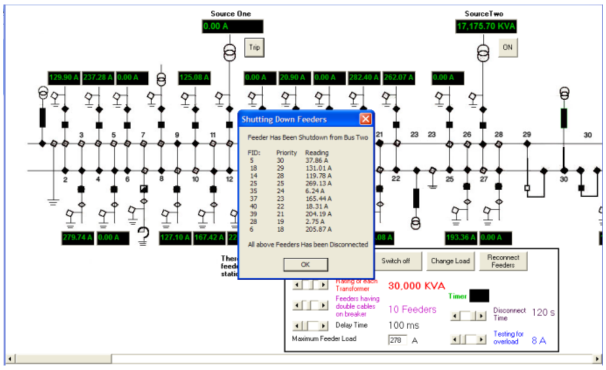

Fig.(7)

The following Fig.(8) shows the program response if the user like to change the priority list of the feeder.

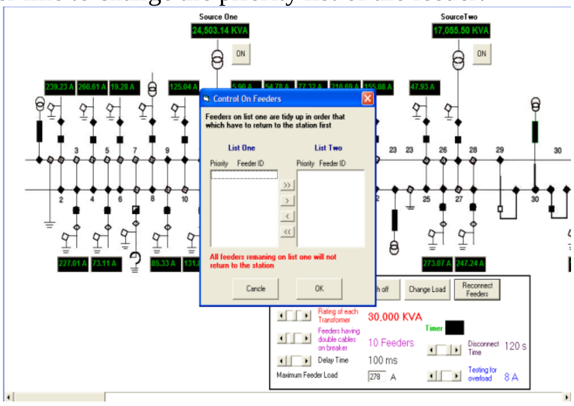

Fig.(8)

Other reliable advantages of the designed computerized controller are the possibility to enter the value of the allowable maximum feeder load. This advantage means that the program is applicable for different feeder ratings. The data of the maximum load of the feeder may be entered directly in the text box shown in the bottom of the interface.

XI. CONCLUSION

The following conclusions can be drawn:

1- A proposed policy for the relief of network overloads have been discussed and tested in this paper. This policy is divided into three phases as follows:-

Phase 1: Optimum phase-shifting transformer adjustment to eliminate or minimize system overloading.

Phase 2: Economic shift in generation to eliminate/minimize system overloading.

Phase 3: If some lines are still overloaded after the application of the previous control actions, load shedding is recommended to eliminate the remaining overloads while observing voltage levels and stability constraints.

2- The non-linear programming using

SUMT algorithm has the following advantages.

a) Accurate model for load shedding problem (objective function and all constraint) can be used.

b) The starting point in SUMT algorithm may be feasible or non-feasible. This condition is very important during studies of power networks problems specially load shedding because often after emergency condition the network will be in a non-feasible region, this condition is supplied to the SUMT and it will search for a feasible starting point.

c) Number of problem variable in SUMT algorithm is reduced to about one third of the number of variables when using Kuhn-Tucker technique with Lagrange multipliers.

d)The algorithm is capable of handling both quality and inequality constraints.

e) Conversion is fast.

The designed system allows to change the substation setting of the component parameter such as transformer rating, feeder rating, feeder cables, delay tripping and on time and other parameters.

Moreover, the system allows redistributing the loads according to predefined priority list. Furthermore, the program interacts with the user through instant messaging to indicate the operation condition and the feeder loading and the source responses.

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