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POWER FACTOR CORRECTION IN A RADIAL DISTRIBUTION SYSTEM USING OPTIMAL CAPACITOR PLACEMENT FOR BAGHDAD CITY

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Abstract: In recent years the nature of load has changed drastically and different electrical equipment's. mercury lamps, transformers, motors, switchgears are running inherently at low power factor. Planning of electrical distribution networks is considered of highest priority at the present time in Baghdad city, due to the huge increase in electrical power demand and expansions imposed on distribution networks as a result of the great and rapid urban - development. This work presents the new and efficient approach for capacitor placement in radial distribution network that determine the optimal locations and size of capacitor with the main objective for the improving voltage profile, reducing active power losses and improving power factor. This work includes two parts: part one implementation on the IEEE 33-bus test system using CYMDIST software program, as a tool for the simulation of a distribution network and performing the required analysis. The results, shows a good matching as compared with previous work mentioned in the literature and used for the same network but the analysis of different ways. , and in part two, we select actual sector of Baghdad city distribution network that is Al Adel_33/11kV_feeders 2, 3, 6, and 7 (11 kV_93 bus) network is depicted for the implementation of this analysis. The results using backward / forward load flow method, show that minimum power losses and improving voltage profile had been achieved. So the network can be operate in normal condition without any violating operational constraints.

Keywords: *Capacitor Placement; Power Losses, Improving Power Factor, Backward / Forward Load Flow Method, CYMDIST Software Program.*

تصحيح معامل القدرة في نظام توزيع شعاعي باستخدام التنسيب الأمثل للمتسعات في مدينة بغداد

الخلاصة: في السنوات الأخيرة تغيرت الحمولة الطبيعية تغيرا جذريا وباستخدام مختلف الاجهزة الكهربائية ، مثل مصابيح الزئبق والمحولات والمحركات ولوحات المفاتيح الكهربائية والتي تعمل بطبيعتها في معامل القدرة المنخفض. ويعتبر التخطيط لشبكات التوزيع الكهربائية أولوية قصوى في الوقت الحاضر في مدينة بغداد، وذلك بسبب الزيادة الكبيرة في الطلب على الطاقة الكهربائية والتوسعات المفروضة على شبكات التوزيع نتيجة للتنمية الحضرية الكبيرة والسريعة. هذا العمل يعرض نهج جديد وكفوء لوضع متسعات في شبكة توزيع شعاعي التي تحدد المواقع والحجم الأمثل للمتسعات مع الهدف الرئيسي لتحسين الجهد، والحد من خسائر االقدرة وتحسين معامل القدرة. ويشمل هذا العمل جزئين: في الجزء الأول الذي تم تنفيذه على نظام اختبار IEEE 33-bus باستخدام برنامج CYMDIST ، كأداة لمحاكاة شبكة التوزيع وإجراء التحليل المطلوب. وتظهر النتائج مطابقة جيدة مقارنة مع النتائج المنشورة في البحوث ذات العلاقة والمستخدمة لنفس الشبكة ولكن بطرق تحليل مختلفة ، وفي الجزء الثاني، تم اختيار القطاع الفعلي لشبكة توزيع مدينة بغداد الذي هو عبارة عن شبكة بغداد /حي العدل ذات الجهد (11/33 كي .في) للمغذيات 2و3و6و7 (11كي .في _ 93 مقطع) لتنفيذ هذا التحليل. وتظهر النتائج باستخدام طريقة تدفق الحمل للخلف / الأمام، أن الحد الأدنى من خسائر الطاقة وتحسين الجهد قد تحقق. وبالتالي فإن الشبكة يمكن أن تعمل في حالة طبيعية دون أي انتهاك للقيود التشغيلية .

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1. Introduction

The objective for adding the capacitor in best location in radial distribution network is to satisfy; reduce in line losses, improve in voltage profile and increase reliability of the network. Whereas the low voltage level and heavily overloaded because the expanded for system without proper planning in distribution networks are, the large in power loss portion among the power system sections, which are generation, transmission, and distribution, belongs to the distribution section, such that the line losses at the distribution level constitute about 5%-13% of the total power generation [1]. The loss minimization in distribution systems has assumed greater significance recently since the trend towards distribution automation will require the most efficient operating scenario for economic viability variations. The advantages with the addition of shunt capacitors (fixed or switched) are to improve the power factor, and the voltage profile, power loss reduction , increases available capacity (release additional kVA capacity) of feeders and the stability of the distribution system. Therefore it is important to find optimal location and sizes of capacitors in the system to achieve the above mentioned objectives [2]. Reactive power compensation plays an important role in the planning of an electrical system. Many different optimization techniques and algorithms have been proposed in the past. Schmill [3] developed a basic theory of optimal capacitor placement. He presented his well-known 2/3 rule for the placement of one capacitor assuming a uniform load and a uniform distribution feeder. In [4], capacitor placement was applied as a multi -objective problem to reduce the annual cost sum of the power loss and the capacitors, as well as to improve the voltage profile. In Huang [5] an immune-based optimization technique is proposed for radial distribution system in order to reach optimal point of capacitor banks allocation optimization problem. In Baghzouz, [6] non-linear loads effect on the best point sites of capacitor banks in radial system was analyzed. In Venkatesh et al [7], combination of evolutionary programming (EP) algorithm with fuzzy logic, was proposed in placement of the optimal capacitor banks. In this work, the CYMDIST software program is applied to determine the optimal location and size of capacitors for power losses reduction and voltage profile improvement...etc. CYMDIST offers several features to assist in automated model construction with a large library of various components from different manufacturers, unbalanced power flow, support for time varying loads and generation, and ability to be integrated with external tools including MATLAB and other programs.

2. Mathematical Model

2.1. Load Allocation Method

In this work the connected kVA load allocation technique provided by CYMDIST software is used which distributes the substation load demand (entered by the user in amperes for each phase) along the feeder according to the connected kVA of the distribution transformers.

The Connected kVA algorithm can be expressed mathematically as follows [8]:

$$\mathrm{kVA_T} = \sum_{i}^{m} \mathrm{KVA_{C(i)}} \times \mathrm{LF} \tag{1}$$

$$\mathrm{kW_{a(i)}} = \mathrm{kW_d} \times \left[\frac{\mathrm{KVA_{C(i)}} \times \mathrm{LF}}{\mathrm{kVA_T}}\right] \tag{2}$$

$$\mathrm{kVAr_{a(i)}} = \mathrm{kW_{a(i)}} \times \sqrt{\left(\frac{1}{\mathrm{P.F}}\right)^2 - 1} \tag{3}$$

Where:

$\mathrm{kVA_T}$: The total connected (kVA) $\mathrm{kVA_c}$: The connected (kVA)
$\mathrm{kW_{a(i)}}$: kW allocated on section (i) $\mathrm{kW_d}$: The demand (kW)
$\mathrm{kVAr_{a(i)}}$: kVAr allocated on section (i) LF: load factor P.F: The source power factor

2.2. Load flow method (Backward/Forward sweep algorithm)

On a radial distribution system, load constraints can be described by a set of power flow equations at different load levels. The (backward/forward sweep algorithm), solves the load flow equation's of radial distribution networks iteratively by two parts:

In the first part ; The node and branch currents are calculated by the (backward sweep starting from the end nodes back to the source node using Kirchhoff's Current Law (KCL). The end nodes currents are calculated as a function of the end nodes voltages, and the given loads as in equation:

$$\mathrm{I_m} = \left(\frac{\mathrm{S_m}}{\mathrm{V_m}}\right)^* \tag{4}$$

Where:

$\mathrm{I_m}$: Load current at node m (A) $\mathrm{S_m}$: Apparent power at node m (kVA)
$\mathrm{V_m}$: Voltage at node m

For the first iteration the initial end nodes voltages are taken as the nominal bus voltages at these nodes. The backward sweeps calculates branch currents and voltage drop in branches to update nodes voltages back to the source node as in equation:

$$\mathrm{V_z} = \mathrm{V_m} + \mathrm{Z_{z,m}} \times \mathrm{I_{z,m}} \tag{5}$$

Where:

$\mathrm{V_Z}$: Voltage at node z $\mathrm{S_m}$: Apparent power at node m (kVA)

The calculated branch currents are saved to be utilized in the following forward sweep calculations. Finally as a convergence criterion the calculated source voltage is compared to the specified source voltage for mismatch calculation as in equation:

$$\mathrm{Error} = \left||\mathrm{V_s}| - |\mathrm{V_1}|\right| \tag{6}$$

Where:

$\mathrm{V_s}$: Nominal source voltage $\mathrm{V_1}$: Voltage calculated at node 1

In part two the forward sweep starting from the source node to the end nodes the voltage is calculated at each node as a function of the branch currents, using the currents calculated in the previous backward sweep using Kirchhoff's Voltage Law (KVL), with the nominal voltage taken as the source voltage at the starting of each forward sweep as in equation:

$$V_z = V_m - Z_{z,m} \times I_{z,m} \tag{7}$$

The forward and backward sweeps are continues until the calculated source voltage becomes within a specified tolerance with the nominal source voltage [9].

2.3. Optimal Capacitor Placement and Sizing

In the problem definition, size of the capacitors (decision variable) is taken as discrete known values that are generally used in distribution network which are; 150, 200, 300, 600 900 and, 1200 kVAR. Hence, the problem is reduced to finding the locations for these capacitor values such that the power loss and over load on this feeder. The objective function thus formulated is than minimized using CYMDIST as a tool to determine an optimal compensation to solution an optimization problem and optimal capacitor placement. Applying compensation using the CYMDIST module helps in saving additional power, improves the voltage profile, and power factor improved [10].

2.3.1 Optimal Capacitor Placement and Sizing

The optimal capacitor size and placement at proper node should minimize the objective function in equation (8):

$$P_{loss(z+1)} \leq P_{loss(z)} \tag{8}$$

Where:

$P_{LOSS\,(Z)}$: Power losses before capacitor placement

$P_{LOSS\,(Z+1)}$: Power losses after capacitor placement

And satisfy the following constraints:

1. Bus Voltage Limits:

$$V_{min} \leq |V_i| \leq V_{max} \tag{9}$$

Where:

V_{min}: Lower bus voltage limit V_{max}: Upper bus voltage limit

$|V_i|$: rms value of the i^{th} bus voltage

2. The line flow limits: The line load current (I) should be less than the line rated current (I_{rated}).

$$I \leq I_{rated} \tag{10}$$

Where:

I : The line load current I_{rated} : The line rated current

3. Power conservation limits: The algebraic sum of all incoming and outgoing power, including line losses over the whole distribution network should be equal to zero:

$$P_G - \sum_{i=1}^{n} P_D - P_{lt} = 0 \tag{11}$$

Where:

P_G: The power generation P_D: The power demand P_{lt}: The total power losses

4. The number and sizes of permissible capacitor banks constraint:

$$\sum_{i=1}^{m} Q_c \leq Q_t \tag{12}$$

Where:

Q_C: kVAr obtained from the capacitor Q_t: Total reactive power flow requirement

m: Total number of capacitor banks i: The section number

The proposed method for capacitor placement in a balance radial distribution feeder is summarized by the flowchart in figure .1

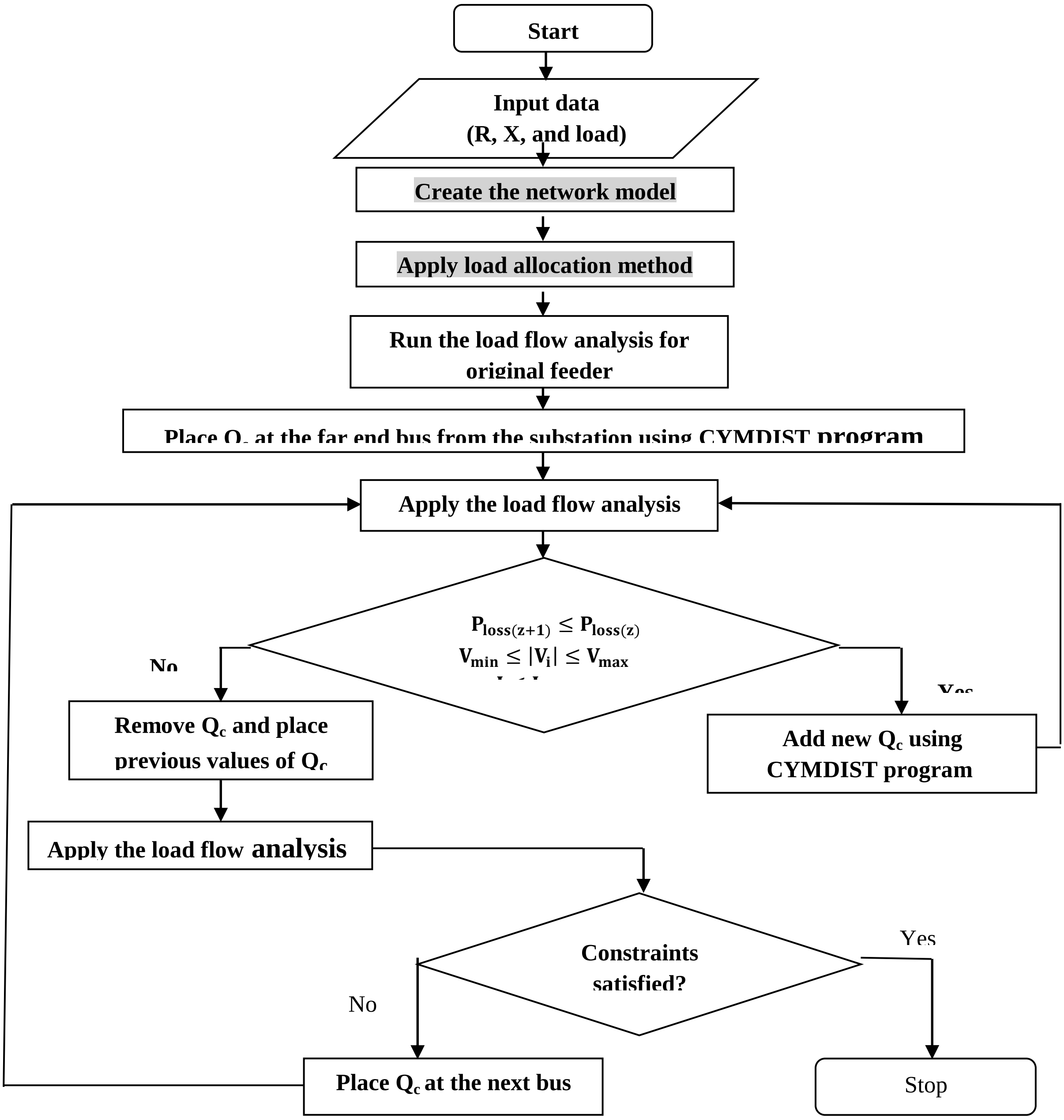

Figure .1 Flowchart of capacitor placement in balance radial distribution network using CYMDIST program [11]

3. Cases Study and Discussion

In this work two cases have been studied, for each case the problem is formulated and a capacitor placement using CYMDIST software are implemented. The modeling process begins with acquiring all the input data required, and the combined processed data are entered or imported from GIS software into CYMDIST to create the distribution system model, with the single line diagram automatically generated. The proposed methodology has been initially applied for the IEEE 33-bus distribution test networks. The results are compared with the solutions obtained from the methodology presented in [4]. Finally, the proposed method was implemented using a practical network from the distribution network in Baghdad city. The network consists from four 11kV distribution feeders emanate from Al-Adel (33/11kV) substation. Before starting, some assumptions are made in this work:

i. Balance voltage drop iterative method is used, the maximum number of iterations are 40 for load flow, and the voltage magnitude convergence error is set to be 0.01%.
ii. After applying capacitor placement, the rms value of bus voltages will be kept inside acceptable tolerance limits (±5 %).
iii. The objective functions of the capacitor placement are to minimize kW losses in network, improve voltage and the common reasons for the provision of power factor correction capacitors include; the reduction in the load on feeders, ability of the supply to support additional load reducing the load on distribution network components، and therefore can result in an extension of their useful life and this would improve the integrity of the system.
iv. Load factor for the IEEE-33 bus test system, and Al- Adel_33/11kV_feeders 2, 3, 6, and 7 distribution networks, are equal to 100 %.
v. All the loads have the same power factor = 0.8 lag.

3.1 Case 1: Optimal Capacitor Placement for IEEE-33, bus Test System

The single-line diagram of the 12.66 kV, 33-bus test system is illustrated in figure 2. According to reference [12, 13], the initial system real power loss was 202.7 kW and this is verified by CYMDIST program. After applying the load flow for the initial configuration, it can be noted that, this feeder operates in an abnormal condition with 17 sections at drop voltage, as shown in figure 3. After applying capacitor placement using CYMDIST program, the top five sections are selected as optimal candidate locations and the amount of kVAR injected are 150 kVAR/ phase in sections (3, 6, 7, and 30) and 200 kVAR/ phase in section 15. Table (1) illustrates the load summary of the IEEE 33-bus test system before and after reactive power compensation. According to reference [12], the initial system operate at minimum voltage equal to 0.925 p.u. at node 30, and this is verified by CYMDIST program, and after applying optimal capacitor placement method, the final power loss after reactive power compensation is 138.26 kW (savings is 62.9 kW), and the final minimum voltage of the IEEE 33-bus test system was 0.943 p.u compared with the results of vector distribution load flow (VDLF) method and a Particle Swarm Optimization

(PSO), as illustrated in table (2). Figure. 3 shows the allocation of the capacitors placement.

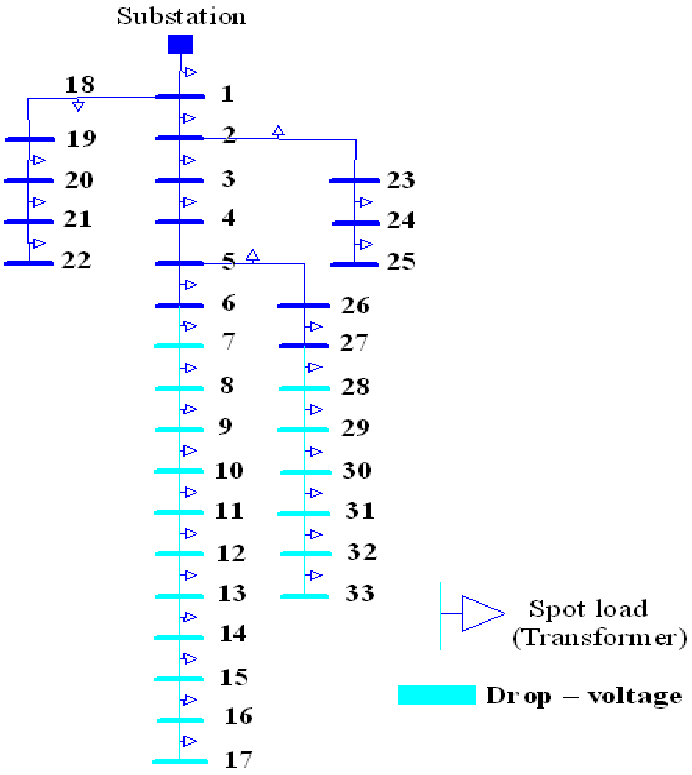

Figure.2. single line diagram of 33- bus distribution system before capacitor

Table 1. Load summary of the IEEE 33-bus test system before and after compensation at peak load (100%).

Description	Total load before compensation				Total load after compensation			
	kW	kVAR	kVA	P.F	kW	kVAR	kVA	P.F
System load	3715	2300	4369.36	0.85	3715	2300	4369.36	0.85
Total adjusted shunt capacitor	---	0.0	---	---	---	2220.16	---	---
System losses	**202.7**	108.72	230.02	0.88	**138.26**	76.56	158.04	0.87
System supply	**3917.72**	**2408.7**	4598.95	0.85	**3853.28**	**156.37**	3856.45	0.99

Table 2. Simulation results of the IEEE 33-bus test system Comparison between (VDLF method, PSO) and CYMDIST.

Description	**Uncompensated**			**Compensated**		
	Proposed CYMDIST	VDLF method	Particle Swarm Optimization (PSO)	Proposed CYMDIST	VDLF method MATLAB [12]	Particle Swarm Optimization (PSO)[13]
Total losses (kW)	202.70	202.7069	202.7069	138.26	143.7255	143.7255
Loss reduction (kW)	---	---	---	64.44	29.096866	29.096866
Maximum voltage (p.u.)	1	1	1	1	1	1
Minimum voltage (p.u.) at nod 30	0.925	0.913041	0.913041	0.943	0.925082	0.925082

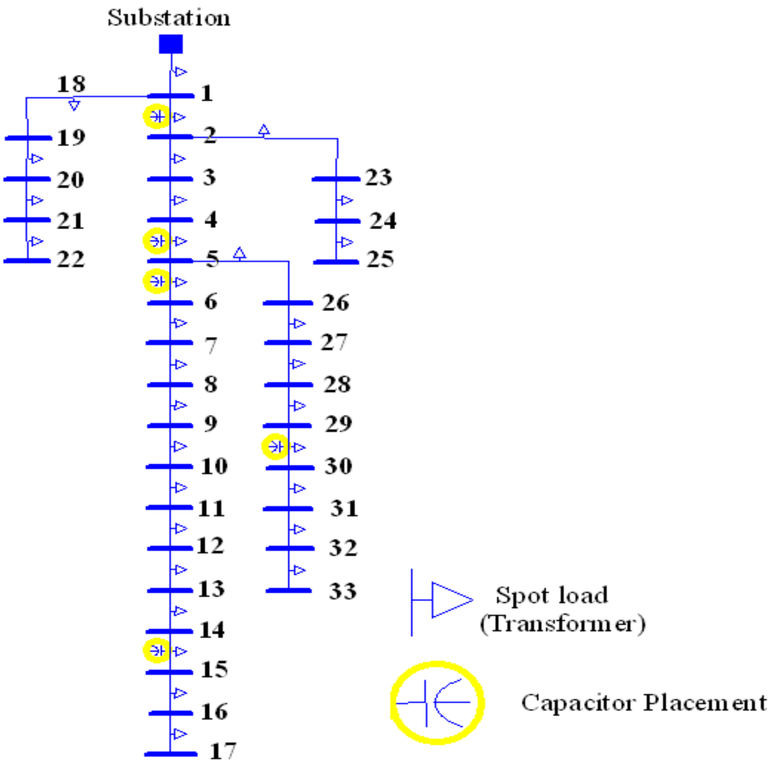

Figure 3. The capacitors allocation at the receiving nodes of the, 33- bus test system

Table 3. Illustrated Optimal location and size of capacitors of the 33- bus test system at peak load conditions (100% loading).

CYMDIST software program							VDLF method and PSO	
Bus (Id)	Load level for capacitors operation	capacitors kV(L-L)	capacitors (kVAR/phase)	Total Q (kVAR)	Loss reduction (kW)	Total Q Adjusted (kVAR)	Bus (Id)	capacitors (kVAR)
3	≤ 60%	12.66	150	450	35.4	444.032	8	300
6	≤ 60%	12.66	150	450	24.3	444.032	15	300
7	≤ 60 %	12.66	150	450	0.9	444.032	20	300
30	= 100 %	12.66	150	450	0.7	444.032	21	300
15	≤ 60 %	12.66	200	600	1.6	444.032	24	300
---	---	---	---	---	62.9	2220.16	26	300
---	---	---	---	---	---	---	28	300
---	---	---	---	---	---	---	27	600
Total kVAR				2400	---	---	---	2700

Depending on the duration value for the peak load from table 3, the maximum load current in feeder IEEE-33 bus test system before and after capacitor placement are 209.7 Ampere, and 175.7 Ampere , respectively. Figure 4 show the bus voltage profile before and after capacitor placement using CYMDIST software for the 33-bus test system. It is shown that the voltage magnitude of each bus will improved and became closer approximate to 1 p.u after placing the optimum capacitor sizes at the candidate buses.

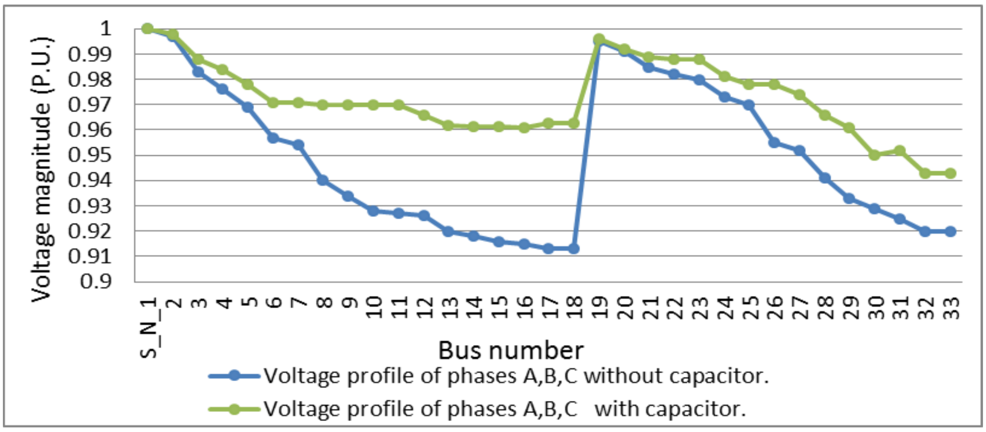

Figure 4. Voltage profile for the 33- bus test system with and without reactive power compensation

From figure 5, section_1 (1001 m length) has 780.83 downstream kVAR/phase before compensation. This value is reduced to 52.125 after compensation as shown in figure 6 and similarly for the other sections. Sections that have a capacitor become a source of reactive power, the overall active and reactive power losses will be reduced. The overall P.F is corrected from 0.85 to 0.99.

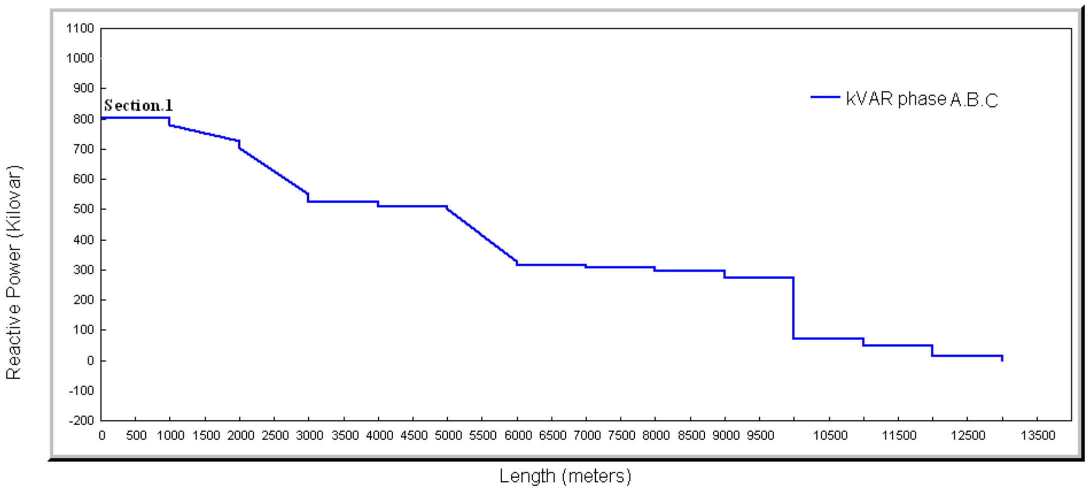

Figure 5. Q- Reactive power profile of 33-bus test system before capacitor placement

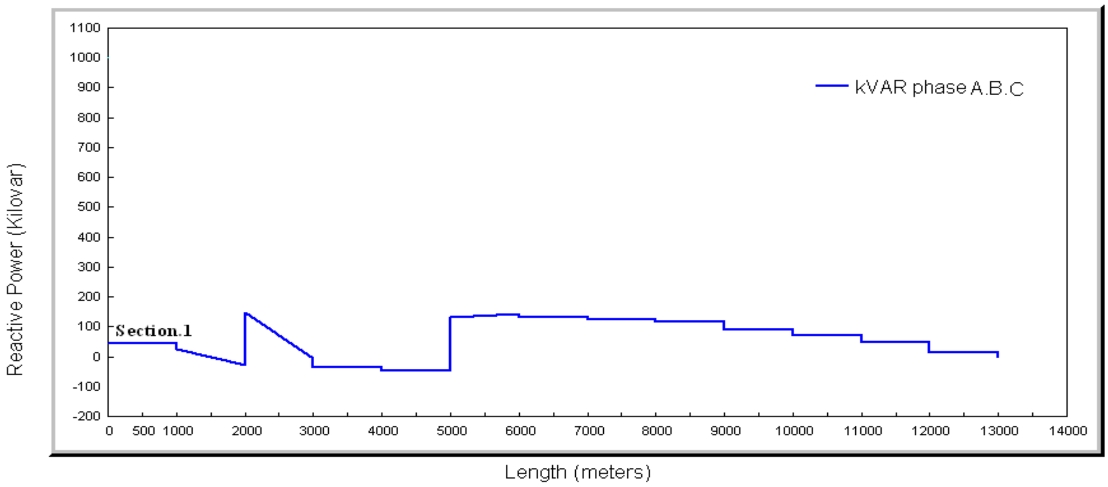

Figure 6. Q- Reactive power profile of 33-bus test system after capacitor placement

3.2. Case 2:Al_ Adel 33/11kV substation

To implement the proposed method on an actual distribution network in Baghdad city, the chosen network was (Al_ Adel) distribution network. The capacity of (Al_ Adel 33/11 kV) substation is (2*31.5 MVA), delta-delta connection, and There are fourteen (11 kV) feeders outgoing from Al_ Adel substation serving a large area of mixed residential, commercial, industrial, and trading loads. Only four feeders are considered in this work. This network is a part of the distribution system in Baghdad city which is rated at 11 kV, base MVA =100, and frequency of 50 Hz with 91 line sections, 93 buses. The schematic diagram of Al_ Adel distribution network by CYMDIST, and depending on the global positioning system (GPS) and geographic information system (GIS) is shown in figure 7. The coordinates are entered to the CYMDIST module as x and y coordinates for the buses to build, the model and specify the actual length of the network sections. The load for Al_ Adel feeders is mixed, approximately 90% residential and 10 % commercial.

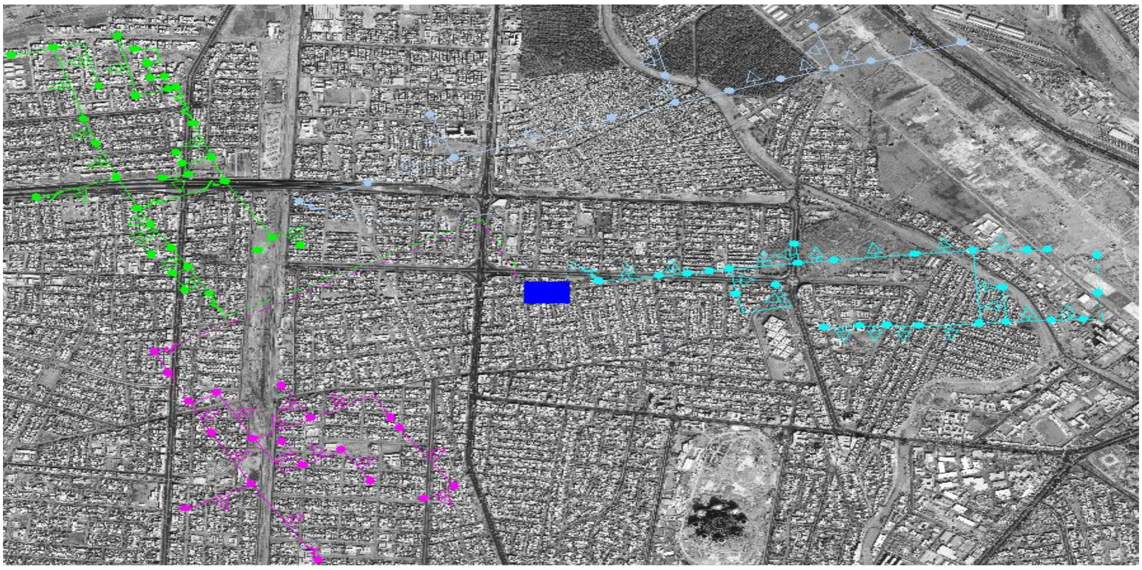

Figure 7. Al_ Adel distribution network model based on (GPS) and (GIS) data.

By using load allocation method as illustrated in item (2.1) with 0.01 tolerance for accuracy, loads are distributed in all sections for each phase depending on the current and power factor values at the sending end of each feeder and the secondary of (11/0.4 kV) (Delta- Grounded wye) transformer capacities, as illustrated in table 5.

Table 5. The current at the sending end of each feeder of Al_ Adel distribution network.

Name Feeder	Current (A) for each phase	P.F (%)	Transformer capacity (kVA) Spot load
Al_ Adel _2	202	80	250 kVA 400 kVA
Al_ Adel _3	230	80	250 kVA 400 kVA 1000 kVA
Al_ Adel _6	170	80	250 kVA 400 kVA
Al_ Adel _7	321	80	250 kVA 400 kVA 1000 kVA

After applying the load flow, there are 3 sections that operate in overloaded condition as shown in figure 8. The simulation results illustrated in table 6, shows the load summary before and after kVAR compensation, and the initial system real power losses after load flow for all feeders were 263.06 kW. After applying the reactive power compensation of this problem by increasing the capacity of these feeders to minimize losses and to distribute loads on a regular basis among feeders. The final power loss after reactive power compensation became 172.14 kW, so the total reduction in power losses after compensation became 90.92 kW. Optimal locations of capacitors are shown in figure 9, and table 7 shows the optimal of capacitor placement and sizing.

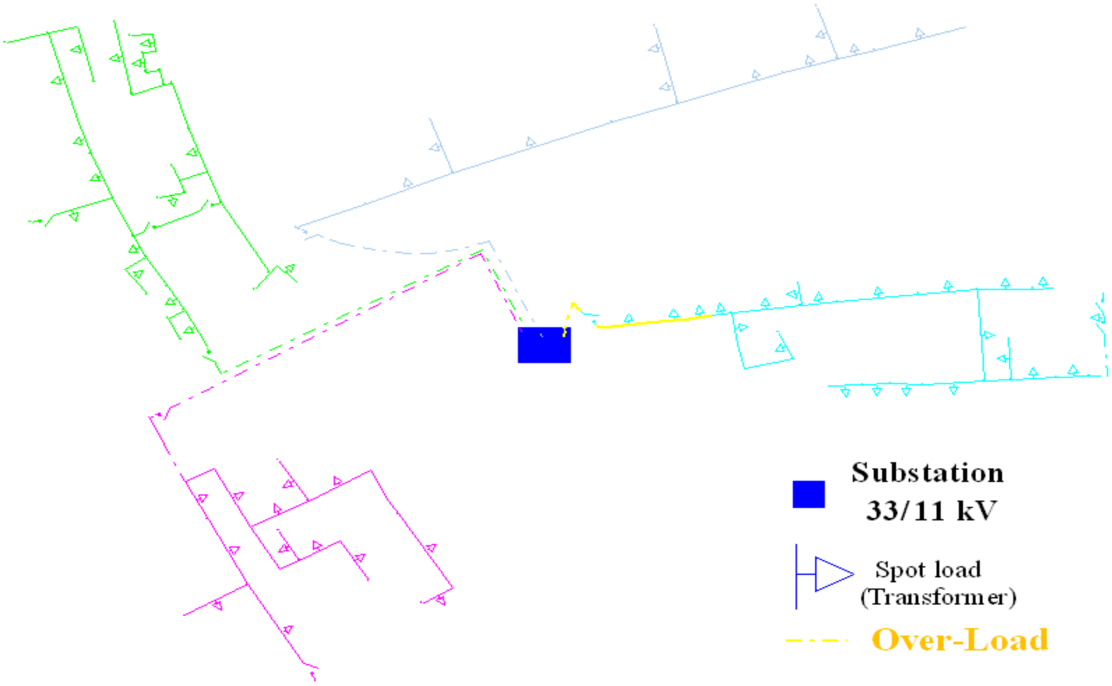

Figure 8. Abnormal conditions for Al_ Adel distribution network before kVAR compensation

Table 6. Load summary before and after kVAR compensation of Al_ Adel distribution network at peak load.

Al_ Adel _ feeders no. 2, 3,6, and 7 33/11/0.4 kV		System total loading	Total adjusted shunt capacitor (kVAR)	System total losses	System Total supply
Before, kVAR compensation	kW	13684.62	---	263.06	13947.66
	kVAR	10242.99	Feeder no.2 = 0 Feeder no.3 = 0 Feeder no.6 = 0 Feeder no.7 = 0	253.4	10468.63
	kVA	17093.51	---	365.25	17439.31
	P.F%. av	0.8	---	0.74	0.8
After, kVAR compensation	kW	13683.87	---	172.13	13855.9

kVAR	10242.11	Feeder no.2 = 1448.88 Feeder no.3 = 1732.93 Feeder no.6 = 1301.6 Feeder no.7 = 1860.72	165.45	3608.68
kVA	10816.66	---	238.75	14318.12
P.F% av	0.8	---	0.72	0.9677

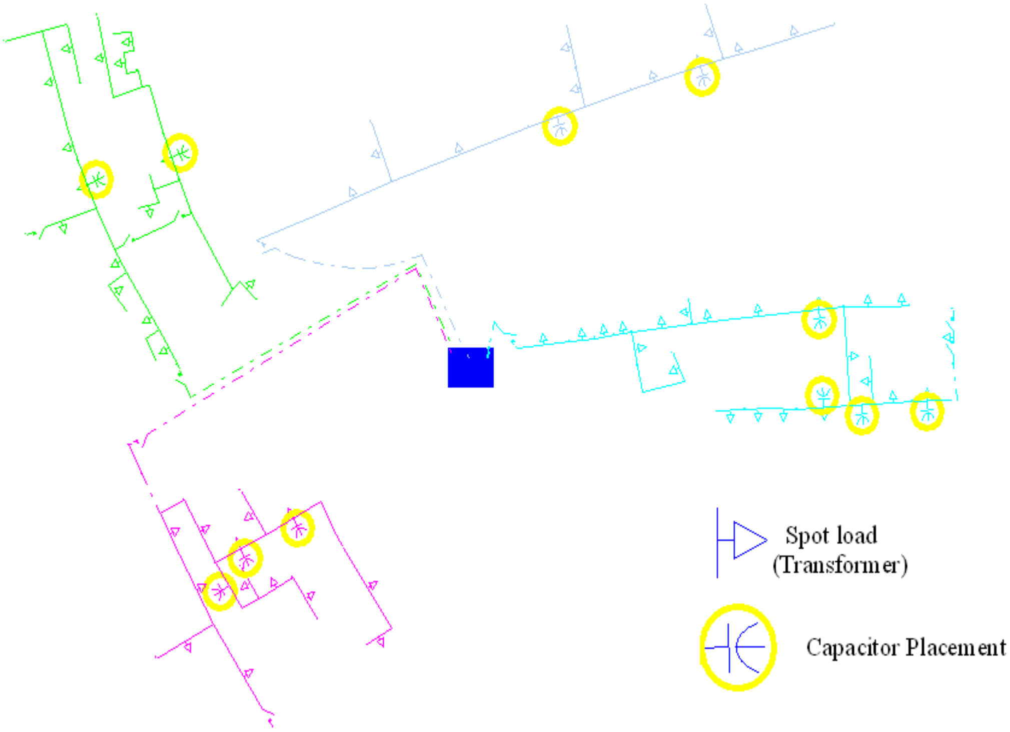

Figure 9. Optimal capacitor placement for Al_ Adel distribution network.

Table 7. Optimal location and size of capacitors for Al_ Adel distribution network at peak load conditions (100% loading).

Node (Id)	Capacitor KV (L-L)	Total capacitors (kVAR/phase)	Total Losses (kW) in each feeder	
			Before compensation	After compensation
Al_ Adel _feeder _2: P.F corrected to 0.9647				
12	11	600	51.26	34.50
25	11	900		
Total		1500		
Al_ Adel _ feeder _3: P.F corrected to 0.9704				
43	11	450	67.53	44.87
47	11	450		
49	11	900		
Total		1800		
Al_ Adel _ feeder _6: P.F corrected to 0.9704				

58	11	450	48.12	31.39
63	11	900		
Total		1350		
Al_ Adel _ feeder _7: P.F corrected to 0.9652				
78	11	450	96.15	61.48
80	11	600		
84	11	450		
87	11	900		
Total		2400		

Figure 10 show the bus voltage profile for Al_ Adel _feeders 2, 3, 6 and 7 before and after kVAR compensation. It is shown that after applying kVAR compensation, the overall voltage magnitudes will drop significantly within the specific limits. These values of voltage are improved after applying network allocation of capacitors in these feeders, so that they became closer to approximate 1 p.u.

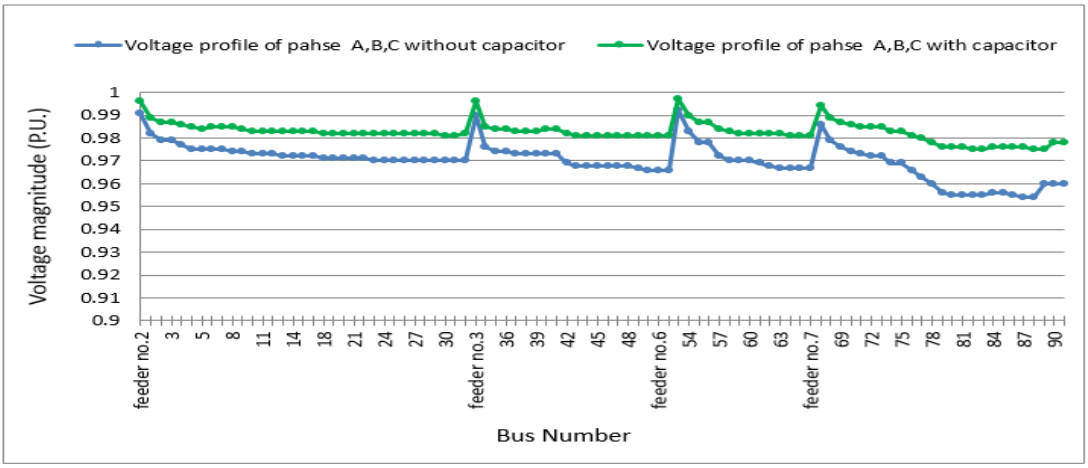

Figure 10. Voltage profile of Al_ Adel _feeders 2, 3, 6 and 7 before and after kVAR compensation

Figures (11 to18) shows the behavior of the total downstream reactive power profile with respect to distances for Al_ Adel _feeders 2, 3, 6 and 7, of each section for the longest path from the substation that feed this network to end bus.

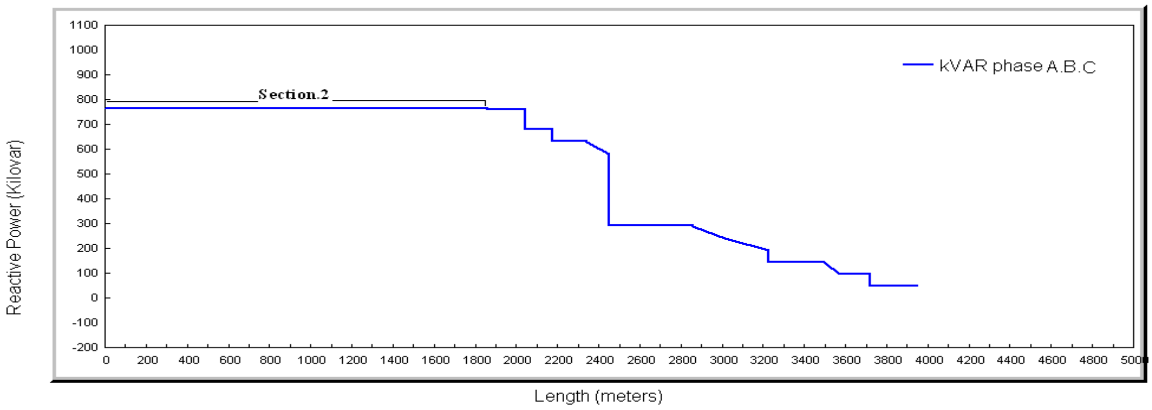

Figure 11. Q- Reactive power profile of Al_ Adel _ feeder_ 2 before capacitor placement

In figures 11 and 12; section_2 (1861.1 m length) has 759.62 downstream kVAR/phase before Q-compensation; this value is reduced to 274.22 kVAR/phase after placement of capacitors. Also the total neutral line current in feeder is improved from 200 to 166 Ampere.

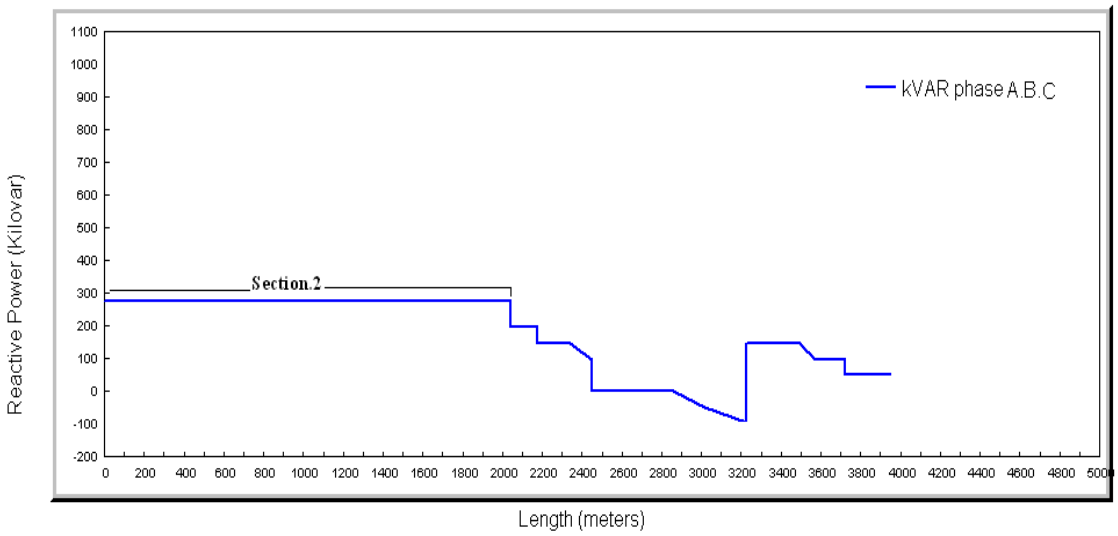

Figure 12. Q- Reactive power profile of Al_ Adel _feeder_ 2 after capacitor placement

In figures 13 and 14; section .33 (2090.1 m length) has 863.01 downstream kVAR/phase before Q-compensation; this value is reduced to 282.45 kVAR/phase after placement of capacitors. Also the total neutral line current in feeder is improved from 230 to 187 Ampere.

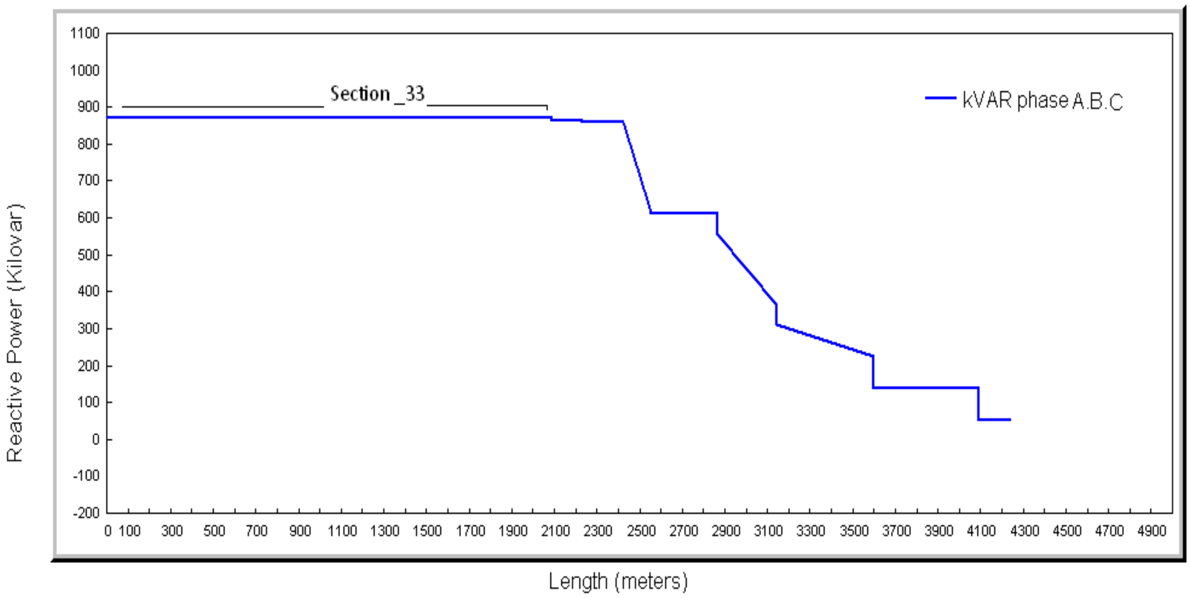

Figure 13. Q- Reactive power profile of Al_ Adel _feeder _ 3 before capacitor placement.

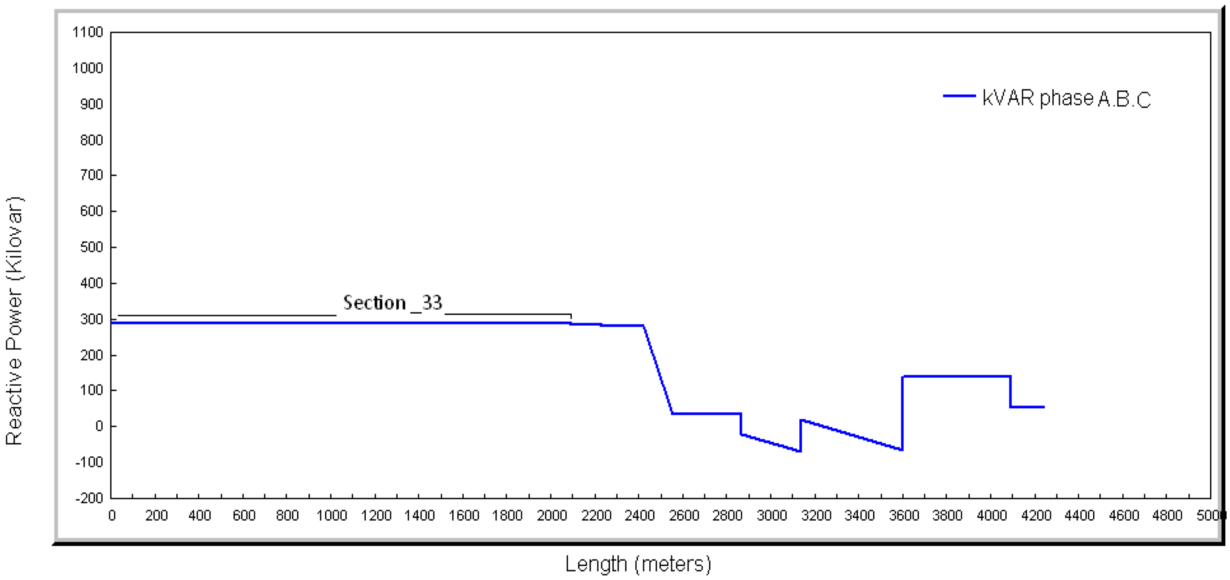

Figure 14. Q- Reactive power profile of Al_ Adel _feeder _ 3 after capacitor placement

In figures 15 and 16; section .33 (1349.4 m length) has 643.59 downstream kVAR/phase before Q-compensation; this value is reduced to 205.4 kVAR/phase after placement of capacitors. Also the total neutral line current in feeder is improved from 170 to 138 Ampere.

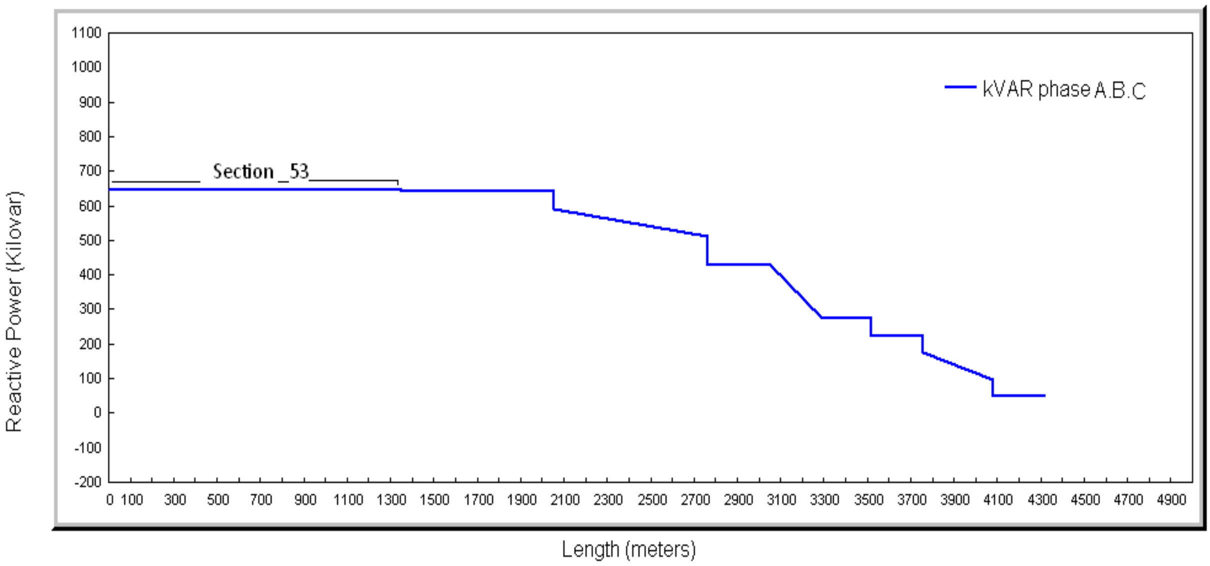

Figure 15. Q- Reactive power profile of Al_ Adel _feeder _ 6 before capacitor placement

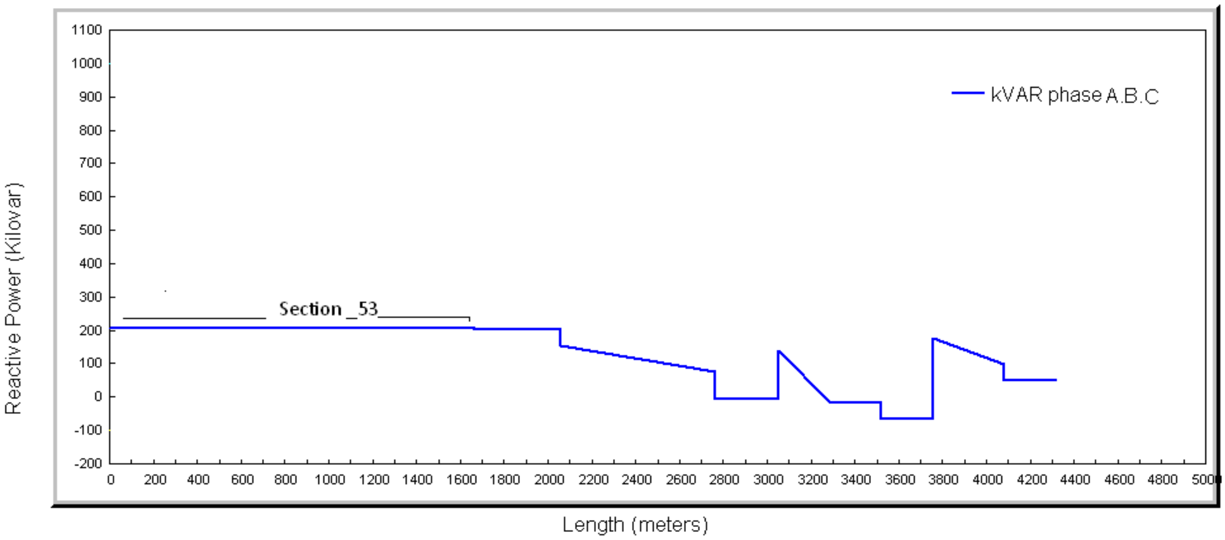

Figure 16. Q- Reactive power profile of Al_ Adel _feeder _ 6 after capacitor placement

In figures 17 and 18; section .67 (186.15 m length) has 1206.5 downstream kVAR/phase before Q-compensation; this value is reduced to 431.72 kVAR/phase after placement of capacitors. Also the total neutral lines current in feeder is improved from 320 to 260 Ampere.

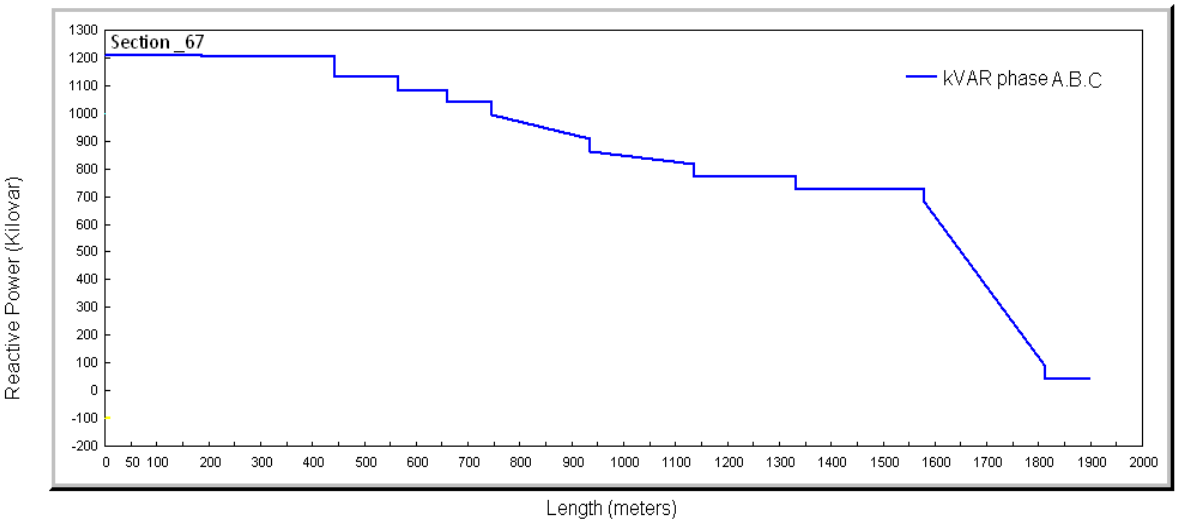

Figure 17. Q- Reactive power profile of Al_ Adel _feeder _ 7 before capacitor placement.

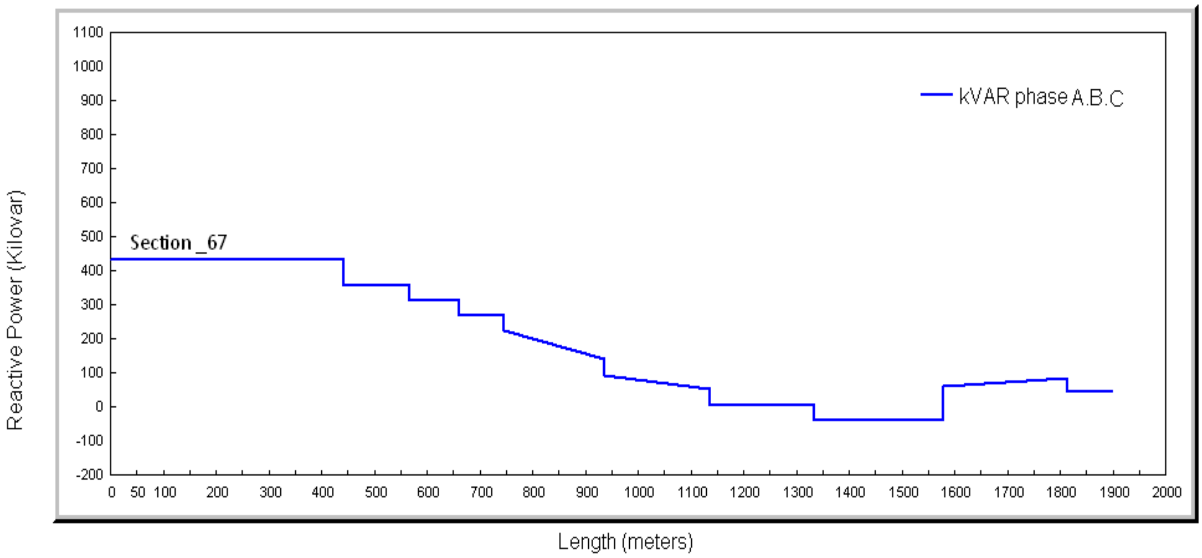

Figure 18. Q- Reactive power profile of Al_ Adel _feeder _ 7 after capacitor placement.

The overall active and reactive power losses will be reduced. The overall P.F. feeders is improved as illustrated in table 6.

4. Conclusions

This work presents the placement of capacitor in a balanced radial distribution network. The proposed method is tested on IEEE 33- bus test system and actual distribution network in Baghdad city and the simulation results are reported. The sizing and location of capacitor in radial distribution network of IEEE 33-bus test system and actual distribution network was done by CYMDIST. The comparison was considered between the CYMDIST and (VDLF method, PSO) .Hence the results that are reported under the proposed method show the better performance than VDLF method and particle swarm optimization (PSO). From the results obtained several important observations can be concluded as, the power losses of distribution network can be efficiently reduced by proper placement of capacitor. However the voltage profile can also be improved. It is observed that due to decreased power losses the net saving were decreased. The following areas, are identified for future work:

1. The study, has been on balanced distribution system. The capacitor allocation problem can be extended, to un-balanced distribution network.
2. The allocation of static VAR compensator’s can be considered in unbalanced distribution network.

5. Abbreviations

GPS	Global Positioning System
GIS	Geographic Information System
VDLF	vector distribution load flow
PSO	Particle Swarm Optimization
av	The average

Section_1	Top Head Feeder No.1 (33-bus Test System)
Section_2	Top Head Feeder No.2 (Al_ Adel network)
Section_33	Top Head Feeder No.3 (Al_ Adel network)
Section_53	Top Head Feeder No.6 (Al_ Adel network)
Section_67	Top Head Feeder No.7 (Al_ Adel network)

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