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OPTIMAL OPERATION OF DISTRIBUTION NETWORKS

By

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STATEMENT

This dissertaion is submitted to Ain Shams University for the degree of Master in Electrical Engineering.

The work included in this thesis was carried out by the author. No part of this thesis has been submitted for a degree or qualification at other university or institution.

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ABSTRACT

The thesis concerns the formulation and calculations of optimal reactive power of radial distribution feeder.

Different cases of capacitor banks installation on the feeder are considered. A new formule for cost function is developed. Computer calculations are applied on AGOUZA 11 k.v. distribution feeder as a real study system. optimal capacitor sizing and location for minimum losses and cost for different conditions are obtained.

The effect of load variation is also considered.

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NOMENCLATURE

I	Load current with componants (i_p & i_q)	(Amp)
v	Source voltage	(Volt)
ϕ	Lagging angle between (I & V)	
$\cos\phi$	Power factor	
PL	Power losses befor compensation	(Watt)
PL_c	Power losses with capacitor effect	(Watt)
J	Cost function	
KP	Cost factor for peak power	(L.E/KVA)
K_e	Cost factor for energy	(L.E/ KWH)
K_c	Cost factor with capacitor current	(L.E/Cap A)
EL	Energy losses befor compensation	(W.H.)
EL_c	Energy losses after compensation	(W.H.)
λ	Reactive currents ratio	
C	Capacitor compensation ratio	
$a\&b$	Constants of I_c & cap. cost relationship	

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CHAPTER I

INTRODUCTION

.1 GENERAL

Capacitors are widely installed for reactive power compensation in distribution systems. This leads to power and energy reduction, voltage regulation and system capacity release.

The extent of these benefits depends greatly on how to install capacitors on the system and the optimal sizes of these capacitors such that these benefits are achieved and the net savings from the peak loss power and energy reduction over a given period is maximized.

1.2 LOAD COMPENSATION AND POWER FACTOR IMPROVEMENT

The wide expansion of electrification networks beside the increase of motor installations and other inductive loads causes a

significant decrease in the power factor of the system.

Most A.C electrical machines, which are inductive in nature, draw from the main supply an apparent power in terms of kilovolt-amperes (KVA). The apparent power consists of two components represented vectorially in Fig. (1.1) : active power (kW) and reactive power (KVAR)

The ratio of active(real) power (K W) and the apparent power (KVA) is known as power factor, $\cos \phi$, where ϕ is the angle between these two components. (It is the same angle between drawn current and corresponding voltage.).

The effect of power factor on the relation between KW and KVAR is indicated in the block diagram in Fig. (1.2) (assuming apparent power of 100 KVA). [8]

The real component (KW) of power supplies the work energy, while the reactive component (lagging KVAR) is supplied to the motor to magnetize the field and does not perform useful work.

At low power factor, the reactive component (KVAR) is high and

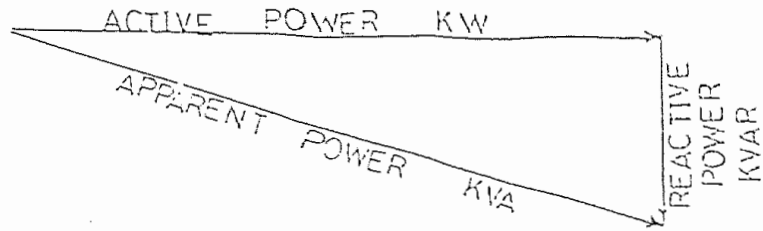


Fig. (1.1) Components of system load.

NIL KVAR	43.59 KVAR	60 KVAR	71.4 KVAR
100 kw	90 kw	80 kw	70 kw
unity p.f.	p.f.=0.9	p.f.=0.8	p.f.=0.7

Fig.(1.2) 100 KVA loads at various power factor .

being supplied from the generators to the load through power transformers and lines. This increases the burden on lines and causes additional losses.

If a capacitor is connected across the line, it draws leading current i.e. it draws leading KVAR from the system and then neutralises the lagging KVAR drawn from the system by the inductive loads. Then the loss in the line is reduced and the voltage condition is also improved. Hence with the use of capacitors the system supply conditions can be improved. In other words more useful power can be delivered with the same supply system which means better utilization of available power. Therefore, it is necessary to improve the power factor of the system by supplying leading KVAR. This can be usually done by installing capacitor across the feeder. Almost no cost is involved in maintenance. Power factor correction by the capacitor is thus more economical, efficient and satisfactory.

1.3 EFFECT OF INSTALLING SHUNT CAPACITORS :

The installation of shunt capacitors across feeders would result in the following advantages :[11]

1. Benefits to the consumers :

1. A substantial reduction in the power cost, due to reduced KVA demand and elimination of penalty for low power factor (where tariff is based on KVA demand).

- ii. Reducing losses and less over heating in the consumer equipment, such as, cables, motors, etc.
- iii. More stable voltage which means better and more efficient performances of the motors and other equipment.
- iv. Increasing the possibility of connecting more consumer's equipment to the same installation.

. Benefits to power supply industries:

- i. Reduction of losses in lines and transformers.
- ii. Release of power system capacity which enables additional load to be connected to the same system without additional capital investment.
- iii. Improvement in voltage profile.
- iv. Reduction of over loading means less heating of cables, conductors, transformers etc.
- v. Better utilization of the capacity of the generators, transformers, switchgear, cables, lines etc. means increase in efficiency of the system.

Effects of capacitors in reducing the line losses due to the improvement in power factor are shown through typical values in Table (1.1) [11].