Ain Shams University
Faculty Of Engineering
Electrical Engineering Department

# OPTIMAL OPERATION OF DISTRIBUTION NETWORKS

By

ENG . KHALID IBRAHIM MOHAMED

Submitted In.Partial Fullfilment Of The Requirement
Of M.Sc. Degree In Electrical
Engineering



Under The Supervision

DR. Mohamed M. Mansour
Associate Prof ,Ain shams University
DR. Soliman A. Soliman
Associate Prof ,Ain shams University
DR. Mohamed A. EL Hadidy
Egyptian Electricity Authority

1993

# EXAMINATION COMMITTEE

EXAMINERS Signature

1- PROF DR : AHMED HASAN A. AMER
Prof ; Faculty Of Engineering
Ain Shams University

2- DR : MAHMOUD HEGAZI H. SALEH
Cairo Electrical Distribution Company

3- DR : MOHAMED MOHAMED S. MANSOUR
Associate Prof ; Faculty Of Enginneering
Ain Shams University

بسم الله الرحمن الرحيم

# 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.

Date : ٥ \ ١٠ \ ٩٣

Signature :

Name : Khaled Ibrahim Mohamed

# 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.

# ACKNOWLEDGEMENTS

First of all thanks to my " GOD "

I wish to thank Dr. Mohamed M. Mansour to his effort in finalizing the research and guidance writing the thesis. My special thanks go to Dr. Soliman A. Soliman For his continuous supervision : guidaunce and encouragement during the course of research My gratitude is extended to Dr. Mohamed A. EL Hadidy for his encouragement. I would like to thank Prof. Dr. Ibrahim M. EL Shair for suggesting the research point and encouragement during the period of his supervision.

My gratitude and thanks are also extended to my boss Mr. Eng. Abd EL Hamid Esmail for his help and interest.

I would like to thank Eng. Walid Aly Seif EL-Islam for his help in computer work.

Finally many thanks to my wife and children for their support.

# CONTENTS

# NOMENCLATURE

| | | |
|---|---|---|
| I | Load current with componants (ip & iq) | ( Amp ) |
| v | Source voltage | ( Volt ) |
| $\phi$ | Lagging angle between ( I & V ) | |
| Cos$\phi$ | Power factor | |
| PL | Power losses befor compensation | ( Watt ) |
| PLc | Power losses with capacitor effect | ( Watt ) |
| J | Cost function | |
| KP | Cost factor for peak power | ( L.E/KVA ) |
| Ke | Cost factor for energy | ( L.E/ KWH ) |
| Kc | Cost factor with capacitor current | ( L.E/Cap A) |
| EL | Energy losses befor compensation | ( W.H.) |
| ELc | Energy losses after compensation | ( W.H. ) |
| $\lambda$ | Reactive currents ratio | |
| C | Capacitor compensation ratio | |
| a&b | Constants of $I_c$ & cap. cost relationship | |

# LIST OF FIGURES

# CHAPTER I

# INTRODUCTION

## .1 GENERAL

Capacitors are widely installed for reactive power compe_ sation in distribution systems.This leads to power and energy ·eduction, 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 ιificant decrease in the power factor of the system.

Most A.C electrical machines, which are inductive in nature, ν from the main supply an apparent power in terms of kilovolt-eres (KVA).The apparent power consists of two componants resented vectorially in Fig. (1.1) :active power (kw) and ctive power (KVAR)

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

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

The real component (KW) of power supplys the work energy, ile the reactive componant (lagging KVAR) is supplied to the tor to magnitize the field and does not perform useful work.

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

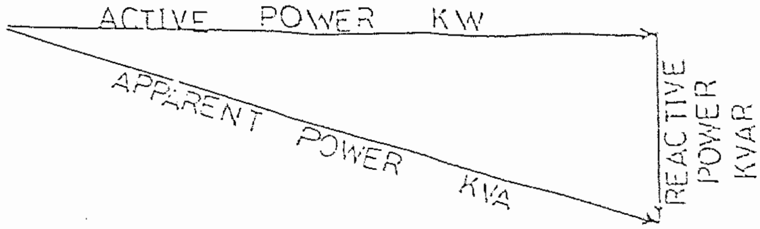


Fig. (1.1) Components of system load.

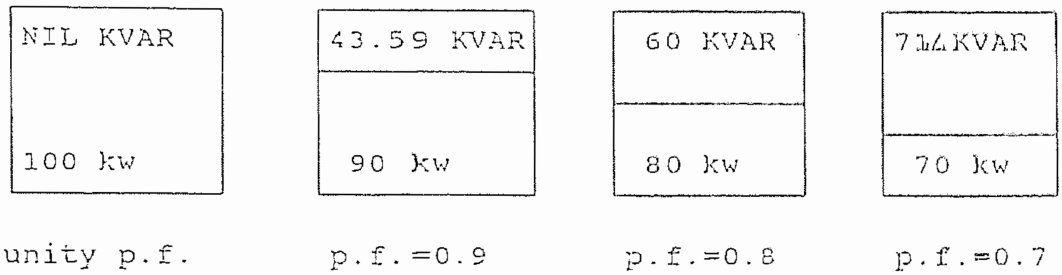


Fig.( 1.2) 100 KVA loads at various power factor .

eing supplied from the generators to the load through power ransformers and lines. This increases the burden on lines and auses additional losses.

If a capacitor is connected across the line, it draws leading urrent i.e. it draws leading KVAR from the system and then eutralises the lagging KVAR drawn from the system by the nductive loads. Then the loss in the line is reduced and the oltage condition is also improved. Hence with the use of apacitors the system supply conditions can be improved. In other ords more useful power can be delivered with the same supply ystem which means better utilization of available power. herefore, it is necessary to improve the power factor of the ystem by supplying leading K VAR. This can be usually done by nstalling capacitor across the feeder. Almost no cost is nvolved in maintenance. Power factor correction by the capacitor s thus more economical, efficient and satisfactory.

## 1.3 EFFECT OF INSTALLING SHUNT CAPACITORS :

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

1. Benefits to the consumers :

   i. 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 ulilization 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].