SOFTWARE FOR REACTIVE POWER COMPENSATION IN WINDMILLS

PROJECT REPORT

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in partial fulfillment of the requirements
for the award of the degree of
Bachelor of Engineering in
Electrical and Electronics Engineering
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CERTIFICATE

This is to certify that the project entitled

SOFTWARE FOR REACTIVE POWER COMPENSATION IN WINDMILLS

has been submitted by

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14/3/2001

(Guide) (Head Of Department)

Certified that the candidate with University Register no.------------------

was examined in project work viva-voce Examination held on -----------

(Internal Examiner) (External Examiner)

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Whom ever so it may concern

This is to certify that following students of **Kumaraguru College of Technology** of Electrical and Electronics Engineering

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had undergone their project work from Dec 2000 to March 2001. The conduct of the students during the particular period of time was found to be good.

Date : 09.03.2001
Place : Kethanur

For SANGEETH CARTER WIND POWER (P) LTD,

9/3/2001
[MURUGAN] Authorised Signatory.

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SYNOPSIS

With the advent of technology the demand for electrical power is increasing over recent years. This demand can be met only to a certain extent with conventional sources of energy. Non-conventional sources of energy are to be used to generate power to meet the growing demand.

The commonly available renewable sources of energy are wind, solar, geothermal, tidal, MHD. Among these the most advantageous and profit yielding source is 'wind'. Induction generators are used in comparison to Synchronous generator, as 'Wind Energy Converters', for tapping the large potential present in wind. Although in synchronous generator the RkVA compensation required is less, a 'synchronizing circuitry' is essential for synchronizing its operation with the grid. Due to the various difficulties faced in synchronization induction generator has gained much importance.

The induction generator requires significant amount of reactive power from the grid and it depends on wind velocity. When the velocity of wind is low reactive power consumption is more, which in turn burdens the grid. Due to this, the power factor is reduced significantly at low wind speed.

Data corresponding to each windmill are obtained from digital meters sequentially. Through the microprocessor unit present in each windmill the data are passed to the centralized data acquisition system. From this these data are given as input to the system through a Co-processor. ‘ C ‘ code is written for accessing the ports of the system through which the data’s obtained from the Co-processor are sent for calculating the reactive power and its corresponding compensation.

The software coding is done using Visual Basic as front end and MS Access as the back end. Provisions are made for operating the windmill manually or automatically. A database is also maintained for referring the previous days, months and years active or apparent power consumption, compensation, and maximum reactive power between a certain periods of time. The compensated value is matched with pre calculated kVAR values. As per the matched kVAR values the compensation is provided at the output as software senses the addresses of relay units to the corresponding microprocessor kit present at each windmill. Depending on the kVAR compensation required the capacitor banks are switched in automatically.

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PRINCIPLE NOMENCLATURE

P_w	-	Power available from a windmill in Watts
ρ	-	Air density in kg/m^3
A	-	Area swept by windmill rotor in m^2
r	-	Rotor radius
V	-	Wind speed in m/s
P	-	Power in wind
C_p	-	Power coefficient
S	-	Slip
V_g	-	Voltage at induction generator terminal
V_s	-	Grid voltage
I_s	-	Grid current
δ	-	Angle between V_g and V_s
β	-	Impedance angle of transmission line
ϕ	-	Power factor angle
I_g	-	Current from generator
Z	-	Impedance of the grid
I_c	-	Reactive component of current (capacitive)
I_r	-	Reactive component of current (inductive)
I_a	-	Vector sum of I_c and I_r
Cos ϕ	-	Power factor
NCES	-	Non-Conventional Energy Sources
IG	-	Induction Generator
GCIG	-	Grid Connected Induction Generator
WEG	-	Wind Electric Generator

CHAPTER 1

INTRODUCTION

Electricity is one of the vital and basic inputs necessary for the economic development of a country. India, being a developing country experiences a progressively higher level of energy consumption. At present India has an installed capacity of over 1,00,000 MW comprising 86,000 MW in utilities and 14,000 MW in non-utilities. It is estimated that the demand will rise to 3,85,000 MW in 2020 A.D. as the demand for power is increasing every year at rate of 7.5%, keen interest is taken in all possible sources of energy, from which it can be generated.

1.1 NON-CONVENTIONAL ENERGY SOURCES [NCES]

During the past few decades the advanced technological nations of the world have been engaged in an energy and resources race that has brought us to the position of energy crisis. Many developing countries have also been engaged in this race, during the last two decades or so. It is now widely recognized that the fossil fuels and other conventional resources, presently used in the generation of electrical energy, may not be either sufficient or suitable to keep pace with the ever increasing world demand for electrical energy. In the prospects for meeting this demand and avoiding a crisis in supply would be improved if new and alternative energy sources could be developed.

The source of energy can be broadly classified as non-renewable such as thermal, nuclear and renewable such as biomass, wind, solar, tidal and magneto hydrodynamic generation (MHD). As renewable energy sources are clean, non-polluting and available in abundance the non-conventional energy sources are given much importance.

Economical pressures and environmental impacts in recent years, have forced us to concentrate on non-conventional energy sources (NCES). These sources have emerged as larger potential sources of energy in India and World. Remarkable development has been made in India to tap large amount of energy from NCES, especially after the creation of ministry of non-conventional energy sources (MNES). The support provided by the includes

- Budgetary support by the government for demonstration projects
- Extending institutional finance from Indian renewable energy development agency (IREDA) and other financial

institutions to commercially viable projects

- Promoting private investments through fiscal incentives such as tax holidays, depreciation allowance, exemption from excise duty and central sales taxes, custom duty concessions, remunerative prices for the power produced by NCES and facilities towards wheeling and banking.

The Non-Conventional Energy Source, which includes solar, wind and tidal have a very large potential of energy in them. According to a survey, the total energy emitted by the sun is estimated as 3.85×10^{23} kW, out of which the earth receives 1.8×10^{14} kW, which is several times more than the energy needed on earth. The energy, which the earth receives annually from the sun, is of the order of 1.6×10^{16} kWh.

India being close to the tropics has a tremendous solar power equivalent to 492 billion kW/year. Small hydro power plants could provide 10,000 MW of power, ocean thermal power 50,000 MW, sea waves and tides 30,000 MW, bio energy 17,000 MW and drought animal power could provide 30,000 MW of energy.

1.2 WIND POWER IN INDIA

Even though many MCES have large potential of energy, tapping of energy is most economical and easier. Wind has for long been recognized as an abundant source of energy. India is among top three countries in world in the field of wind power generation.

Wind has been used in several countries for water pumping, grain grinding, to operate sawmills and oil presses since ancient times. Winds are caused by pressure differences between different regions. They carry enormous quantity of energy. To tap the large potential in wind, so as to produce electrical energy, wing energy generators (WEG) are used. This uses an electrical generator (synchronous or asynchronous, the later being widely used), rotated by a wind turbine through gear mechanism. Modern designs utilize the aircraft technology by using aerofoil blades. Such blades reduce the rotational drag and enhance the power availability. However experience has shown that many technical possibilities such as blade pitch controllers, inversal joints not only increases the cost, but may also lead to lower reliability.

1.3 GENERAL PERFORMANCE OF WINDMILLS

The kinetic energy per unit volume is 0.5 ρv^2 (ρ is the density of air particles and v is the wind velocity). This means that the energy per second or power is 0.5 $\rho A v^3$. Since available power varies as a cube of wind velocity, the windmills produce greatest power at high wind velocity. For every windmill the maximum wind velocity has to be specified. When it exceeds the rated value, the windmill has to be shut down for safety reasons. A minimum wind velocity is necessary to justify the operation i.e. the 'cut in' speed at which the system losses equals extracted wind power.

The ratio of peak rated wind velocity to the average wind velocity is an important parameter that governs the overall performance of the windmill system. For a generator of rated power, a low peak to average to wind velocity ratio means a large rotor of windmill, while a high ratio requires a small rotor windmill. A large rotor windmill is more expensive but gives greater average output and balance between two is necessary. Since the power output varies as a cube of wind speed, average output is considerably small as compared to the rated output resulting in a low load factor (around 30% or so). The inconsistent nature of wind necessitates some form of energy storage or an alternative supply source during times of low wind velocity.

1.4 SCOPE OF PROJECT

Any electrical power system will suffer from the major problems like consumption of reactive power, which results in low power factor, variations in load, fluctuation in voltage. It is estimated that about 21% of the total power generate in India is lost by way of transmission and distribution losses, which are considered as very high, when compared with the international average of 8%. A wind energy generator (WEG) also cannot be free from such problems. The main problem in wind energy generator (WEG) is its consumption of reactive power from the grid in grid-connected mode. At very low wind speed conditions, the amount of reactive power consumed even exceeds the amount of active power it generates placing undue burden on the grid. Hence the detail study on the performance of wind driven grid connected induction generators (GCIGs) is a must to apply any solution to rectify this problem of VAR consumption by the WEG.

This project entitled **"SOFTWARE FOR REACTIVE POWER COMPENSATION IN WINDMILL"** is actually a proposal and it is designed for satisfying the requirements specified by SANGEETH WINDMILLS, Kethanur, TamilNadu. The main aim of our project is to code software and the hardware section namely data acquisition system coprocessor unit will all be incorporated by them after they accept our proposal.

Signet windmills have totally 27 windmills around Kethanur. For fully atomizing their process they had projected their requirement and for this we had written software.

This project is also going to be submitted as proposal to "WINDPRO". Project has greater flexibility, its user friendly. The data's keyed in are used for calculating the active, apparent power etc. The output of this software is sensed by microprocessor and it checks for the appropriate addresses of capacitor banks through a relay and switches them for providing compensation.

CHAPTER 2

AN OVERVIEW OF WIND ELECTRIC GENERATORS

2.1 POWER GENERATION FROM WIND BY WEGs

Wind energy as an exploitable resource is now a reality testified by hundreds of wind farms installed in the length and breadth of India, generating electricity and feeding to the local grids. India is one of the countries making all efforts for fostering the development of WEGs and establishing wind farms.

Several companies worldwide in various capacities like 40 kW, 60 kW, 180 kW, and 225 kW etc manufacture the WEGs. Pole - changing type self - excited induction generators are also manufactured in the capacities like 40/250 kW, 60/250 kW etc. **Table 2.1** gives the list of WEGs manufacturers in India and their foreign collaborators.

The private sector organizations are taking much interest due to the concessions given by the MNES. Manufacturers NEPC-MICON limited, a public limited company setup in 1986 and promoted by Khemka group in association with MICON, a leading Danish firm in wind energy, has installed over 750 WEGs of different capacities. The central government organization BHEL has entered into WEGs production in collaboration with M/s. Nordex of Denmark.

NEPC is well versed in tubular towers, whereas BHEL has specialized in the construction of lattice tower structure. The later being more advantageous. BHEL has installed more than 200 WEGs in coastal areas of Gujarat, AndhraPradhesh, Tamilnadu and Maharashtra. M/s. Madras cements Ltd., has commissioned 30 WEGs of 225 kW capacity at Poolawadi in Coimbatore and a 4 MW wind farm at Muppandal, TamilNadu, which is a very large capacity single wind energy park in private sector in Asia. The installed WEG capacity in India till March 1996 is given in **Table 2.2.**

The basic block diagram of a Wind Energy Conversion System (WECS) is shown in **Fig 2.1.** Wind farms may have WEG as a stand-alone type; power station delivering power to some local consumer or it may be grid-connected type that delivers power to the grid. By using GCIG, power transfer from the wind farm site to the place of load, which is away from the wind farm are possible. This is known as wheeling system.

The wind turbines (aero-turbines) with three or two blades are rotated by the wind blowing at specified speed (usually the power delivery starts, when the wind velocity is more than 6 m/s). The wind turbines are of two types, that is horizontal axis and vertical axis. Vertical axis types were used at an earlier stage for agricultural purposes. Now almost all the WEGs are coupled to the horizontal axis type wind turbines. This wind turbine in turn rotates the WEG, which is coupled to it through gearbox and coupling arrangements.

The electrical connections of windmills are shown in **Fig 2.2.** The power output from these wind electric generators depends upon the wind velocity, rotor diameter, continuous availability of wind and the alignment of axis of the rotor with the axis of wind direction. Power available from the windmill is proportional to the cube of wind speed

i.e., $P_w = 0.5\rho AV^3$ ------- 2.1

where,

P_w = Power available in watts.

ρ = Air density, which equals 1.225 kg/m^3 at sea level.

A = Area of the rotor.

V = Wind velocity.

2.2 SELECTION OF SITE FOR WEGs

The selection of site is one of the most important aspects of planning for proposed WEGs. A wrong site may render the whole project completely worthless. The main factors governing selection of site are as under.

2.2.1 WIND AVAILABILITY

The power output of WEG is a function of wind velocity, which varies considerably from place to place. At any place wind velocity varies seasonally, diurnally, hourly and over shorter periods of time. Before any installation of a commercial scale is undertaken, the wind regime must be assessed in terms of persistency of various wind speeds. It has been estimated that an annual mean wind speed of about 18 Kmph (i.e., 5m/s) or more is needed for the installation of an economically viable WEGs. Even in most windy locations, the short-term variation in wind speed may cause an irregularity of delivered energy. Therefore wind data for a period of at least one year should be collected for different prospective sites. This data should include wind speed (i.e., mean hourly wind speed, mean monthly wind speed, frequency distribution of wind speed), direction, turbulence, frequency of gusts and dust storms etc.

2.2.2 AVAILABILITY OF LAND

Installation of WEGs requires large wind farms. An installation of 1 MW requires about 25 acres. The actual land used directly for WEGs is only about 10 per cent of this value. The remaining land may be used for cultivation of low height vegetation. However it is necessary that this vegetation should not disturb 'wind resource'.

2.2.3 ACCESS TO LAND

The land should be accessible for transportation of machinery and constructional material.

2.2.4 GRID STABILITY

The WEGs will feed the power grid. Evidently the grid should be free from voltage and frequency variations as far as possible

2.3 TECHNICAL CHOICES

Small wind turbines have speeds in (100-300) rpm range. Large wind turbines`(used for feeding into grid) are slow speed machines (30-60) rpm.

A direct drive gives better efficiency and is preferred in small system. It is desirable to use a matched generator with the wind turbine in small system to get good reliability.

Large size WEG feeding into the grid mostly uses induction generator, which operates at a speed higher than synchronous speed. When the wind turbine is to be started, the machine works as induction motor and draws power from the grid. A grid connected wind turbine can operate in fixed or variable speed mode.

When WEG is operating in fixed speed mode, the generator is directly connected to the grid because frequency of WEG is constant. The induction generator draws its excitation from the grid. Var drain of the grid is an important aspect of operation.

2.4 BASIC PRINCIPLE OF WIND ELECTRIC GENERATORS

The basic principle or theory of generation of electricity from wind is no different from that of hydroelectric power generation. A conductor of electricity, rotating inside a magnetic field results in the induction of an electromotive force. In case of wind energy conversion systems, the rotary motion for the conductor is caused by winds impinging on a set of blades mounted on a tower, whereas in hydro, the movement is obtained from the flow of water through the turbine blades. It therefore emerges that, in order to extract electrical energy from wind, all that is required is to provide a rotary motion from the wind. This may look simple; however it is a very complex task to produce quality power that can be fed into a grid of power utility. The task becomes further complicated, when it is necessary to optimize the extraction and make the process safe.

When induction motor runs faster than its synchronous speed, an induction motor works as a generator called as 'Induction Generator'. It converts the mechanical energy it receives into electrical energy and the stator releases this energy. The schematic diagram of Grid Connected Induction Generator (GCIG) is shown in **Fig. 2.3**. As soon as motor speed exceeds its synchronous speed, it starts delivering active power P to the three-phase line. However, for creating its own magnetic own magnetic field, it absorbs reactive power q from the line to which it is connected.

The active power generated is directly proportional to the slip above the synchronous speed. If a polyphase induction motor while connected to constant voltage and frequency mains is mechanically coupled to a prime mover and is driven by it at a speed higher than synchronous speed, the rotor overtakes the rotating magnetic field and the rotor conductors cut the magnetic flux in a reverse direction to motor rotation. As a result, the emf and currents in the rotor will reverse their direction. Consequently the reaction force between rotating field and rotor currents also changes it's direction and opposes the rotation. To maintain this rotation mechanical energy is required to be delivered to the rotor the magnetizing current remaining the same, since the rotating field conditions are the same in an induction generator.

The power of the machine under such condition is negative i.e., the machine delivers electric energy to the mains instead of taking it from mains. The slip of the induction machine operating as a generator is negative and the direction of its emf, now coincides with active component of current instead of being opposed to it, as is the case in a motor.

With the increase in negative slip, the inductive reactance of the rotor increases and as a result the phase shifts between the emf and current in the rotor also increases. On the other hand, the rotor emf increases in proportion to the slip, and since the braking torque of an induction generator is expressed in the same way as the torque of a motor

$$T \propto \Phi_2 I_2 \cos \Phi_2 \qquad \text{------- 2.2}$$

It follows that in the same way as for a motor with slip corresponding to the condition $S=R_2/X_2$ there will be maximum torque above which the operation of the machine will be unstable. Thus, the torque-slip characteristics of the machine as a generator resembles those of a machine as motor as shown in **Fig 2.4.**

An induction generator supplies an active current to the mains, but at the same time it receives from the mains, but at the same time it receives from the mains a lagging reactive current (magnetizing current), in the same way as motor. Therefore, an induction generator cannot operate independently, and, operating in parallel and feeding it into the mains, it reduces its power factor through its reactive current.

2.5 TYPES OF WEGs

WEGs can be classified into many types, depending on the mode of connection, the direction in which the axis is placed, the control system adopted, the placement of the blade, etc. the types of WEGs are enumerated below.

MODE OF CONNECTION

@ Stand alone.

@ Grid connected.

@ Hybrid.

AXIS

@ Horizontal.

@ Vertical.

PLACEMENT OF ROTOR

@ Upwind

@ Down wind

NUMBER OF BLADES

@ Three bladed.

@ Two bladed.

@ Single bladed.

REGULATION

@ Stall.

@ Pitch.

@ Passive pitch.

@ Active stall.

SPEED OF ROTOR

@ Single speed.

@ Dual speed.

@ Variable speed

GENERATOR

@ Induction.

@ Synchronous.

2.5.1 MODE OF CONNECTION

Unlike in hydro or steam turbines, the energy input to WEG is neither stable nor it could be stored and regulated to match the load on the System, since wind speed and energy varies second to second or minute to minute. Therefore the output of a WEG, which varies with input wind energy, has either to be absorbed in full, or a storage system for absorbing the electrical energy produced by the WEG should be created. **Fig 2.5** shows how WEGs are classified based on mode of connection. If a WEG is operated on a stand-alone mode, meaning that is connected independently to feed a load, firstly, the supply will be available only when wind is available. Because of this serious constraint, the utility of stand –alone mode is very limited and not popular. Generally this mode is used for charging batteries in remote locations, where power from grid is not available. However, when the WEG is connected to the grid, because of the stiffness of the grid, the variations in output of a WEG are very easily absorbed and the grid frequency can be maintained by regulating power generation from other generating sources in the grid. It is for this reason, globally, all the WEGs produced presently are horizontal axis. In remote areas, where grid is not available, wind farms could be operated in parallel with diesel electric generators, which can be regulated to take the variations in WEGs output.

2.5.2 AXIS

In a horizontal axis turbine, the shaft connecting the rotor (blades) and the generator is kept horizontal and the blades are placed in a vertical plane. In this type an elevated support (tower) is necessary to provide enough ground clearance for the rotor, which is connected to one end of the shaft. In vertical axis turbine the shaft is placed vertically and the rotor blades are embedded to both ends of the shaft. Though horizontal and vertical axis WEGs were produced and installed, it is the horizontal axis WEGs that finally sustained and all the WEGs that have been produced presently are horizontal axis wind electric generators.

2.6 MAIN COMPONENTS OF WEGs

The major components of WEG are tower, standing on a well designed foundations, to support a nacelle which houses a speed up gearbox, an electric generator, a set of brakes, bearings and a yawing mechanism and a set of blades connected to the gear box through a hub. Control panel and power panel are normally located at the bottom of the towers.

2.6.1 TOWERS

Two main forms of towers, lattice and tubular, are used. Lattice towers are cheap and easily transportable. Further it is easy to galvanise the tower to protect it from corrosion. The main disadvantages are its appearance and the nacelle it is exposed. Concrete towers are used for larger turbines. The height of the tower depends on wind regime where wind form is set up. The higher the tower more is the energy generation.

2.6.2 GEARBOX

Gearbox used in a WEG is different from that what is used for other purposes. Whereas the gearbox in a WEG steps up the speed, the gear box used for other purposes are invariably reduction gears. Generally, two types of gearboxes, parallel shaft and planetary type are used. As the difference in speed between rotor and generator is large, the gearbox ratio and input torques are high. While parallel shaft gearboxes are simple in design, easy to maintain, the planetary gearboxes have complex designed and are difficult to maintain. Because of the low mass, the planetary gearboxes are less expensive. On the account of this, planetary gearboxes are preferred for large unit sizes. Presently, gearless WEGs have also come into market with unique generator designs.

2.6.3 BEARINGS AND ROTOR SUPPORT SYSTEM

There are many ways in which the rotor in a WEG is supported and connected to the gearbox and generator. The rotor may be directly connected to the gearbox shaft or the rotor may be connected through a separate low speed shaft. The former system generally called as integrated system is compact, allows the use of smaller bedplate and cover, with fewer components and is less expensive. The disadvantage, however the service of gearbox is cumbersome since the rotor may have to be removed. In later arrangement, through the use of separate low speed shaft, either taper roller bearings, or spherical roller bearings are used. The advantage of using taper roller bearings is that it has high thrust capacity and external loads are not transfer to the gearbox. Alignment and servicing are however difficult in this mode. In the case spherical bearings, alignment is easier but servicing is difficult. Split roller bearings have low thrust capacity and are expensive, but servicing is simpler. Many manufacturers used the integrated system because of the lower cost. Care must be taken to limit the shaft over hang to the minimum with light rotor weight.

2.6.4 BRAKES

Brakes are important safety requirements. Brakes are used to bring the WEG to a stop under normal operating conditions either when the wind speed is low or when the wind speed reaches cut off stage, or when grid fails or under emergency conditions when any part of the WEG fails or attain a run away speed. As a minimum, there shall be two independent fail-safe brakes capable of bringing the WEGs to halt, even when there is a power supply failure and under high wind conditions. One of these brakes shall be arrow dynamic. Normally, an arrow dynamic brake, either rotation of the tip of the rotor or fully feathering of the blade is used to slow down the rotor speed and then the mechanical brake is applied to bring the rotor to a halt. However, each braking system shall be capable of bringing the rotor to halt even when the other brake is defective. It may be desirable to fit the mechanical brake to the low speed shaft, so that the operation of the brake does not depend on the integrity of the gearbox; however, it is to be noted that the torque on the low speed shaft is very high and it is costly.

In some designs, the nacelle is turned away from the wind to reduce power in high winds and in extreme conditions, the WEG can be stopped with the nacelle turned such that the axis is at right angle to the wind direction.

2.6.5 GENERATOR

By far the vast majority of the turbines use induction generators. They are less expensive and it reduces the cost of other parts of WEG. They have a simple control system, inherent flexibility and damping. Speed control is not required for start up: but it has the disadvantage that it has to derive its magnetizing power from the grid, requiring installation of capacitors to correct power factor to a level acceptable to the utility.

2.6.6 YAW SYSTEM

Yawing is an important requirement for maximizing generation in a WEG. The requirement is that the rotors swept area plane should be perpendicular to the wind direction, so that the wind area swept by the rotor is maximum. The yawing could be on free mode or on powered mode. Free yaw normally works in three ways, using either fan tile or tail vane or down wind rotor. In practice free yawing is not preferred and powered yaw is invariably used.

Powered yaw use a rotary actuator, engaging a gear ring mounted at the top of the tower. A wind vane usually mounted on the top of the nacelle senses the relative wind direction and the WEG controller operates the yaw drives. The most common form of yaw bearing is a standard slewing ring, either ball or cross roller type.

2.7 ADVANTAGES OF WIND ELECTRIC GENERATORS (INDUCTION GENERATOR)

- Induction generator does not hunt or drop out of synchronism.
- It is simple and rugged in constructions.
- It is cheaper in cost and easy to maintain.
- When short-circuited it delivers little or no sustained power, because its excitation quickly becomes zero.

COMPANY NAME	COLLABORATOR	YEAR
NEPC-MICON Ltd., Chennai	MICON, Denmark	1986
BHEL, Ranipet (Trichy)	NORDEX, Denmark	1992
Aban Loyd Chiles Offshore Ltd., Anna salai, Chennai.	Kenetech Corp., USA	1994
TTG Industries, Ayanambakkam, Chennai	HUSUMER, Germany	1993
Textool Company Ltd., Ganapathy, Coimbatore.	Nordtank Energy Group, Denmark	1994
Vestas RRB India Ltd., Chennai	Vestas Wind System, Denmark	1987
Sree Rayalaseema Power Corp. Ltd., Hyderabad	Danskvin Windkraft Services, Denmark	1994
Enercon (India) Ltd., Vikhroli, Mumbai	Enercon, Germany	1994
Flovel Tacke (P) Ltd., Faridabad	Flovel Tacke (P) Ltd., Denamrk	1994
Das Largerwey wind Turbines Ltd., Chennai	-----------	1995
Wind Power Ltd., Mumbai.	Ned Wind, Netherlands	1995
Enviro-Clean System Ltd., Hyderabad.	Chase Corp., USA	1995

Table 2.1 Leading WEG manufacturing companies in India

STATE	DEMONSTRATION PROJECTS	PRIVATE SECTOR	TOTAL PROJECTS
Tamil Nadu	19.355	537.035	556.390
Gujarat	16.345	99.328	115.673
Andhra Pradesh	3.050	41.850	44.900
Karnataka	2.575	---	2.575
Kerala	2.022	---	2.025
Maharashtara	2.600	---	2.600
Madhya Pradesh	0.590	6.300	6.890
Orissa	1.100	---	1.100
Others	0.465	---	0.465
Total	48.105	684.513	732.618

Table 2.2 Installed WEG capacity in India till March 31,1996

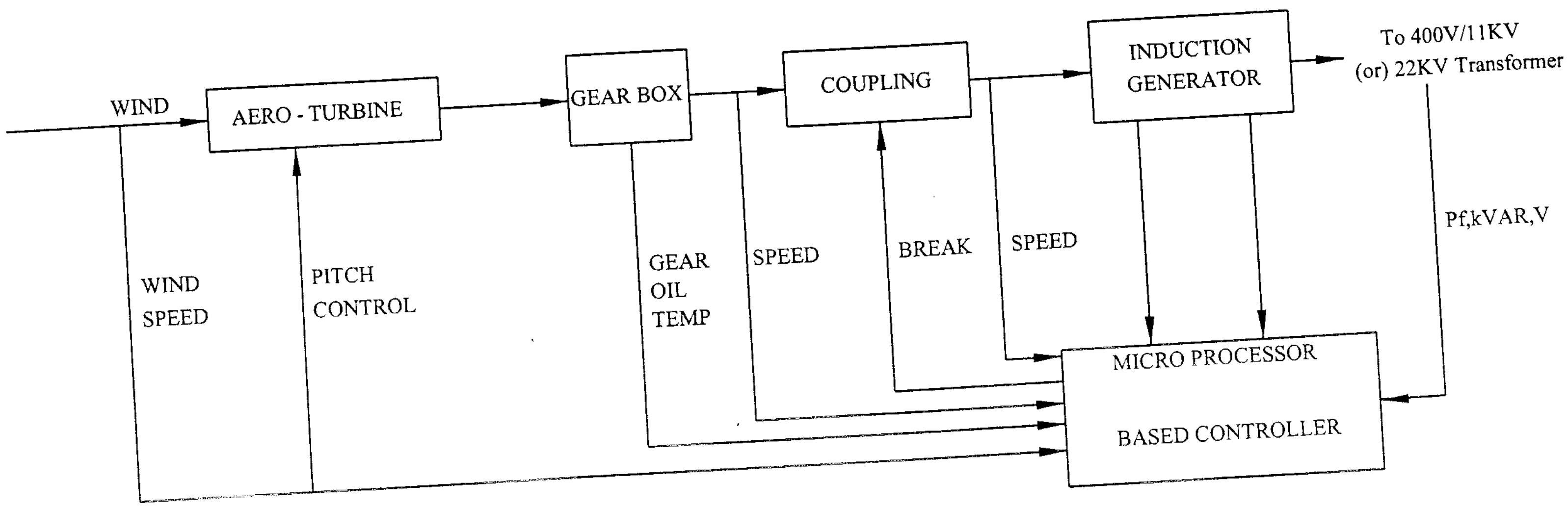


FIG 2.1 BASIC CONFIGURATION OF WECS

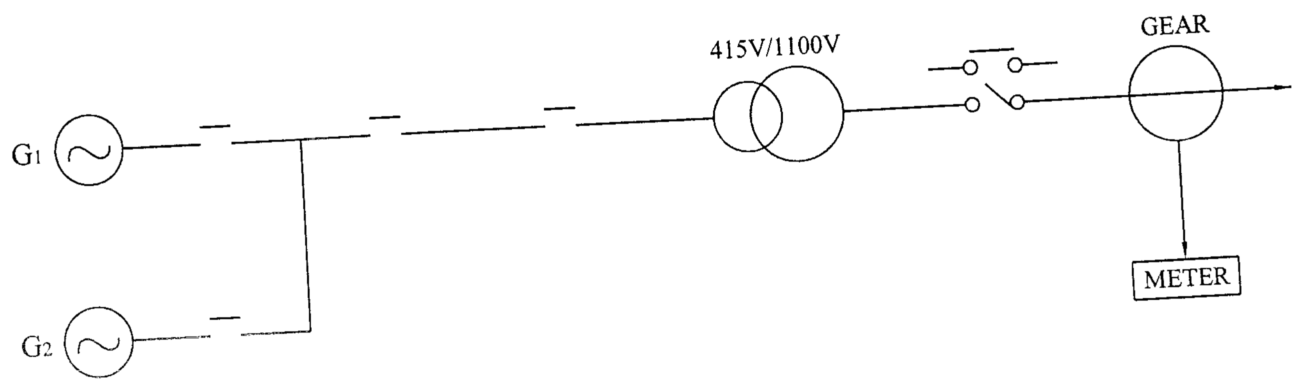


FIG 2.2 Electrical Connection of Windmill

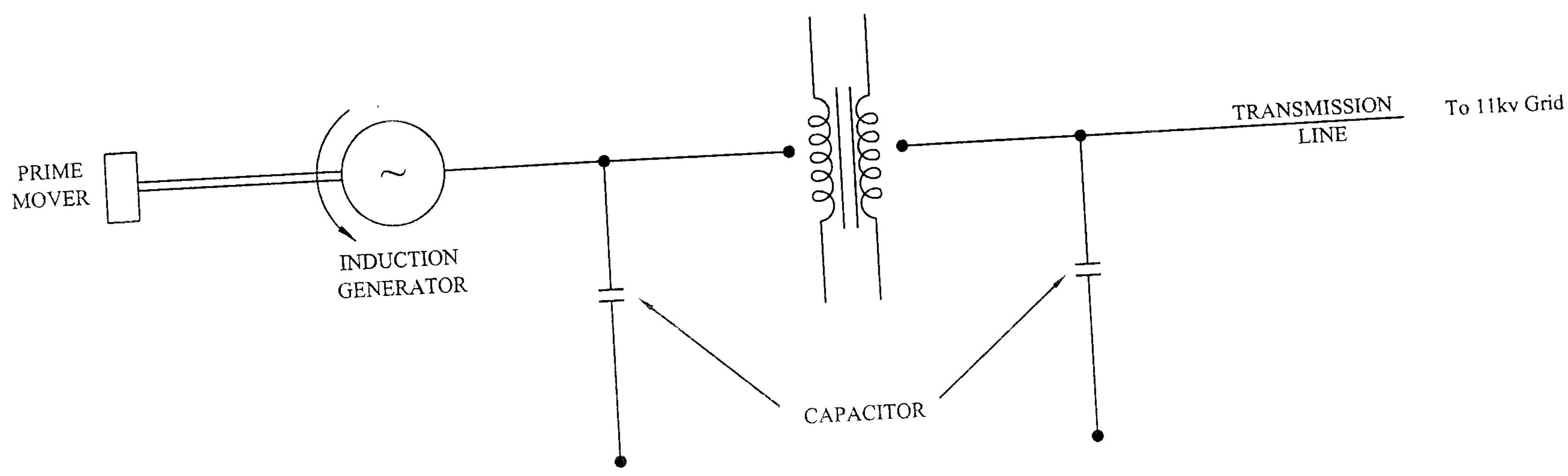


FIG 2.3 SCHEMATIC DIAGRAM OF GCIG.

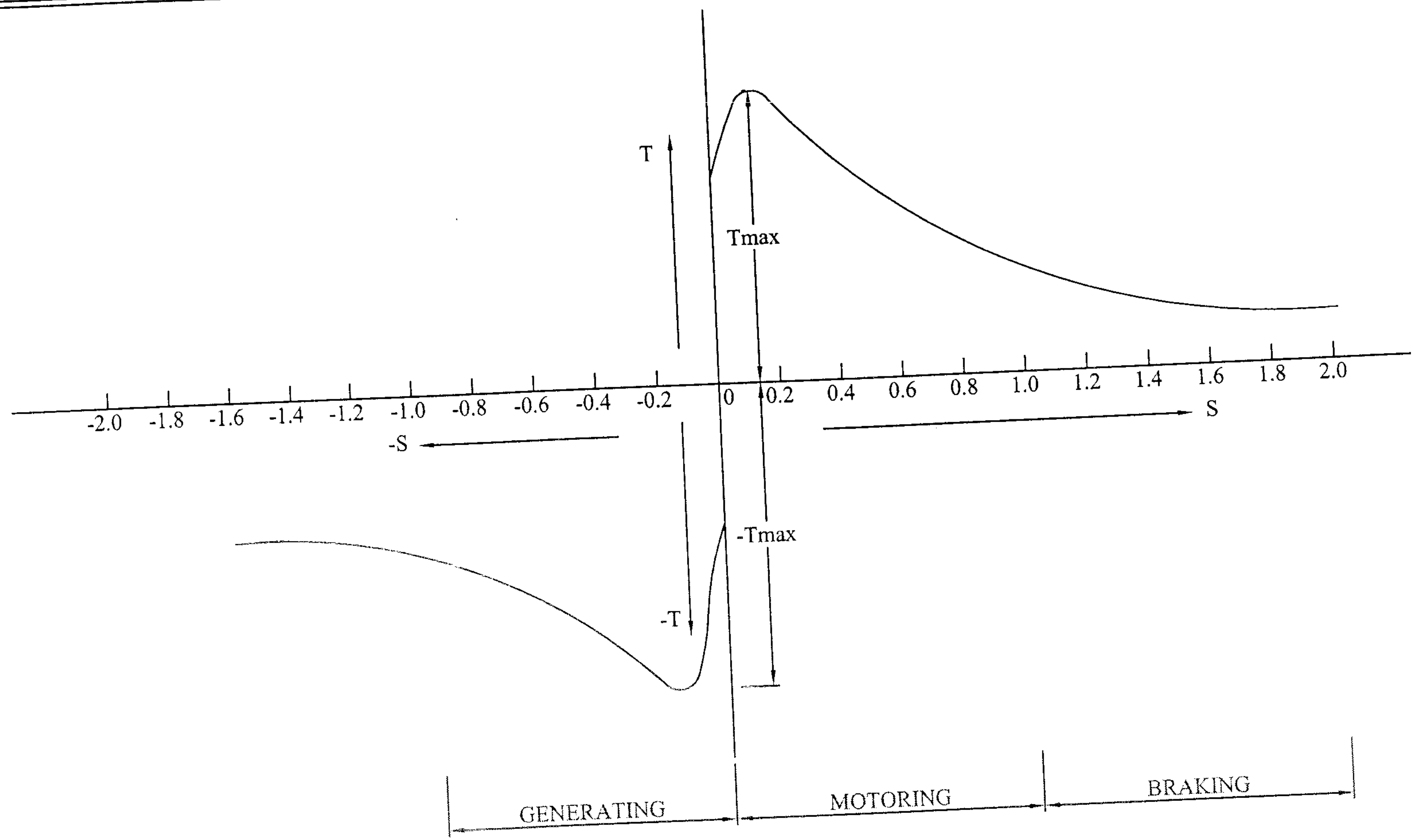


FIG 2.4 Torque-Slip Characteristics of Induction Machine

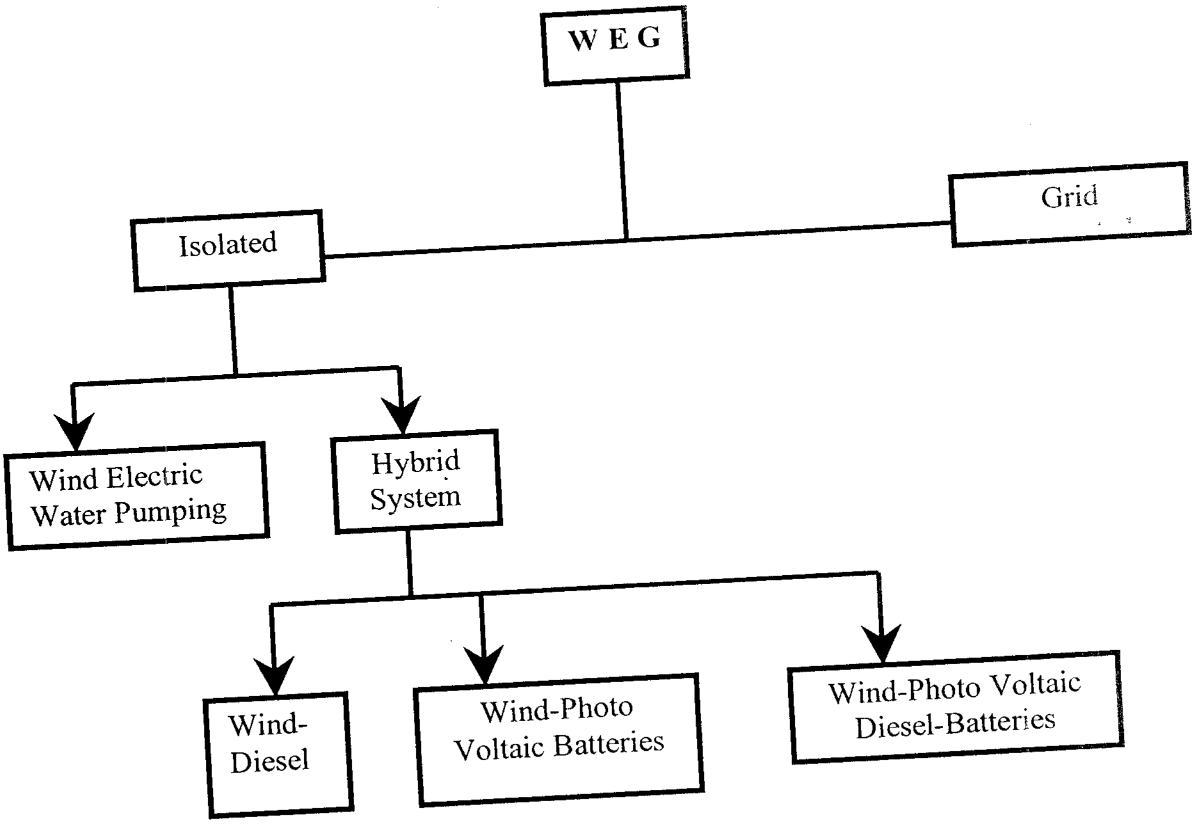


Fig 2.5 Classification based on mode of connection

CHAPTER 3

VAR COMPENSATION FOR GCIG

As per the study, it is estimated that in India average of transmission and distribution loss is around 21% and in TamilNadu alone it is 15%. The main reason for high transmission and distribution loss in our country is the weak and inadequate sub-transmission and distribution system, large-scale rural electrification, inadequate reactive compensation at the load points and improper load management etc.

3.1 REACTIVE POWER

The electrical equipments like transformers, motors and bulk of the other electrical appliances used in industrial, domestic, agriculture and commercial sectors require magnetic fields for their operations. To establish the magnetic field and sustain it, these equipments need reactive power, which is arising from the energy temporarily stored in the load for part of the AC cycle and returned to the supply system at a later stage in the cycle. The energy stored may be in the magnetic fields, as in the case of motors, chokes in the fluorescent lights etc. or electrostatic fields as in capacitors, stored charge in the insulation of underground cables etc.

This characteristics of the load, is described by its power factor, which is expressed as

$$\text{Power factor} = \frac{\text{Real power in watts}}{\text{Apparent power in volt-amperes}}$$

The two types of energy storage are time shifted and thus complementary. They occur at different stages of AC cycle to the extent that while first one is storing the energy, the other is returning its stored energy to the supply source. This time-shift is expressed as the sign of the power factor (-ve or lagging for inductive loads and +ve or leading for capacitive loads).

The reactive power is generated in the field by

I. Alternators
II. EHV Transmission lines
III. Synchronous condensers
IV. HT/LT shunt capacitors.

The Reactive power is consumed by

I. Inductive loads
II. T & D lines and transformers, as reactive losses.

If the available reactive power matches with the reactive power requirement, then the grid voltage profile will be good. When there is mismatch, it leads to under/over voltage conditions and the grid experience voltage instability.

3.2 NEED FOR REACTIVE COMPENSATION

The presence of loads with a large requirement for reactive power is detrimental to the power system. The consumers cannot extract any increase in reactive power but it will increase only in the current flow on the power system and hence contributes to system losses. Thus the consumption of additional unwanted reactive power results in system instability, power transformers get unnecessarily loaded due to high reactive power and net "Real Power availability" for the system gets reduced. Also this leads to excessive voltage regulation. These higher current flows for the same "Real Power" due to large transfers of reactive power can be ameliorated by the introduction of reactive power close to the load.

This is described as "Reactive Compensation" and may take the form of dynamic compensation i.e., rotating machines, whose excitation can be varied so that the device may either generate or absorb reactive power through shunt capacitor banks.

However, the above largely applies only if there is a heavy demand for reactive power in the power system. If there is insufficient lagging power factor loads to absorb the reactive power, this excessive reactive power generation leads to excessive system voltage. Application of reactive compensation will be more effective, if applied as close to the reactive loads.

3.3 CONSUMPTION OF REACTIVE POWER BY GCIG

In grid connected wind turbines, the IG's draw reactive power from the grid and in turn delivers active power to the grid. Drawing of reactive power means lowering the power factor of the grid. To avoid low power factor, wind turbine control system is provided with capacitors to compensate the reactive power drawn form the grid. The power factor correction requirements determine the total amount of capacitors required i.e., kVAR required.

Due to the two-way transfer of active and reactive power, the voltage profile scenario becomes complex and is given by eq. 3.1

$$V_g = V_s \cos \delta + I_g Z \cos (\beta + \Phi) \quad \text{-------- 3.1}$$

where,

V_g = Voltage at IG terminal

V_s = Voltage of grid supply

δ = Angle between V_g & V_s. This angle increases with power output from the wind turbine.

I_g = Current output from IG.

Z = impedance of grid transmission line (dependent on size and spacing of conductor used in grid line).

B = Impedance angle related to reactance/resistance ratio of transmission line (this ratio is higher in case of high voltage of transmission line).

Φ = Power factor angle.

From the above equation, it can be observed that

1. Effect of Z and β gets decided on selection of transmission line.
2. V_g shall increase with decrease in the value of Φ (as power factor increases)
3. V_g shall increase as $(\beta + \Phi)$ reduces below 90° and V_g shall decrease as $(\beta + \Phi)$ increases beyond 90°.

If V_g increases or decreases by more than 12% it shall be necessary to disconnect the IG to avoid burning out of the IG due to high voltage, or inability of IG to produce power due to low voltage.

So it is extremely important to study Z, β and power factor compensation capacitor rating to ensure permissible voltage variation at the terminals of IG.

3.3.1 REACTIVE CURRENT REQUIRED FOR POWER FACTOR IMPROVEMENT

If the current supplied to the circuit is I amperes, lagging the voltage by an angle Φ, the current can be resolved into two components, one is I_a along with the voltage vector and the other is I_r in quartered with the voltage vector as shown in **Fig. 3.1.**

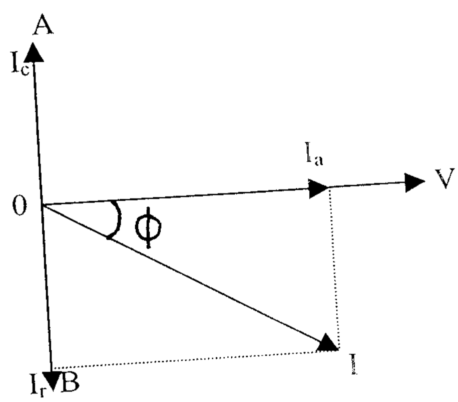


Fig.3.1 Phasor representation of reactive current

To improve the power factor, angle Φ should be decreased and for unity power factor, reactive component I sin Φ (i.e. I_r) is to be decreased. This is achieved by introducing a leading current I_c of magnitude equal to the reactive component, in the circuit as shown by OA in **Fig. 3.1**

The vector sum of I_a, I_r and I_c is I_a, which is in phase with the voltage resulting UPF.

$$I_c = I_r = I \sin \Phi$$

$$= I (1- \cos^2 \Phi)^{0.5} \quad \text{------- 3.2}$$

$$= I (1-(pf)^2)^{0.5}$$

3.3.2 Power factor improvement by static capacitors

$$I_c = \omega CV = 2\pi fCV \quad \text{------- 3.3}$$

From equation (3.2), $2\pi fCV = I (1-(pf)^2)^{0.5}$

Therefore $C = I/2\pi fCV (1-(pf)^2)^{0.5}$ Farads ------- 3.4

Also Power $P = Vi \cos \Phi = VI (pf)$ Watts ------- 3.5

Therefore $I = P/V (pf)$ Amps ------- 3.6

Substituting the value for I from equation (3.6) into equation (3.4),

$$C = (P * (1-(pf)^2)^{0.5}) / (V^2 * (pf) * 2\pi f) \text{ Farads}$$

$$C = (P * (1/(pf)^2 - 1)^{0.5}) / (V^2 * 2\pi f) \text{ Farads}$$

$$C = (P * 10^6 ((1/\cos^2 \Phi) - 1)^{0.5}) / (V^2 * 2\pi f) \text{ Micro Farads------ 3.7}$$

So the capacitance required is inversely proportional to the power factor

3.3.3 Fixed (Base) and Variable Compensation

As some portion of the reactive power consumed by the IG is of fixed value regardless of the wind condition, this part can be compensated by fixed shunt capacitors. M/s Baron Power Ltd., has conducted a study and suggested that the fixed compensation can be provided on both HV and LV sides.

The remaining portion varies with the conditions of the wind and it has to be compensated by switched capacitors. Because the fixed capacitors are limited by the voltage rise under high wind conditions.

3.3.4 Optimum location of capacitors

Planning for reactive power basically involves choice of proper size, type and location of reactive power equipment required to maintain a proper balance between reactive power demand and reactive power generation.

Both low voltage and high voltage capacitors are equally capable of compensating the kVAR consumption of the IGs. The fixed compensation for kVAR may be provided on HV side of the individual two-pole substation of each windmill. In a wind farm situated at Perungudi consists of two feeders with each feeder connected to 16-wind turbine IGs. In this, group compensation using HT capacitors of 1500 kVAR is provided in each feeder.

However, if capacitors are fixed nearer to the IGs that is on LV side in the cables and transmission line feeders may be selected with lower ratings. Fixed compensation can be provided either on LV or HV and dynamic compensation using switched capacitors can be provided only on LV side.

3.3.5 Determining the kVAR requirement

The problems pertaining to power factor corruption by static capacitors can be dealt within the following 2 ways:

1. Constant kW assumption
2. Constant kVA assumption

As kW export of the IGs varies continuously from instant to instant, the second type is suitable.

3.3.5.1 CONSTANT kVA CONSUMPTION

In this method, the kVAR of the condenser capacity per kVA, to rise power factor from cos Φ_1 to cos Φ_2 is given by the difference of the sins of the angles of Φ_1 and Φ_2 as shown in **Fig. 3.2.**

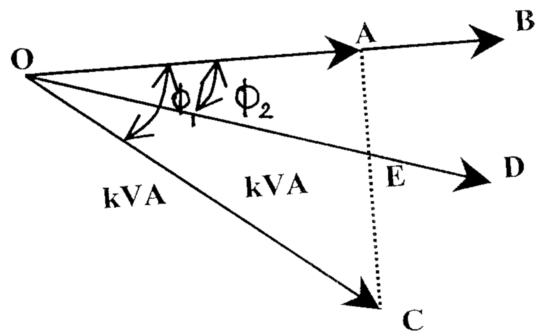


Fig. 3.2 Phasor diagram for finding kVAR

Let OA be the load supplied at cos Φ_1 lagging, the load kVA is represented by OC which is to be kept constant. Let the power factor be improved to cos Φ_2 and be represented by OD. Since kVA is to be kept constant, with center 'O' and radius equal to OC, an arc is drawn to cut OD at D. DE is parallel to OA to cut AD at E. CE represents the kVAR capacity of phase advancing plant.

From the **Fig. 3.2.** CE = kVA sin Φ_1 – kVA sin Φ_2.

= kVA (sin Φ_1 – sin Φ_2)

Power increase due to improved power factor is AB and is given as

$$AB = kVA (\cos \Phi_1 - \cos \Phi_2)$$

kVA capacity of the capacitor banks is given by CD

i.e., $CD = (CE^2 + ED^2)^{1/2}$

$$= [kVA (\sin \Phi_1 - \sin \Phi_2)^2 + (\cos \Phi_1 - \cos \Phi_2)^2]^{1/2}$$

3.3.6 Existing system - Status and drawbacks

In the existing system, fixed compensation is not provided. Only the variable compensation is provided, which is realized by microprocessor based controller (wind power 2000). The cut-in and cutout of the capacitor is controlled by the microprocessor in the following manner.

When the kVAR production is negative a check is made to see if the kVAR is consumption plus 25% of the "set point of maximum positive compensation" is larger than the value of the capacitor bank to be cut-in. If it is larger, then capacitor bank is cut-in. The capacitor bank is cutout, when the kW production is zero or when the kVAR production larger than the "set point of maximum positive compensation" for one second. The set point of maximum positive compensation is 12.5 kVAR.

A case study has been considered to understand the drawbacks of the existing system. Here the WEG was made to run without the capacitor banks and the actual kVAR consumption was recorded for various load conditions.

From **Table 3.1**, it is obvious that even for a generation of 13 kW (i.e., 30% of its related capacity), the generator consumes 27% kVAR. The drawback in existing system of capacitors switching is explained in **Table 3.2.**

Only in case 3, the value of kVAR import plus set point is greater than the value of the capacitor to be cut-in. So the capacitor bank will be cut-in. For other cases (i.e., up to 21 kVAR import), the capacitor will not be cut-in and so the IG operates at low power factor. This problem can be eliminated by cut-in and cutout of the capacitors of lower ratings in larger no. of steps. To adopt a better solution, a detail study has been conducted at Kethanur and Kayathar wind farms, which are presented in next chapter.

Power Generated in kW	kVAR consumed	Power Factor
0	20	0.06
2	21	0.10
4	24	0.12
6	25	0.17
13	27	0.46
32	28	0.61

Table 3.1. Reactive power consumption pattern (44/250 kW IG)

Case	kW export	kVAR import	Set point	Capacitor bank to be cu-in
1	0	20	3	23 < 24
2	2	21	3	24 = 24
3	4	24	3	27 > 24

Table 3.2 Drawbacks of the existing system

CHAPTER 4

SITE ANALYSIS

As the kVAR import of the GCIG is specific, i.e., varies from site to site even for the machine of same rating and of same make, a detailed site analysis is required. This site analysis includes an extensive study of the existing system, site location, prevailing wind pattern at the site and the performance of the WEGs

As the first phase of study, the data regarding WEGs operating in the Coimbatore circle is collected and are presented here.

4.1 WINDMILL INSTALLATION IN COIMBATORE CIRCLE

4.1.1 Jurisdiction

The following Taluks come under the jurisdiction of this Circle

a. Coimbatore b. Palladam c. Udumalpet

d. Pollachi e. Dharapuram

4.1.2 Wind farm developers

Total number of wind farm developers: 190 Nos.

4.1.3 Windmills

Number of windmills

	Board	Private	Total
No. of units	9	1032	1041
Capacity in MW	2.090	277.645	279.735

Number of windmills not running

	Board	Private	Total
No. of units	1	41	42
Capacity in MW	0.250	11.700	11.950

4.1.4 Generation Details

Year	Private wind Farm		Board wind farm				Total	
			Kethanur		Sulthanpet			
	N o. of units	Gen. In MW	No. of units	Gen. In MW	No. of units	Gen. In MW	No. of units	Gen in MW
1993	-	-	8	0.79	1	0.11	9	0.90
1994	80	9.77	8	2.95	1	0.09	89	12.81
1995	576	103.39	8	2.24	1	0.05	585	105.68
1996	942	294.07	8	1.18	1	0.01	951	295.26
1997	1027	288.77	8	0.96	1	0.01	1036	289.74
1998	1032	28.93	8	0.16	1	0.09	1041	29.18

Table 4.1 Generation details in Coimbatore circle

4.1.5 Wind Farm Substations (WFSS)

Details of WEGs connected to WFSS

Sl. No	Name of wind Farm SS	Installed capacity in MVA	No. of WEGs	Connected Capacity in MW
1	110/33 – 11 kV Kethanur	64	204	53.51
2	110/33 – 11 kV Sulthanpet	48	143	53.97
3	110/33 – 11 kV Edayarpalayam	16	24	5.92
4	110/33 – 11 kV Kethanur	16	20	6.5
5	110/33 – 11 kV kethanur	48	164	48.61

Table 4.2 WEGs connected to other SS

Sl. No.	Substation	Installed capacity in MVA	No. of WEGs	Capacity in MW
1	Udumalpet	58	74	27.21
2	Poolavady	48	241	60.90
3	Negamam	20	12	2.70
4	Dharapuram	50	24	7.30
5	Somanur	10	84	21.01
6	Palladam	10	45	10.52
7	Irugur	48	2	0.45
8	Pongallur	30	4	1.09

Table 4.3 WEGs connected to other SS

4.1.6 Details of TNEB wind farms

Sl. No	Location	No. of WEGs and Capacity	Make	Date of Commissioning
1	Kethanur	8 x 250 kW	NEPC	25.07.93 (2 Nos.)and 5.8.93 (1 No) 15.09.93 (2 Nos.) and 25.9.93 (3 Nos.)
2	Sultanpet	1 x 90 kW	Vestas	18.6.88

Table 4.4 Details of TNEB wind Farms

4.1.7 VAR Compensation

No. of developers who installed the shunt capacitors : 72 Nos.

Capacitors – installed capacity : 5 MVAR

No. of WEGs provided with additional shunt capacitors: 546 Nos. against 1041 WEGS

4.1.8 Details of WEGs installed as on 29.04.99

Sl. No.	Name of the Company (Make)	Capacity in kW	Total number of WEGS
1	NEPC – INDIA LTD.	225 250 400 600	319 67 95 1
2	AMTL	250	136
3	BHEL	250	57
4	BONUS	320	11
5	ENERCON	230	65
6	FLOWEL TACKIE	600	5
7	SANGEETH CARTER	300	18
8	TTG	250	43
9	VESTAS RRB	225	90
10	VESTAS RRB	90	1
11	WINDIA	550	18
12	KIRLOSKAR ELECTRIC	400	3
13	PIONEER WINCON	250	2
14	DAS LARGERWAY	250	5
15	WIND POWER	330	35
16	NORD TANK – TEXTOOL	550	5
17	NORD TANK – TEXTOOL	300	60
	Total		1041

Table 4.5 Details of WEGs installed in Coimbatore circle

4.1.9 Comparison of WEGs

With reference to power factor at different loads (without capacitors)

Sl. No	WEGs Make	Capacity kW	Power Factor at Different Loads			
			100 %	75 %	50 %	25 %
1	Elin	60	0.73	0.65	0.5	0.3
2	CG	60	0.82	0.7	0.7	0.46
3	Jyothi	60	0.82	0.76	0.66	0.53
4	KEC	40	0.87	0.86	0.73	0.54
5	Elin	250	0.84	0.81	0.73	0.54
6	CG	250	0.84	0.79	0.7	0.48
7	Jyothi	250	0.87	0.87	0.8	0.62
8	KEC	250	0.85	0.85	0.77	0.53
9	Elin	100	0.64	0.64	0.51	0.29
10	CG	100	0.74	0.74	0.62	0.39
11	Jyothi	100	0.8	0.8	0.7	0.46
12	KEC	100	0.64	0.64	0.51	0.29
13	Elin	400	0.76	0.76	0.66	0.42
14	CG	400	0.87	0.87	0.8	0.61
15	Jyothi	400	0.85	0.85	0.78	0.56
16	KEC	400	0.86	0.86	0.8	0.6
17	KEC	600	0.87	0.87	0.84	0.61
18	Elin	150	0.74	0.74	0.63	0.4
19	Elin	600	0.84	0.84	0.77	0.56

Table 4.6 Comparison of WEGs with reference to power factor at different loads

With respect to no load current

Sl. No.	WEGs Make	Capacity in kW	No load Current	No load kVAR	Capacitor installed kVAR
1	Jyothi	225/40	122/50	84.5 /34	100
2	Kirloskar	225/40	140/45	97/31	100
3	Elin	250/60	158/58	109.5/40	72
4	CG	250/60	187/45	129/32	72
5	Jyothi	250/60	145/46	95/30	72
6	Kirloskar	400/100	115/96	80/66.5	187.5
7	Jyothi	400/100	142/47	98/33	187.5
8	CG	400/100	123/57	85/40	187.5
9	Elin	400/100	183/62.81	126/44	187.5
10	Kirloskar	600	163	113	176
11	Elin	600/150	118/46	118/46	250

Table 4.7 Comparison of WEGs of different make with respect to no load current

4.2 STUDY CONDUCTED AT KETHANUR WIND FARM

In this project work, a detailed study has been made at two places in TamilNadu, viz., Kethanur and Kayathar wind farms. At Kethanur, many wind farms have been installed by the private organizations, like M/s 20th Century Finance Corporation and M/s AMTL Ltd., at various places and are connected to Kethanur 110/11 kV substation. In these wind farms, most of the WEGs are NEPC – MICON make and Vestas – RRB make WEGs were also installed in some wind farms. The power generated by these WEGs at low voltage (400 volts, 50 Hz, three phase AC) is exported to the grid through a step-up transformer (400V/11 kV, three phase).

In the wind farms run by the private firms, data regarding cumulative values of kWh and RkVAh are recorded in addition to power factor. TNEB emphasis, that the ratio of RkVAh to kWh must be less than 30 %. It is observed that, the data like wind speed, kVAR import, three-phase voltages and currents are not recorded in these wind farms.

The windmills section, TNEB – Coimbatore circle runs a 2 MW wind farm at Kethanur consisting of 8 x 250 kW NEPC make windmills. TNEB maintains a complete record of wind peed, three phase voltages and currents, kVAR import, power factor and frequency whereas, private sector wind farms are not maintaining these details.

The details of WEGs used in Kethanur wind farm are furnished below.

Specification of a 60/250 kW induction generator:

Wind turbine : NEPC make, 3 blade type

Fiber Blades – make : SRSI, Coimbatore

Induction Generator – make : Jyothi Ltd., Vadodara, India

Parameter	Capacity	
	250 kW	60 kW
Frequency	50 Hz	50 Hz
Voltage	400 V	400 V
Connection	Δ	Δ
Current	420 A	420 A
Speed	1512 rpm	1008 rpm

The data observed during the study in the Kethanur wind farm are listed in **Tables 4.8 to 4.18.**

Data collected at Kethanur wind farm

Time Hours	Wind Speed	Voltage Vph	kW	kVAR	Power Factor	Frequency Hz
5	4.8	230	29	98	0.48	48
6	5.6	232	32	99	0.47	48
7	6.2	235	48	98	0.49	48.1
8	7.2	236	58	102	0.5	48
9	8	238	69	104	0.56	48.1
10	6.8	236	52	106	0.58	48
11	9.2	234	101	132	0.69	47.9
12	8.2	226	84	104	0.68	47.9
13	7.6	219	62	98	0.68	47.9
14	8.9	224	98	126	0.72	47.8
15	11.8	215	181	115	0.89	47.9
16	9.6	218	158	131	0.82	48
17	8.2	221	84	112	0.71	47.9
18	9.8	219	140	129	0.8	47.8
19	11.6	224	170	138	0.86	47.8
20	8.7	221	87	121	0.72	47.9
21	8.6	227	97	100	0.72	47.9
22	8.4	224	99	110	0.75	47.8
23	9.2	222	109	117	0.75	48
24	9.5	229	110	129	0.86	48.1
1	10.6	221	121	131	0.78	48.1
2	10.1	224	119	130	0.79	48
3	10.9	222	121	137	0.85	48
4	9.8	227	109	117	0.79	48

Table 4.8 Data recorded on 13/6/2000

Time Hours	Wind Speed	Voltage Vph	kW	kVAR	Power Factor	Frequency Hz
5	5	248	30	48	0.5	48
6	5.3	246	36	45	0.55	48.1
7	5.2	240	34	44	0.5	48.1
8	5.4	238	36	48	0.51	48
9	5.6	237	39	51	0.62	48.1
10	6.2	231	48	55	0.68	48
11	6.8	227	57	61	0.72	47.9
12	8.2	224	90	87	0.78	47.9
13	8.6	222	98	89	0.76	47.8
14	8.4	226	92	107	0.82	47.8
15	6.1	217	38	19	0.78	47.8
16	5.2	219	30	17	0.61	47.8
17	5.4	221	32	19	0.68	47.8
18	5.2	220	28	21	0.69	47.8
19	5.6	224	39	27	0.62	47.9
20	6.1	227	46	39	0.74	48
21	5.2	228	39	42	0.52	48
22	5	229	36	43	0.5	48
23	4.2	230	32	40	0.5	48
24	4.6	231	34	38	0.51	48
1	4	232	30	38	0.46	48
2	4.1	230	30	36	0.42	48
3	3.8	229	26	30	0.39	48
4	3.1	228	21	30	0.39	47.9

Table 4.9 Data recorded on 13/7/2000

Time Hours	Wind Speed	Voltage Vph	kW	kVAR	Power Factor	Frequency Hz
5	6.1	232	49	121	0.37	47.9
6	5.5	231	35	48	0.34	47.9
7	10.2	231	125	147	0.53	47.9
8	9.8	229	118	136	0.51	47.9
9	11.3	218	171	139	0.81	47.9
10	10.4	220	146	119	0.76	47.9
11	8.7	221	98	124	0.72	47.9
12	9.1	221	112	132	0.74	47.9
13	9.6	222	132	140	0.75	47.9
14	10	226	162	150	0.79	47.9
15	13.3	226	200	149	0.79	47.9
16	15	224	248	152	0.8	47.8
17	14.8	224	247	151	0.8	47.8
18	15.2	226	249	156	0.8	47.8
19	13	228	196	136	0.79	47.9
20	11	226	160	128	0.78	47.9
21	10.8	228	158	121	0.68	47.9
22	10.2	226	131	107	0.69	47.8
23	10.4	224	142	117	0.72	47.9
24	10.2	222	121	120	0.73	47.9
1	10.6	227	150	111	0.74	47.9
2	11.2	229	171	120	0.78	47.8
3	11	226	168	118	0.69	47.8
4	10.6	224	148	127	0.65	47.8

Table 4.10 Data recorded on 30/7/2000

Time Hours	Wind Speed	Voltage Vph	kW	kVAR	Power Factor	Frequency Hz
5	7.8	239	80	96	0.72	47.8
6	5.9	238	52	86	0.62	47.9
7	6.4	240	58	102	0.68	47.9
8	9.2	237	104	81	0.76	47.8
9	6.1	229	57	84	0.62	47.8
10	8	226	73	82	0.69	48
11	-	-	-	-	-	-
12	-	-	-	-	-	-
13	7.8	227	68	89	0.68	47.8
14	8	230	72	92	0.72	47.9
15	6.2	231	58	69	0.65	47.8
16	6.8	227	61	72	0.58	47.8
17	6.4	226	56	79	0.46	47.9
18	6.8	227	58	68	0.48	47.8
19	6.9	228	54	69	0.51	47.8
20	6.2	231	59	72	0.52	47.8
21	5.2	238	30	60	0.3	48
22	4.8	237	28	62	0.28	48.1
23	4.6	236	20	70	0.2	48.2
24	3.2	235	15	55	0.35	48
1	3.3	234	18	53	0.4	48.4
2	3.6	235	12	48	0.28	48.4
3	4.1	238	22	52	0.2	48.1
4	4	240	20	53	0.18	48.8

Table 4.11 Data recorded on 13/8/2000

Time Hours	Wind Speed	Voltage Vph	kW	kVAR	Power Factor	Frequency Hz
5	9	250	101	96	0.88	48.6
6	9.6	248	106	98	0.89	48.7
7	9.4	246	108	99	0.9	48.6
8	9.8	246	118	102	0.92	48.7
9	11	248	148	101	0.94	48.9
10	12	249	178	101	0.8	48.7
11	11.8	250	168	101	0.81	48.6
12	11.6	252	162	122	0.79	48.7
13	11.8	256	168	135	0.81	49.4
14	13.8	258	178	131	0.8	50.2
15	14.2	250	201	141	0.78	50.4
16	14.8	252	238	142	0.72	50.1
17	14.2	248	235	129	0.69	50.2
18	14.3	256	232	131	0.78	50.3
19	14.2	260	230	128	0.72	50.1
20	13.8	254	218	158	0.8	50.5
21	10.8	252	141	156	0.83	50.3
22	8.9	256	102	124	0.74	50.3
23	9.8	254	132	148	0.81	50.6
24	9.1	251	106	118	0.78	50.4
1	10.6	252	136	149	0.82	50.1
2	8.6	254	98	116	0.71	50.1
3	9.4	257	112	122	0.8	49.9
4	10.2	256	135	142	0.81	49.8

Table 4.12 Data recorded on 13/9/2000

Time Hours	Wind Speed	Voltage Vph	kW	kVAR	Power Factor	Frequency Hz
5	5.3	240	29	35	0.52	48.2
6	6.4	238	40	32	0.6	48.1
7	6.1	239	37	28	0.55	48.1
8	6.3	228	21	97	0.46	48.3
9	6	218	16	96	0.41	49
10	6.3	227	39	113	0.58	49.4
11	8.9	235	103	134	0.63	50.4
12	9.7	239	139	156	0.68	50.3
13	9.9	234	142	152	0.63	50
14	9.3	235	124	130	0.54	50.3
15	8.6	234	96	117	0.53	49.8
16	10.4	221	151	127	0.77	49.5
17	7.7	216	65	92	0.58	48.5
18	10.4	219	149	137	0.75	48.1
19	9.8	225	140	150	0.68	48
20	8.6	226	96	71	0.54	48.2
21	7.8	231	67	81	0.52	48.4
22	6.2	234	54	68	0.48	48.3
23	5.8	233	42	58	0.4	48.3
24	6	230	52	71	0.35	48.2
1	5.6	231	40	54	0.34	48.5
2	5.8	235	43	57	0.38	48.2
3	4.8	233	29	38	0.27	48.3
4	4.2	231	20	40	0.76	48.4

Table 4.13 Data recorded on 13/10/2000

Time Hours	Wind Speed	Voltage Vph	kW	kVAR	Power Factor	Frequency Hz
5	1.6	238	0	0	1	48.1
6	1.8	234	0	0	1	48
7	1.2	232	0	0	1	48.1
8	1.9	235	0	0	1	48
9	1.1	237	0	0	1	47.7
10	1.8	234	0	0	1	47.9
11	1.6	236	0	0	1	48
12	1.1	237	0	0	1	47.9
13	1.9	238	0	0	1	47.8
14	1.6	236	0	0	1	47.8
15	1.2	234	0	0	1	48
16	1.3	235	5	25	0.35	48.1
17	2.4	234	16	32	0.42	48.2
18	3.2	235	10	33	0.5	48
19	2.8	236	18	28	0.48	48.1
20	3.4	235	0	48	0.01	48.1
21	2	236	0	0	1	48
22	1.6	237	0	0	1	48.1
23	1.2	238	0	0	1	48.1
24	1.1	239	0	0	1	48
1	2.6	242	0	0	1	47.9
2	3	236	0	0	1	48
3	1.6	232	0	0	1	48
4	1.2	234	0	0	1	48

Table 4.14 Data recorded on 13/11/2000

It is evident from these records that, kVAR drawn by the GCIGs with the variation in wind is not linear one, rather it is a complex one. The kW export (active power) to the grid by the machine is also varying with wind speed. At high wind speed conditions, the kW generated by GCIGs is greater than the kVAR drawn. So the power factor, even without compensation is as high as 0.8 (when the wind speed is more than 11 m/s). If compensation by shunt capacitors is provided in this condition, power factor will rise to even unity. At low wind speed conditions, the kVAR import, by GCIG from the grid is greater than the kW generated by it. As a result of this power factor becomes low.

From the study conducted in Coimbatore during 2000, it is observed that, the wind speed conditions are better during the month of July and are poor during November. Graphical representation of wind speed, power factor, kW, kVAR over a day in the two months of July and October are presented in **Graphs 4.1 to4.10**.

4.3 STUDY CONDUCTED AT KAYATHAR WIND FARM

M/s. TamilNadu Newsprints and Papers Ltd. (TNPL), Karur District operates a wind farm at Kayathar, TamilNadu. A 60/250 kW NEPC – MICON make IG is taken up for a study and the data regarding RkVAh, kWh were collected from this wind farm and also listed in tables presents the details of kW and kVAR drawn from the same machine and table lists the relationship between the wind velocity and kW. Table presents the details of kW export of a Vestas 225 kW machine and wind velocity on 22/1/99 at Kayathar – II TNEB substation wind farm.

It is evident form the above study made in the wind farms at Kethanur and Kayathar, the kVAR drawn by the GCIGs are dynamically varying with the changes in wind speed. Presently, the shunt capacitors are cut-in and cut-out in steps of 24 kVAR banks. The intermediate values of kVAR drawn by the GCIGs are left uncompensated. This results in a higher ratio of RkVAh to kWh and lowers the daily average power factor. So, a controller is used for compensation and provides a better solution for this problem by developing software to cut-in and cut-out the capacitors in appropriate values.

Time (Hours)	Feeder – I			Feeder - II		
	Ex.kWh	Ex.RkVAh	Im.RkVAh	Ex.kWh	Ex.RkVAh	Im.RkVAh
22	2466.76	108.23	110.08	3127.77	145.93	1628.45
23	2466.74	108.27	110.10	3127.80	145.97	1628.46
0	2466.80	108.31	110.11	3127.83	146.03	1628.46
1	2466.81	108.31	110.14	3127.85	146.15	1628.46
2	2466.84	108.31	110.18	3127.90	146.24	1628.47
3	2466.86	108.31	110.23	3127.90	146.24	1628.53
4	2466.88	108.31	110.24	3127.93	146.24	1628.57
5	2466.88	108.31	110.29	3127.96	146.25	1628.61
6	2466.88	108.31	110.33	3127.99	146.25	1628.66
7	2466.91	108.47	110.34	3127.99	146.43	1628.67

Table 4.15 Data recorded on 15/7/2000

Rating	kW Export	kVAR Import
250 KW	25	110
	50	112
	80	117
60 KW	5	28
	10	28
	15	29
	20	31
	32	35
	38	35

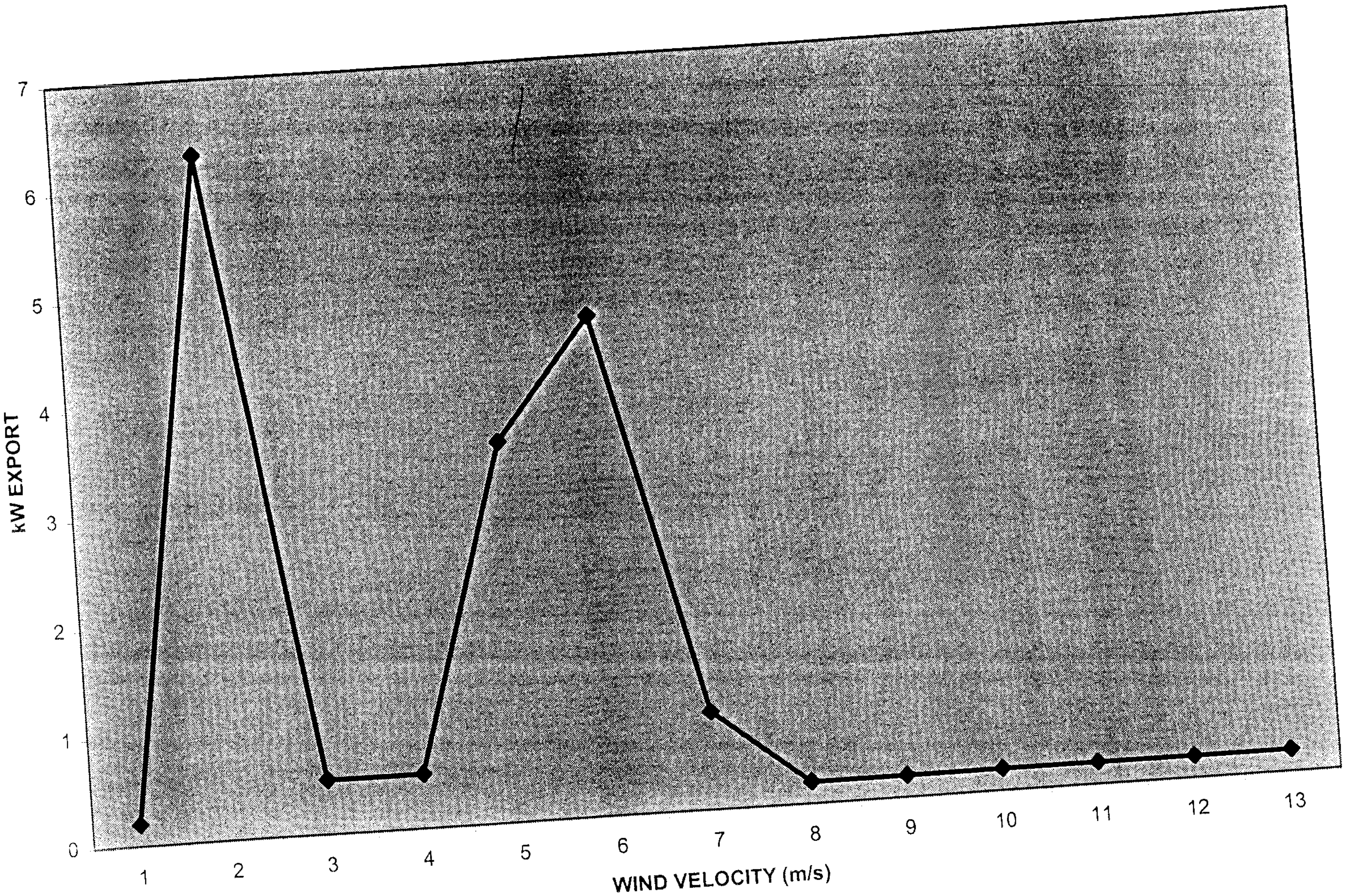
Table 4.16 Data recorded on 19/1/2000

Time (Hours)	Wind Velocity (m/s)	kW Export
22	6.1	43
23	4	12.5
20	3.5	12
1	4.1	13.5
2	6.1	14
3	3.8	11.9
4	5.3	25.7
5	3	5.9
6	1.8	-0.3
7	4.3	20.8

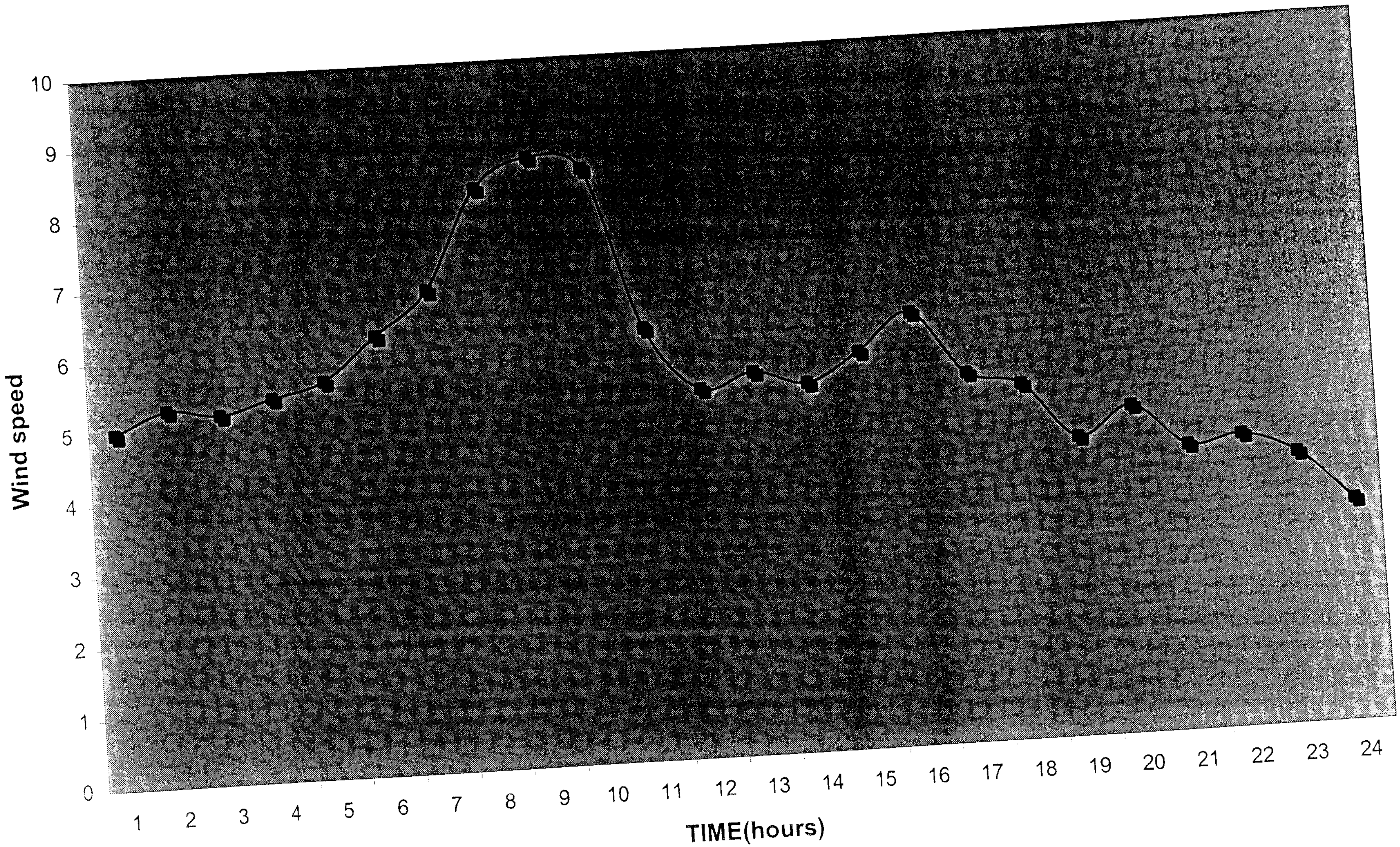
Table 4.17 Data recorded on 15/7/2000

kW Export	Generator Speed (rpm)	Rotor Speed (rpm)	Wind Velocity (m/s)
0.2	728	31.5	3.2
6.3	721	30.7	3.2
0.5	721	30.3	2.8
0.5	720	30.5	3
3.5	724	30.7	2.7
4.6	720	30.6	2.4
0.9	703	30.7	1.7
0.2	435	22.1	2.8
0.2	422	21.8	2.6
0.2	389	20.1	2.9
0.2	381	19.8	2.4
0.2	376	20	2
0.2	386	20.1	2.6

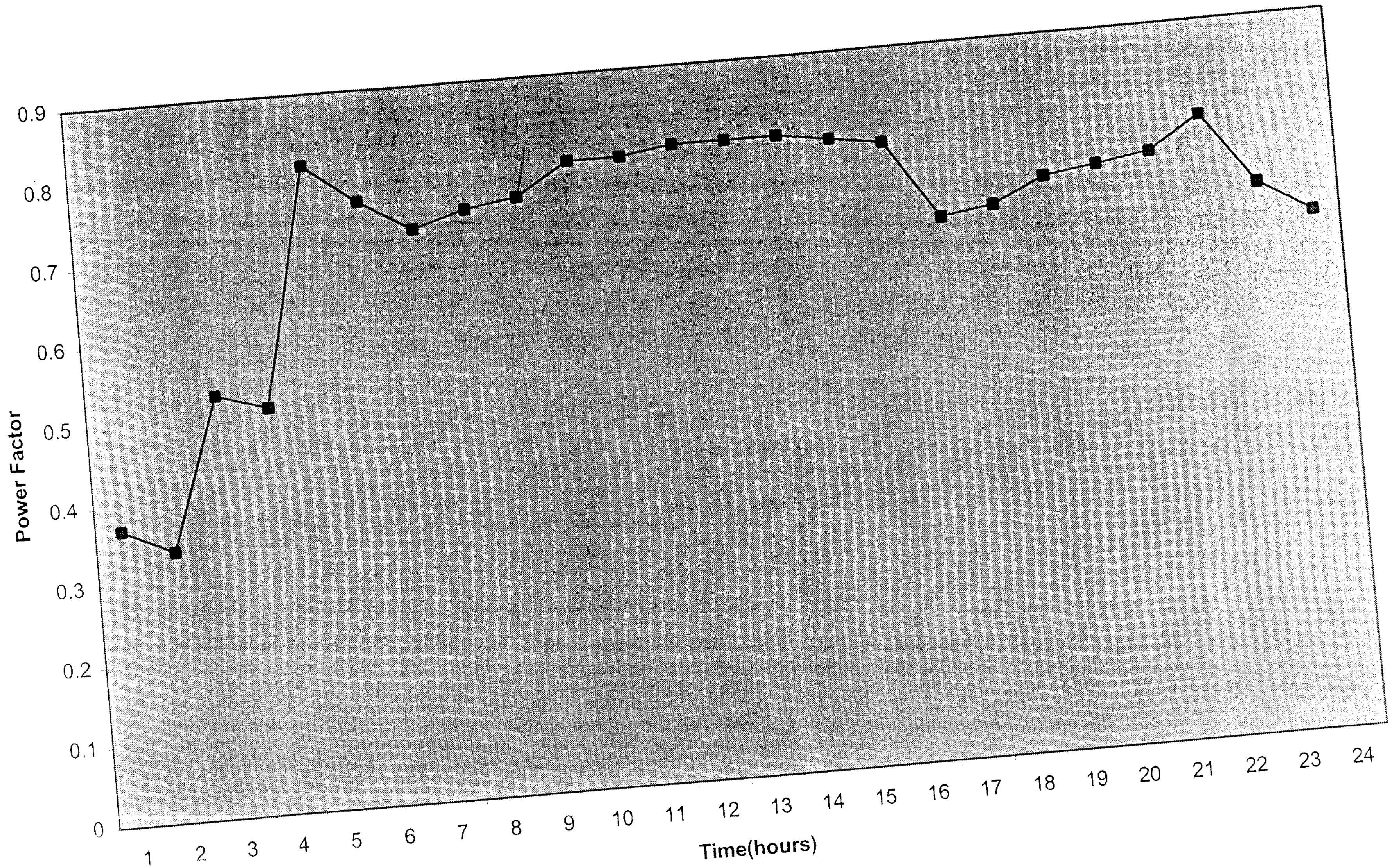
Table 4.18 Data recorded on 22/1/2000



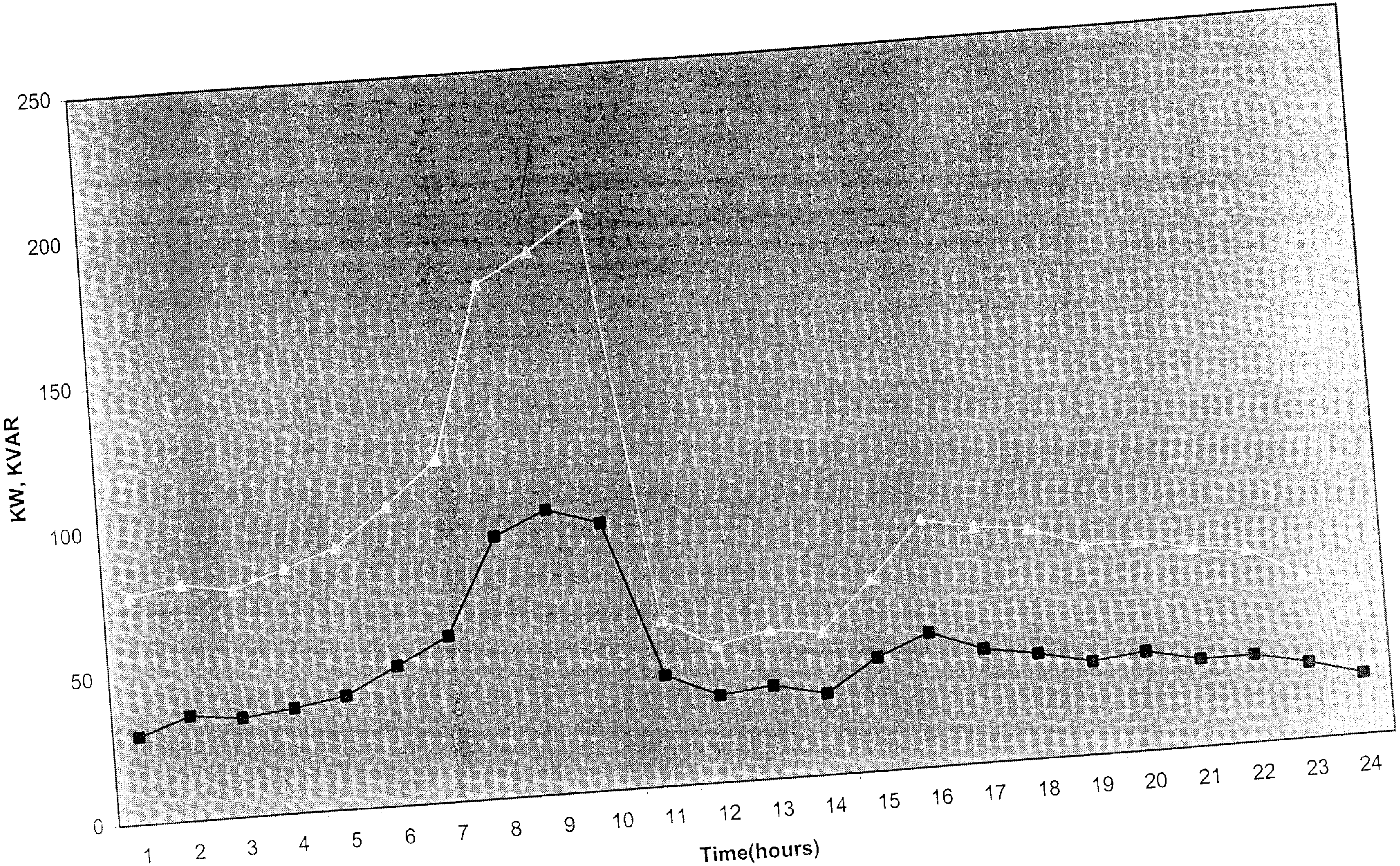
GRAPH 4.0 VARIATIONS kW EXPORT WITH WIND VELOCITY



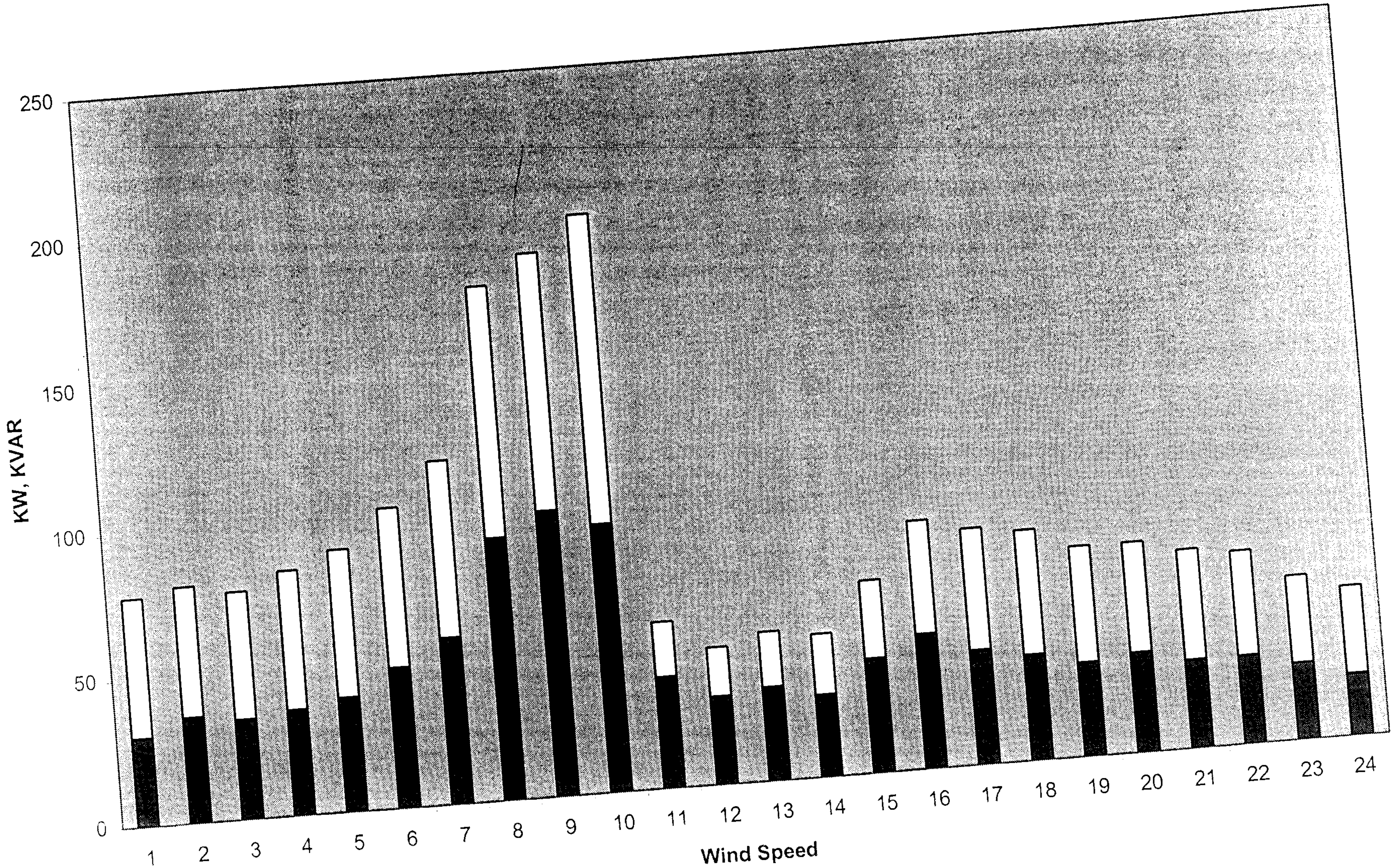
GRAPH 4.1 VARIATIONS OF WIND SPEED OVER A DAY (13/07/200)



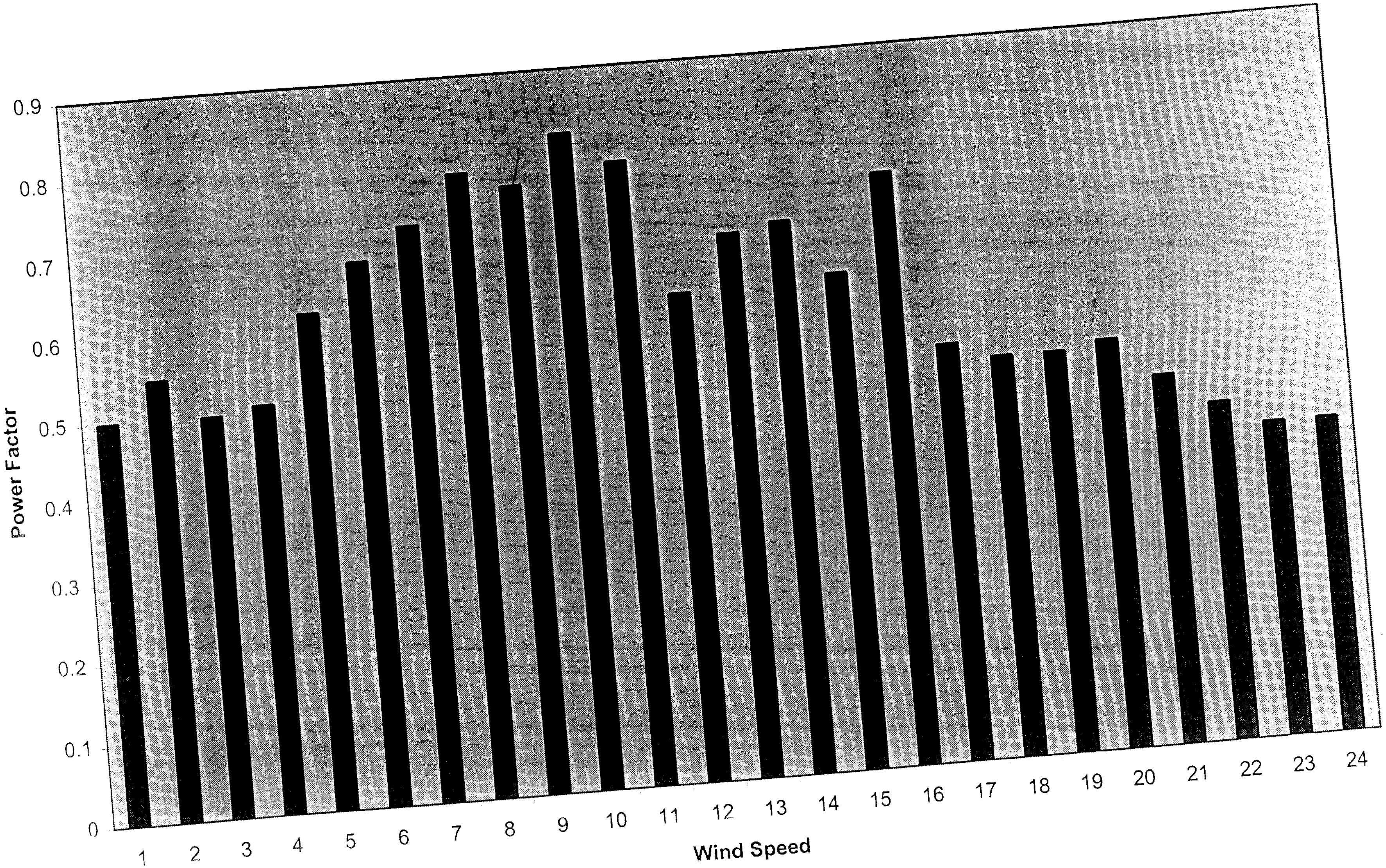
GRAPH 4.2 VARIATIONS OF POWERFACTOR OVER A DAY (13/07/2000)



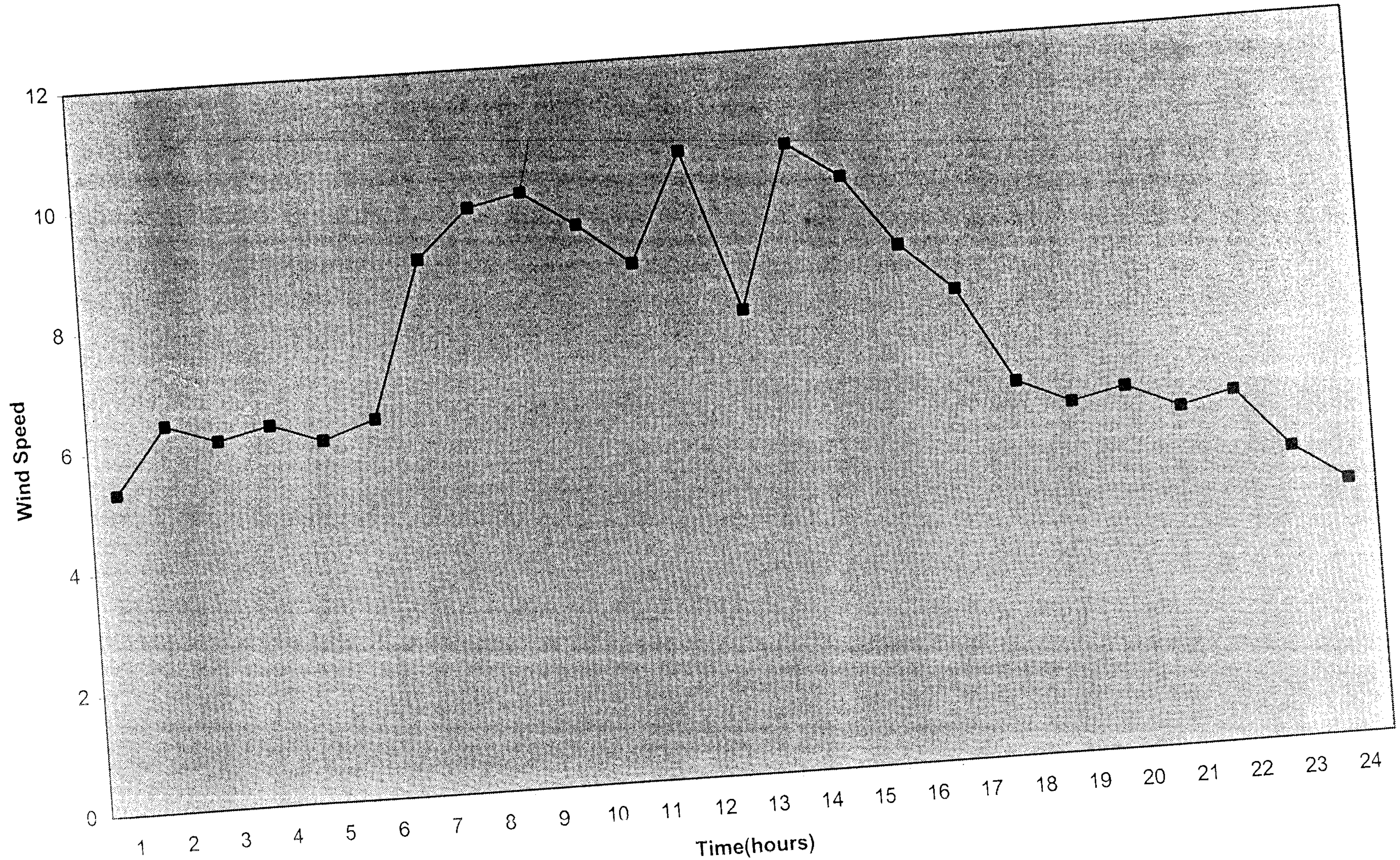
GRAPH 4.3 VARIATIONS OF KW AND KVAR OVER A DAY(13/07/2000)



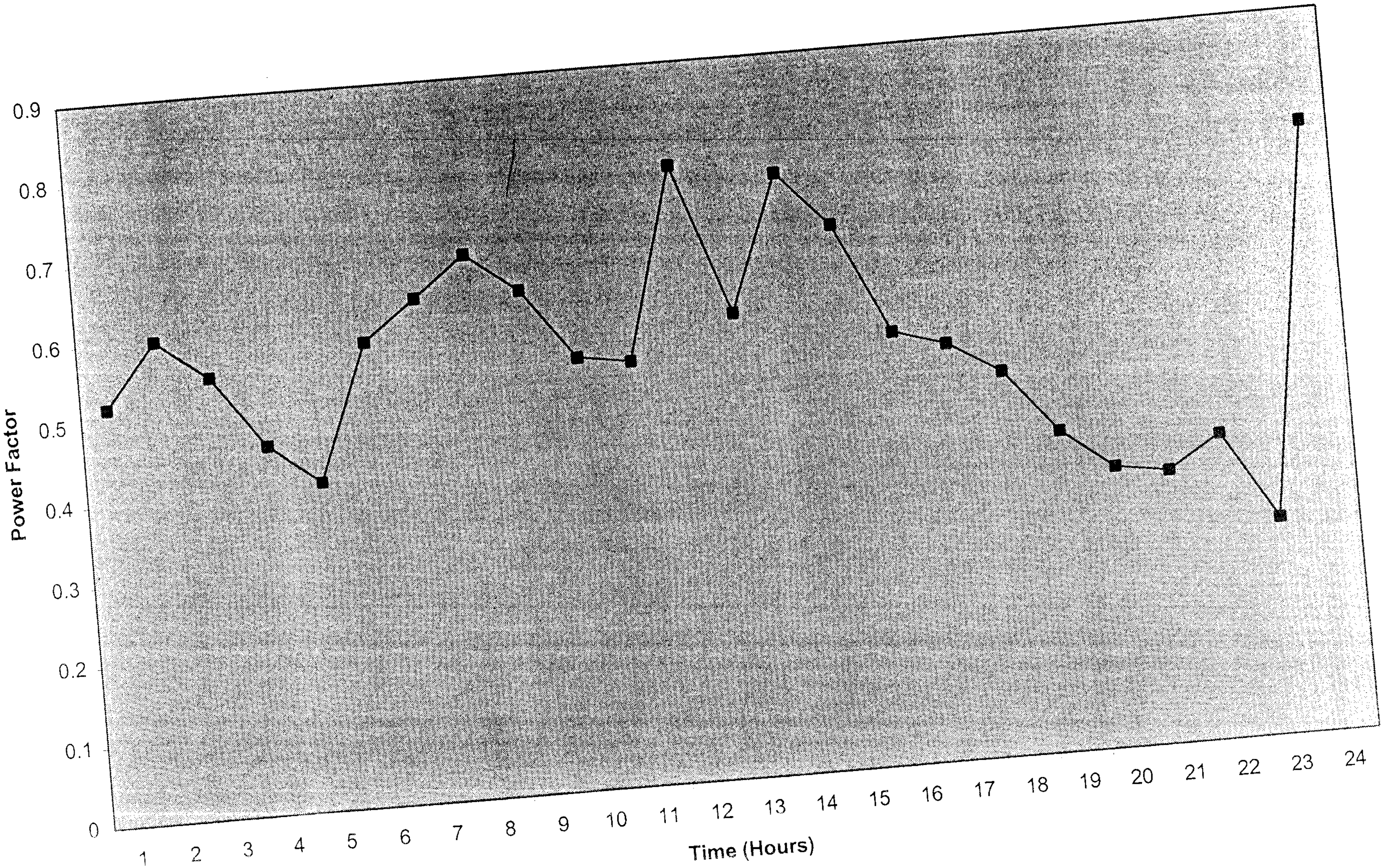
GRAPH 4.4 VARIATIONS OF KW AND KVAR WITH WIND SPEED OVER A DAY (13/07/2000)



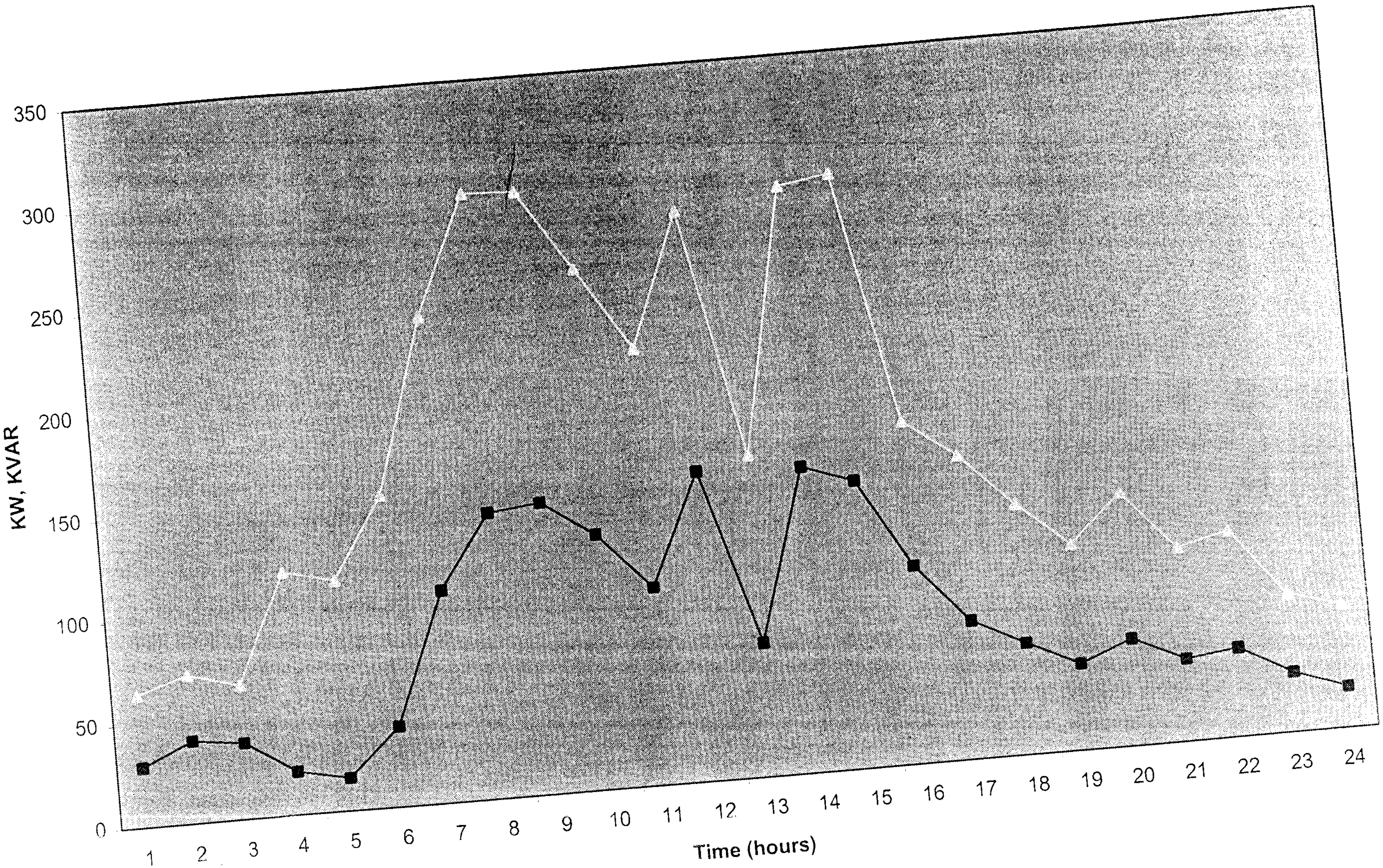
GRAPH 4.5 VARIATIONS OF POWER FACTOR WITH WIND SPEED OVER A DAY (13/07/2000)



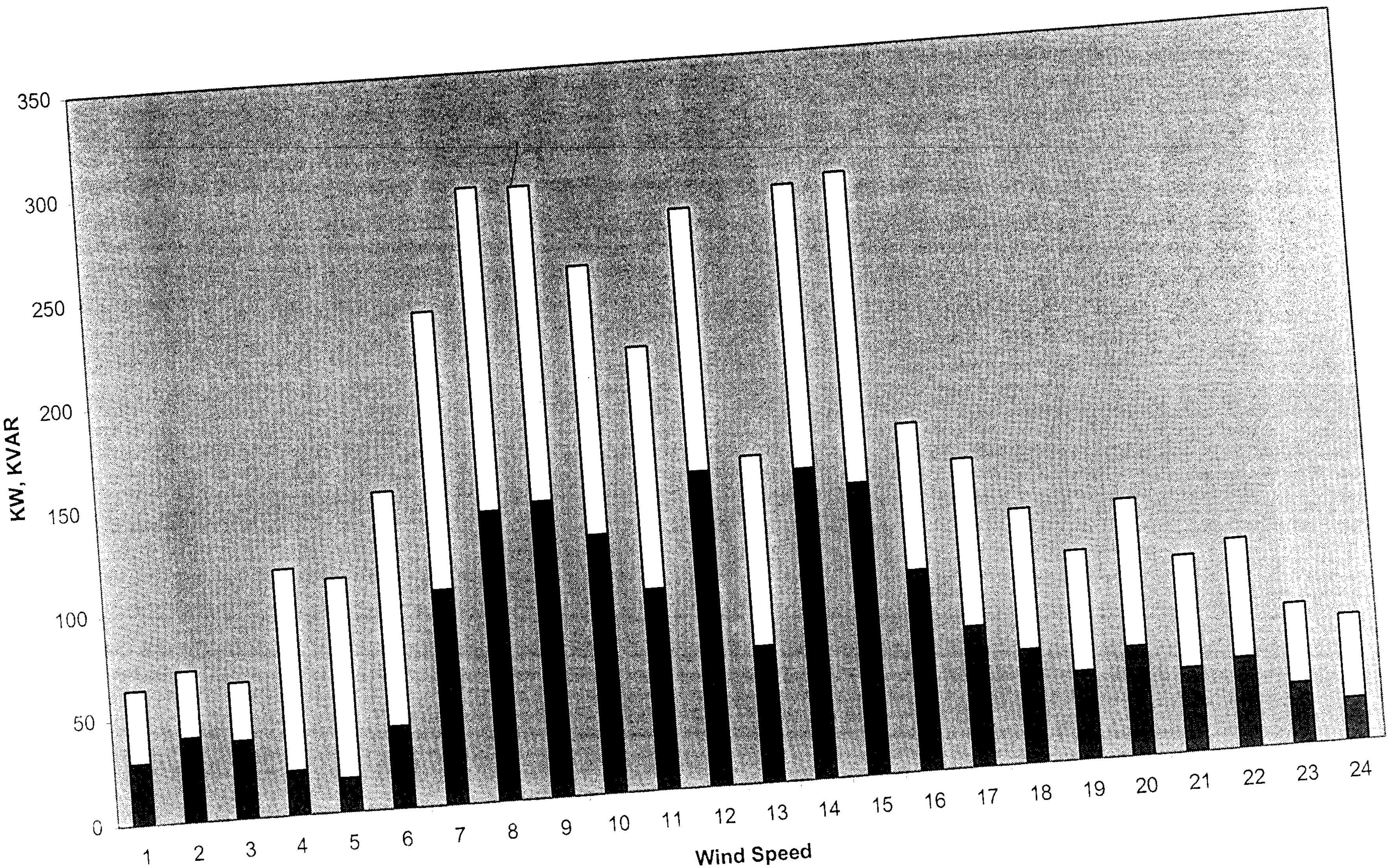
GRAPH 4.6 VARIATIONS OF WIND SPEED OVER A DAY (13/10/2000)



GRAPH 4.7 VARIATIONS OF POWER FACTOR OVER A DAY (13/10/2000)



GRAPH 4.8 VARIATIONS OF KW AND KVAR OVER A DAY (13/10/2000)



GRAPH 4.9 VARIATIONS OF KW AND KVAR WIYH WIND SPEED OVER A DAY (13/10/2000)

CHAPTER 5

SOFTWARE IMPLEMENTATION

5.1 NEED FOR SOFTWARE

Reactive power compensation is one of the major drawbacks that a windmill presently faces in addition to the low wind velocity. The present system has micro - processor based controller that is used for monitoring a single windmill. In such a system although switching of capacitor takes place to a certain extent, the main disadvantage being that the time taken for its switching is very large. To overcome this drawback we go in for an other system, which not only controls more than single windmill but also provide compensation depending upon the type of mode which the user is opting for his/her operation.

In general, software is used which provides a better flexibility as it collects the information about voltage, current, power factor from microprocessor unit which is present in windmills and senses these datas through the ports present in the system. These datas are further processed and depending upon values obtained the corresponding capacitor bank is switched on. In some cases there will be no need for compensation, where the software will disconnect all capacitor banks.

When it comes to a microprocessor the problem of overcompensation is still persisting. This is mainly due to the reason that certain windmills do not have capacitor banks of smaller value, which is to be provided during starting period. At the time of starting a windmill it is to be initiated by a thyristor start switch or contactors up to a speed of 300 rpm. After such speed is attained the windmill starts to rotate with a leading power factor. There is an **Export** of RkVA to the grid which results in an over compensation. This is to be controlled; otherwise it will burden the breakers and switch gears. After a certain period of time windmill starts **Importing** the RkVA from the grid, which in turn burdens the grid. During this period of time windmill has lagging power factor, which is to be compensated by larger values of capacitance. To maintain an actual accord of all these values, we go in for PC based compensation, which will help in quick revival of all the capacitor banks.

5.2 BASIC REQUIREMENTS

The software should be capable of trapping the input data's through the ports for the purpose of calculating the reactive power consumed and the amount of compensation that has to be provided in order to maintain optimal power factor.

The software should continuously monitor the input data's such as voltage, current, frequency, power factor that are readily available at the data acquisition system. The continuous monitoring is essential since the above-mentioned quantities are fluctuating in case of windmills.

The data's from different windmills are sequentially sent to the system port by time-sharing multiplexing wire and dedicated Co-processor unit. The software should also calculate active power, reactive power, and capacitor value essential for compensation. The amount of compensation has to be calculated and maintained in the database for the same with respect to time.

Besides all these functions the software should be programmed in such a way that it should determine which unit of capacitor bank has to be connected to the line for providing the compensation and sense the address of that particular unit to the microprocessor present at each windmills (depending on the address sent by the software the microprocessor should switch on the corresponding relay).

The software should be feasible enough as the user can change the range of power factor improvement. Even it should be able to inform the user to change the capacitor bank value if there occurs any change in the future. The database present can give valuable information about the past-recorded data's like maximum value of reactive power consumed, power factor, reactive power consumed in a particular day, month, year. Single software should be capable of satisfying the above-mentioned requirements for number of windmills.

CHAPTER 6

SOFTWARE DESCRIPTION

6.1 BASIC HARDWARE CONFIGURATION

Machine type	-	HAL Busy bee, Compaq
Processor configuration	-	Pentium II
Operating frequency	-	266 MHZ
Hard disk capacity	-	2.1 GB
Cache memory	-	512 KB
RAM Capacity	-	32 MB
Monitor type	-	SAGA color
Floppy disk	-	1.44 MB
Keyboard type	-	104 keys PC XT/AT

6.2 SOFTWARE CONFIGURATION

Operating system	-	Windows 98
Front end	-	Visual Basic 6.0
Back end	-	MS Access 97

6.3 PROCESS INVOLVED IN INPUT TO THE SOFTWARE

The microprocessor unit present at each windmill traps the data of voltage, current, power factor and frequency, from the corresponding meters and it sends the data to the data acquisition card. In similar manner the data's corresponding to the various windmills are made available at the data acquisition card for particular instant of time.

From the data acquisition card, a dedicated Coprocessor unit sends these data's sequentially to the system through the time-share multiplexing bus. The order of priority starts from the first windmill to the n^{th} windmill. The order in which these data's are send are

- ✓ Address of each windmill.
- ✓ Voltage.
- ✓ Current
- ✓ Power factor
- ✓ Frequency.

6.4 ROLE PLAYED BY THE SOFTWARE

Visual basic is used as front end and MS Access is used as back end. The software is trapping the data's that are sent inside from the printer port by the C program. The C code which is written is first converted to an executable file and it links with the VB code as soon as the software gets installed i.e., Whenever the system is installed .exe file links with the software for accessing the data's from the microprocessor unit. The block diagram shown in **Fig 6.1** shows the actual performance of software.

The linked C code returns the data that are available in the printer port as parameters to the VB code. The data's are presented at the corresponding textbox, which the user can visualize.

From the power factor value obtained the time (t) and phase angle (ϕ) are calculated using the formula $\phi=\omega t$ and corresponding voltage and current pulses are generated. It supports for both leading and lagging power factors.

The values of active power in kW and apparent power in kVA are calculated using the values that are being specified. The chart present in the database comprises of the amount by which the power factor is to be improved. This is linked, then from the present value, the amount of compensation required to improve the power factor to the desired level is selected. The amount of compensation is displayed in the text box. From the required amount of compensation and available capacitor values the software decides the unit that has to be connected.

6.5 FEATURES OF SOFTWARE

6.5.1 Windows 2000 Millennium Edition

Though MS-Dos offered good functionality, the text interface was less interactive and difficult for a common user to get used to. It was not for a layman to grasp and remember the Dos commands. Windows offered a visual or a Graphical User Interface (GUI), which is very easy to use.

Every Dos program had a different user interface, which the user needs lots of time to get adjusted. Windows eliminated such problems by offering a consistent user interface. So the user took no time to learn to interact to these programs.

From the prospective of the user the shift from MS-Dos to windows operating systems involved switching over to graphical user interface from the old Command Line Interface (CLI). Another change the user may fell and appreciate is the ability to windows operating systems to execute several programs simultaneously.

Windows programs are event driven programs and must deal with the keyboard and must deal with the keyboard and mouse inputs that can be directed at numerous user interface objects such as menus and Ms-Dos .the windows programs are driven by events that takes place during the execution of the programs

6.5.2 Visual Basic 6.0

The "Visual" part refers to the methods used to create the Graphical User Interface (GUI). The "Basic" part refers to the Beginners All Purpose Symbolic Instruction Code (BASIC) language.

6.5.2.1 Features of Visual Basic

- Improved data access and client-server model
- Internet and web tools
- Enhanced controls and wizards
- OLE and ActiveX controls, ActiveX DLL, ActiveX EXE

6.5.2.2 New Database features

- ADO - ActiveX Data Objects
- DAO - Data Access Objects, a programming model that allows to programmatically access and manipulate data in local or remote databases, and to manage databases.
- Data Environment Designer - It is a Visual tool for defining ADO connections and commands for a project.
- Data Report Designer – This tool allow to drag and drop information from data view window, which provides in establishing connections to data and viewing or modifying data.

6.5.2.3 New Object Oriented features

- Class persistence that helps to save the values of the properties of class to a file and retrieve them the user request the object.

6.5.2.4 New Integrated Developing Environment features

- VB application wizard help in the entire network of the application.
- Add-In manager allows loading add-in only for a section or loading it whenever VB is started.

- Class Builder Utility that builds the classes for application.

Visual Basic Enterprise edition is most advanced edition and aimed at distributed applications. The changes in data access area and move towards ADO, VB 6.0 have been enhanced in many ways.

6.5.3 MS Access 2000

Microsoft Access 2000 offers many new and improved features to help you create powerful database applications. Microsoft Access provides an array of new and enhanced objects, methods, properties, functions, statements, data types and events to enable you to create powerful database application with Visual Basic.

ODBC Direct is a technology that enables you to work with ODBC database servers without loading the Microsoft jet database engine. ODBC Direct relies on the Microsoft DAO 3.5 object model, so that you can easily modify your existing DAO code to take advantage of ODBC Direct. Microsoft DAO 3.5 includes new objects, methods and properties to support ODBC Direct.

Designing a database, creating and customizing tables, queries, forms and reports and object browser and programming with Visual Basic.

6.5.3.1 Advanced Features Of Ms-Access

Microsoft Access 97 offers many new and improved features to help you create powerful database applications like.

- New objects, properties, methods, and other language elements.
- Accessing the Internet or an intranet from your application.
- Creating custom objects with class modules.
- Customizing menus and toolbars in your application.
- Removing source code from your application.
- Replicating only a specified part of a database.
- Working with version3.5 of the Microsoft jet database engine.
- Using new features in the module window.
- Using the object browser as a reference for objects and their numbers.
- Using DAO to access ODBC database without loading the Microsoft jet database engine.
- Creating a tabbed dialog box or multiple-page form with the tab control.
- Setting references programmatically.
- Using the enhanced debug window.
- Improving compilation performance

6.5.3.2 Data Types

Text: It is used to store text or combination of text and numbers that don't require calculations, such as phone number, pin code etc. This data type can store up to 255 characters.

Memo: It is used to store lengthy or combinations of text and numbers. It allows storing up to 65,535 numbers.

Number: It stores numbers from -32,768 to 32,7679 (No fractions) storage size of this field type is 2 bytes.

Data/time: This field is used to store data and time values. The field size of this data type is 8 bytes.

Currency: It is used to store currency values and numeric data used in mathematical calculations involving data with one to four decimal places. The field size of this data type is 8 types.

Auto Number: It is used to store a unique sequential number or random assigned by Microsoft Access. Whenever a new record is added to the table. Auto number field can't be updated. The Storage size of this data type is four bytes.

6.6 OPERATIONAL PERFORMANCE OF SOFTWARE

The software that being coded in order to switch the appropriate capacitor banks for compensating reactive power consumed consists of main form having three main menus namely

- Settings
- View data.
- Exit

6.6.1 Settings

Setting menu in our software has three main submenus, which are helping the user to select the type of operation they want the system to perform at a particular instant of time. The various submenus, which are functionally called in by, the users are

- Windmills.
- Capacitor banks.
- Power factor improvement.

When the user activates the **'Windmill'** submenu, two modes namely automatic and manual appears on the screen. The user has to select any one of the modes. Depending upon the mode the user has selected the windmill is made to operate. If the user selects the manual mode, then the address of the windmill whose reactive power is to be compensated by switching the capacitor banks are to be connected or disconnected depending upon the type of compensation. In turn if the user has his/her choice over the automatic mode then there is no need for typing the address and by taking into account the concept of time sharing the software monitors the operation of all windmills connected to them by providing a certain time delay. Windmills are given addresses like 1,2,3,4,5,e.t.c. The ports trap the data's that are keyed in and the corresponding data bits are shown in their respective port addresses.

After the mode of operation is being selected the data's are obtained from the microprocessor are got in through the ports and they can also be keyed in using keyboard. When each value is entered the value numbers and their corresponding port addresses are shown. Also the nature of current and voltage pulses for the particular data's are got and these data's also indicate whether the power factor we get is leading or lagging. Here the power factor with a negative prefix is treated as leading and vice versa.

6.6.2 Capacitor bank

This option is used for adding or deleting capacitor units in future which is normally found to depend on the various factors under considerations like wind velocity, operation of WEGs, utility of capacitor banks. Additional capacitor banks are added in case user feels that instead of having a larger value of kVAR like 100 kVAR as a whole, user can split them into smaller values so that the user can use them at the time of leading power factors. This feature of software mainly reduces the burden on the user, as there is no need for changing the assembly language program in case of any change in capacitor banks value.

6.6.3 Power factor improvement

This eases the process of calculating the compensation that is required for overcoming the reactive power consumption in windmills. A chart is been provided and the system checks for the power factor of windmill and the power factor specified by the user. A multiplication factor is being specified and accordingly the capacitor banks are selected by multiplying this multiplication factor as specified in the formula.

The next menu is the **'View data', which** has a database that holds information about the previous days, months, and year's data. It has totally four options. When one option is enabled the others are disenabled. The first option shows all data's including voltage, current, power factor, frequency, active power generated, apparent power, capacitance, compensation required and the date/time when these data's were keyed in.

The next option gives details regarding that are to be recovered between specified periods of time. The third option is used for finding the maximum value of reactive power consumed over a specific period of time. The last and the final option are used for removing the data's from the database.

When the capacitor banks are connected the first sixteen bits are displayed in one color to show their higher level and if the capacitor is disconnected the display has some other color to denote that it is a lower order bit. The last menu is used for exiting the software.

The values that are obtained are used for calculating the time taken and the phase angle. Thus these values are useful in calculating the compensation that is required.

6.7 HALLMARKS OF THE SOFTWARE

- User friendly.
- Highly reliable.
- Time consumption for switching over the capacitor is less.
- Over compensation is given due importance.
- Compensation is provided for more number of windmills.

6.8 SOFTWARE DETAILS

The following pages gives the details about the

- ✓ The general block diagram
- ✓ Flow charts
- ✓ Sample forms
- ✓ Sample codes

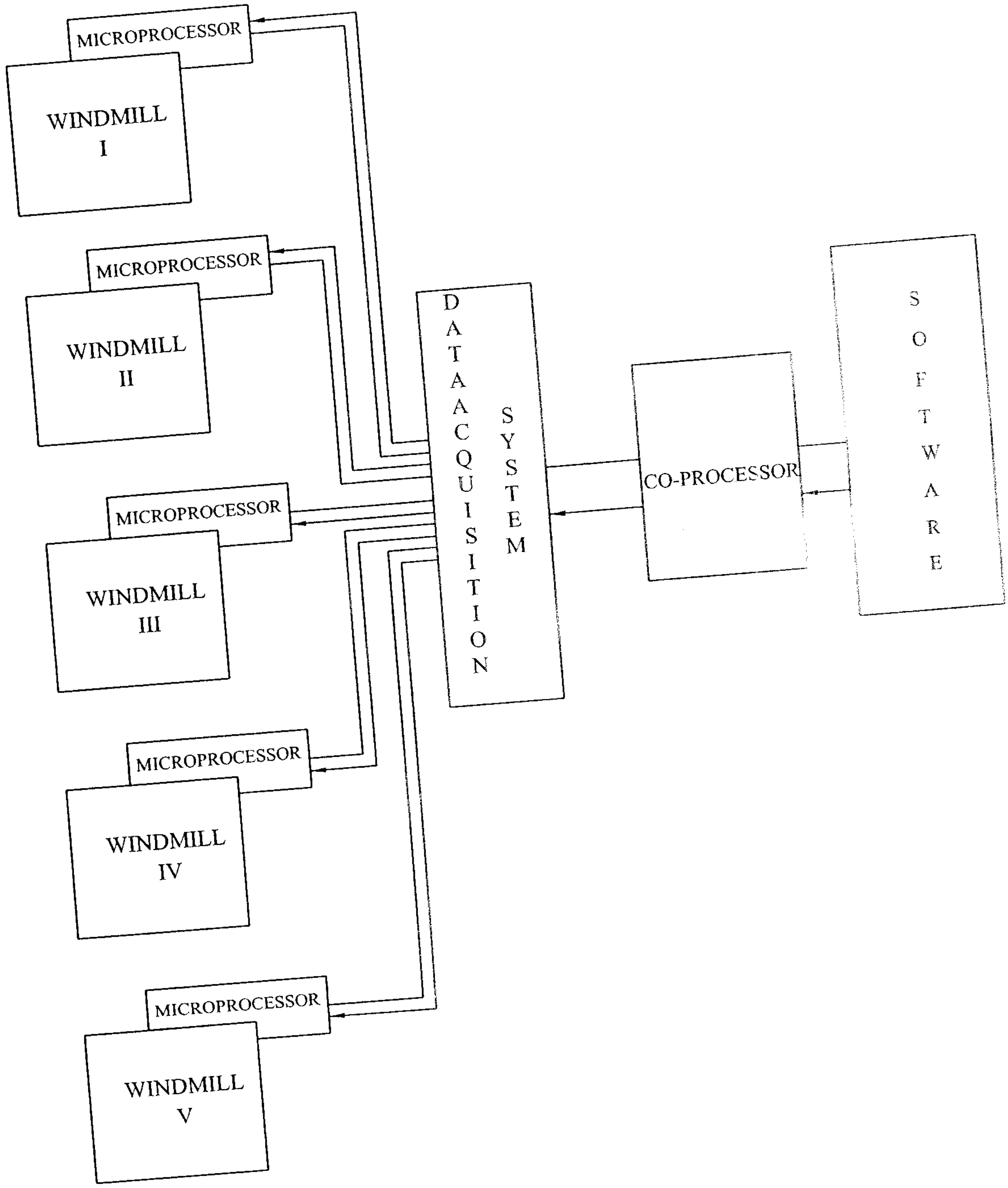
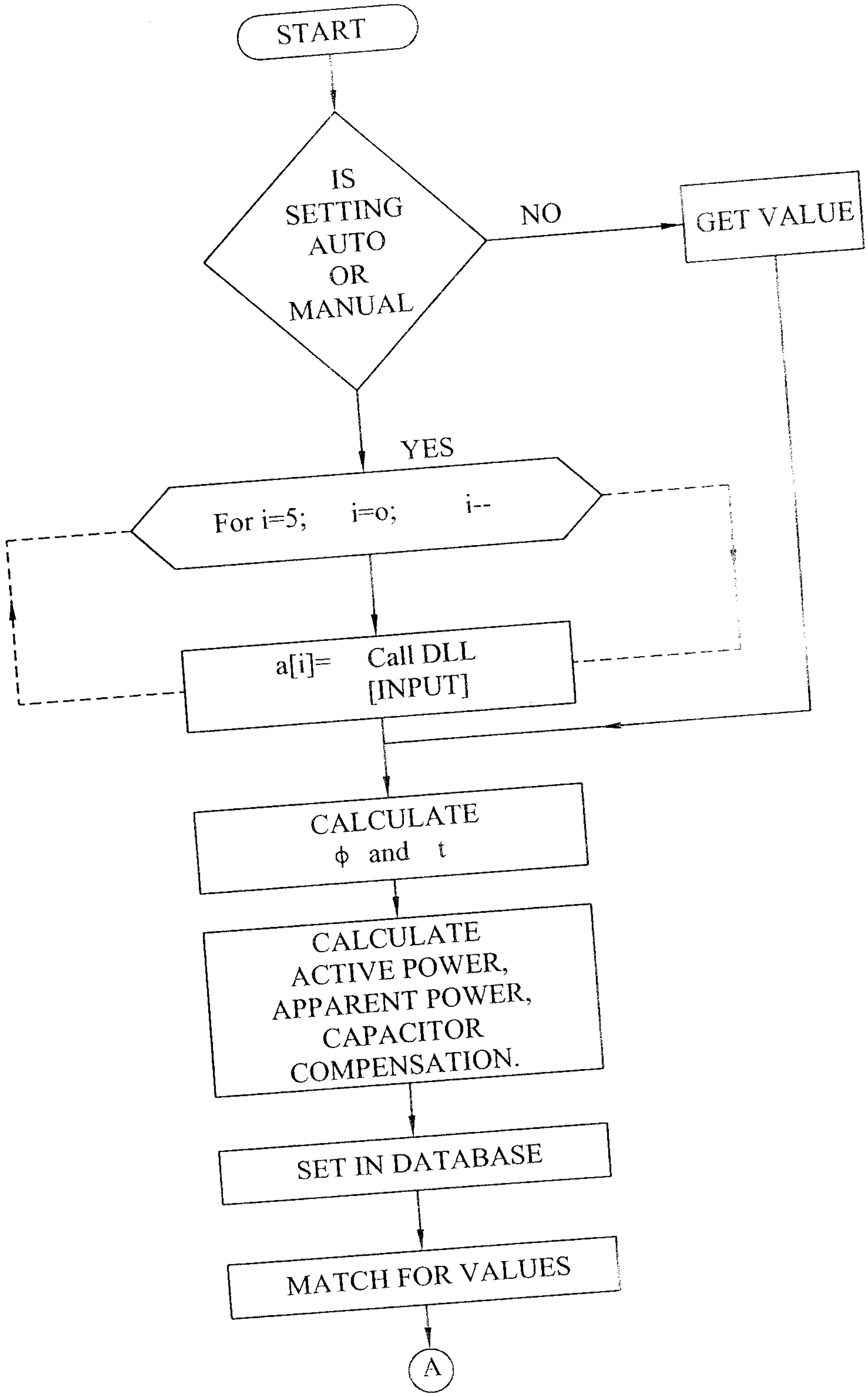
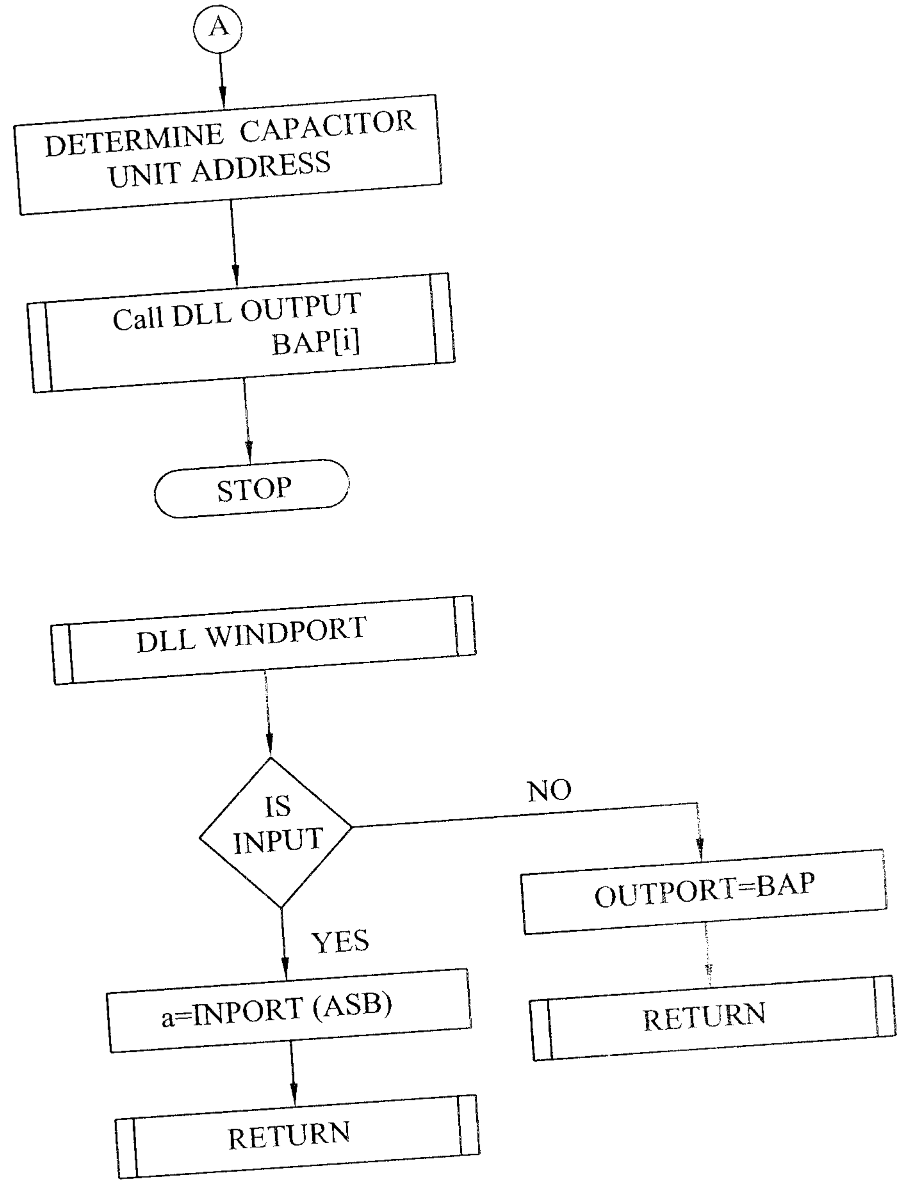
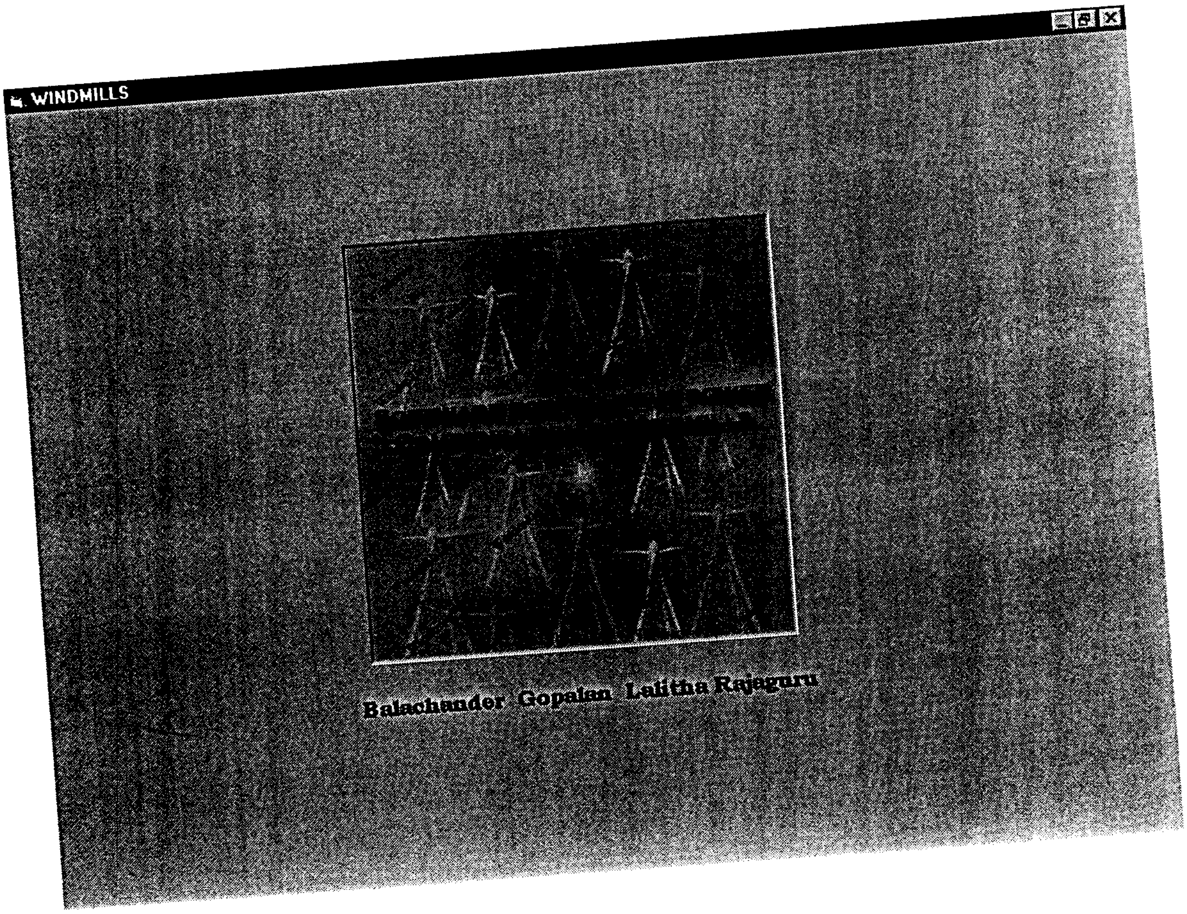


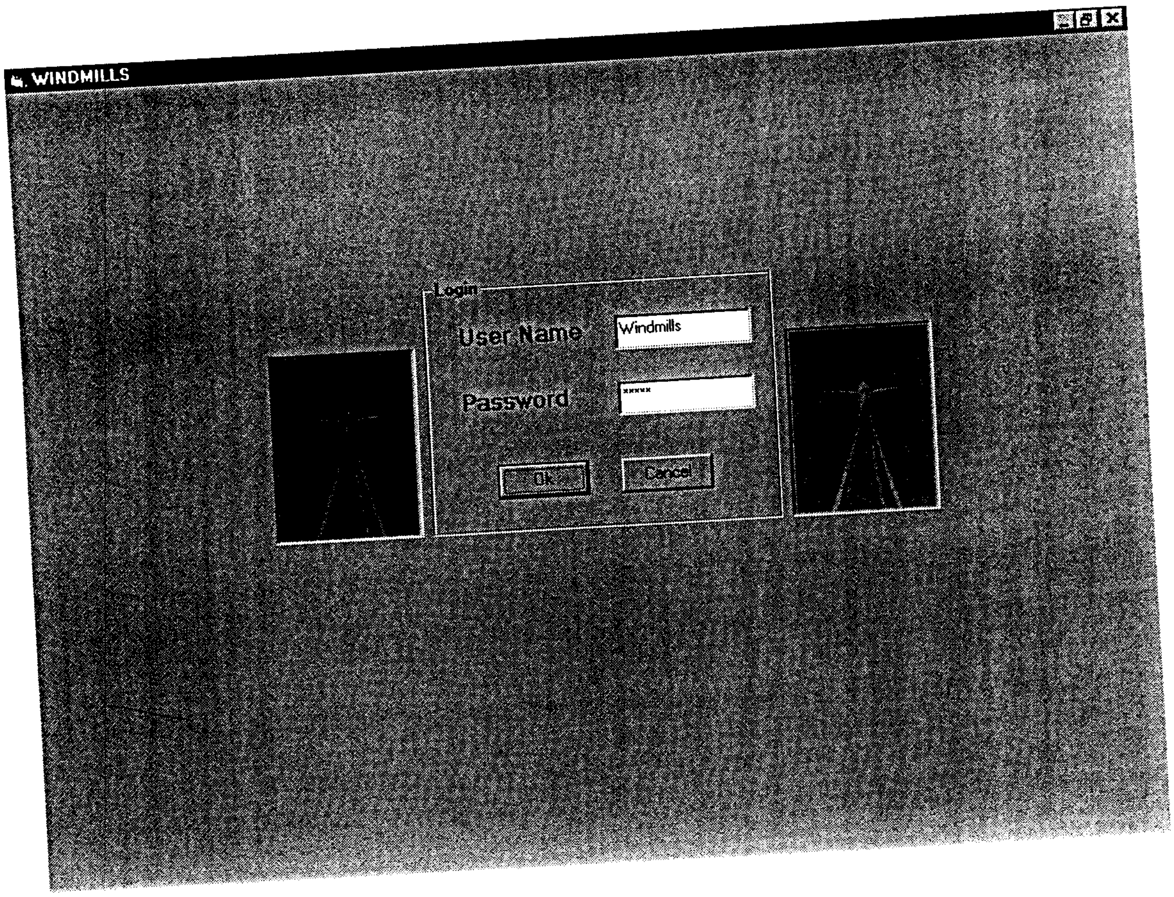
FIG 6.1 GENERAL BLOCK DIGRAM

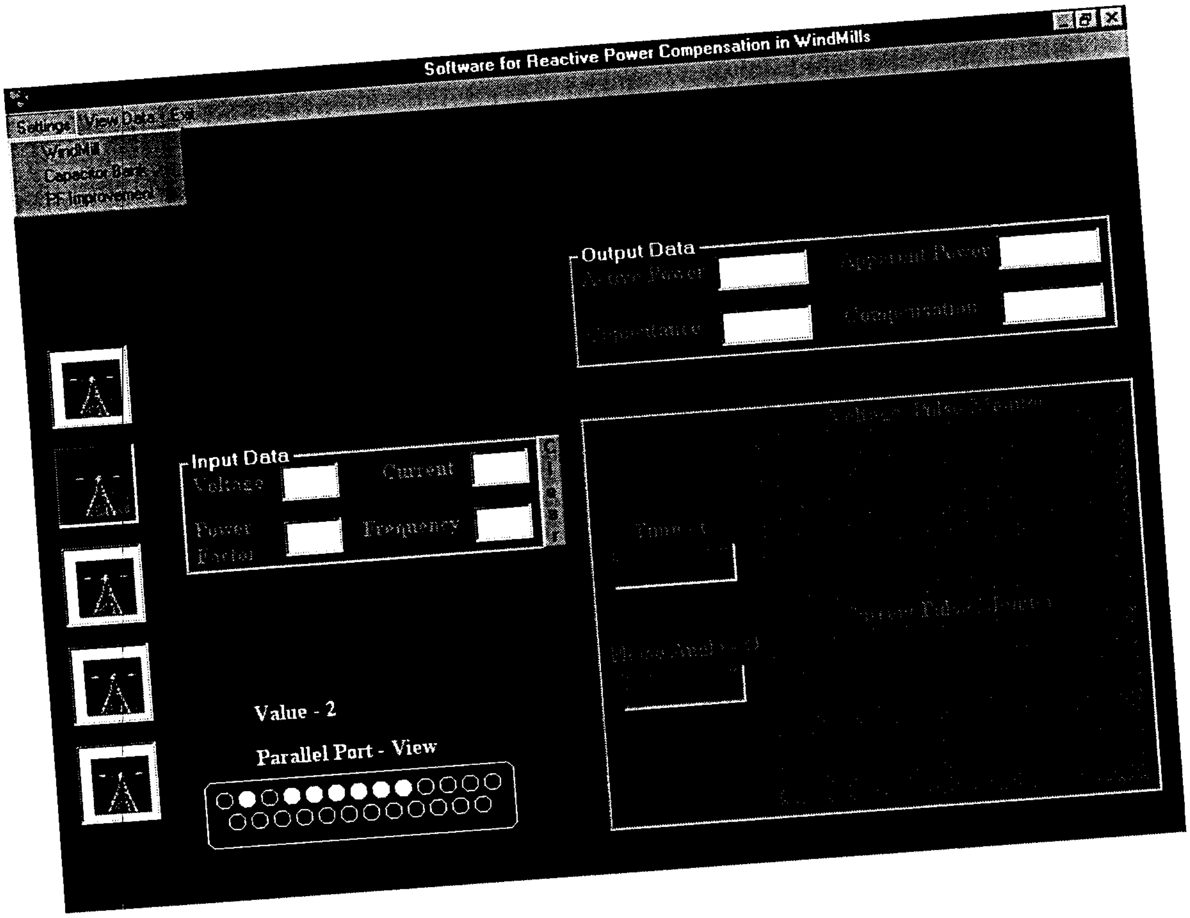
FLOW CHART


START
IS SETTING AUTO OR MANUAL
NO
GET VALUE
YES
For i=5; i=o; i--
a[i]= Call DLL [INPUT]
CALCULATE ϕ and t
CALCULATE ACTIVE POWER, APPARENT POWER, CAPACITOR COMPENSATION.
SET IN DATABASE
MATCH FOR VALUES
A

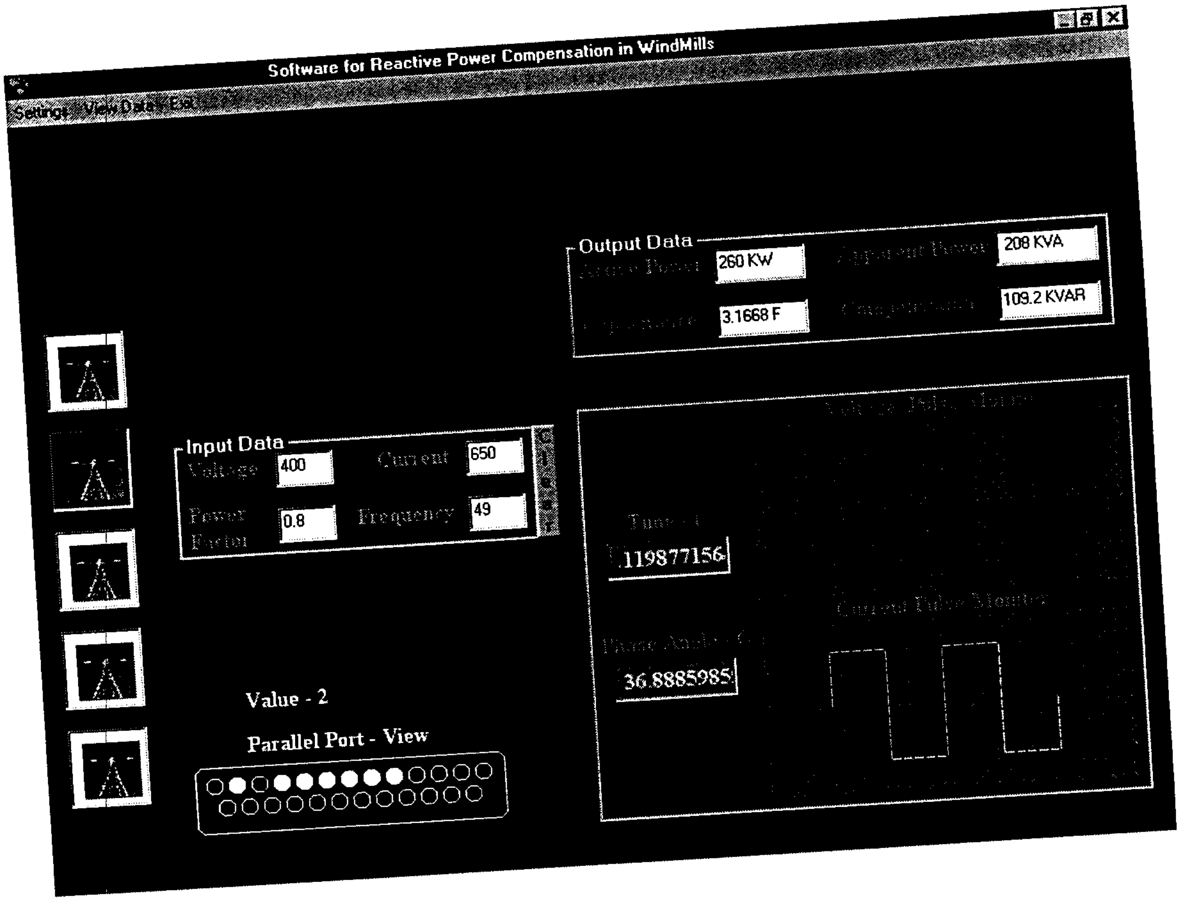

A
DETERMINE CAPACITOR UNIT ADDRESS
Call DLL OUTPUT BAP[i]
STOP
DLL WINDPORT
IS INPUT
NO
YES
OUTPORT=BAP
RETURN
a=INPORT (ASB)
RETURN

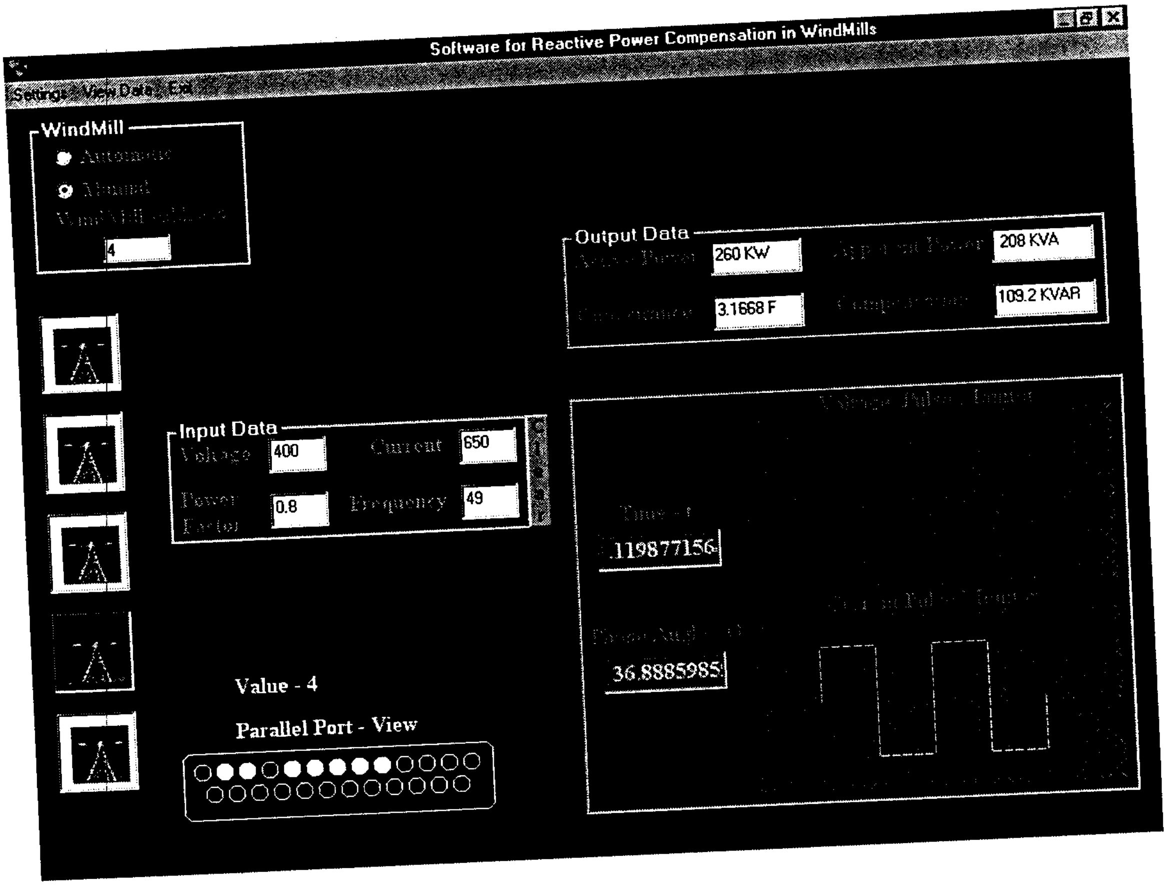

WINDMILLS
Balachander Gopalan Lalitha Rajaguru


WINDMILLS
Login
User Name
Windmills
Password
Ok
Cancel

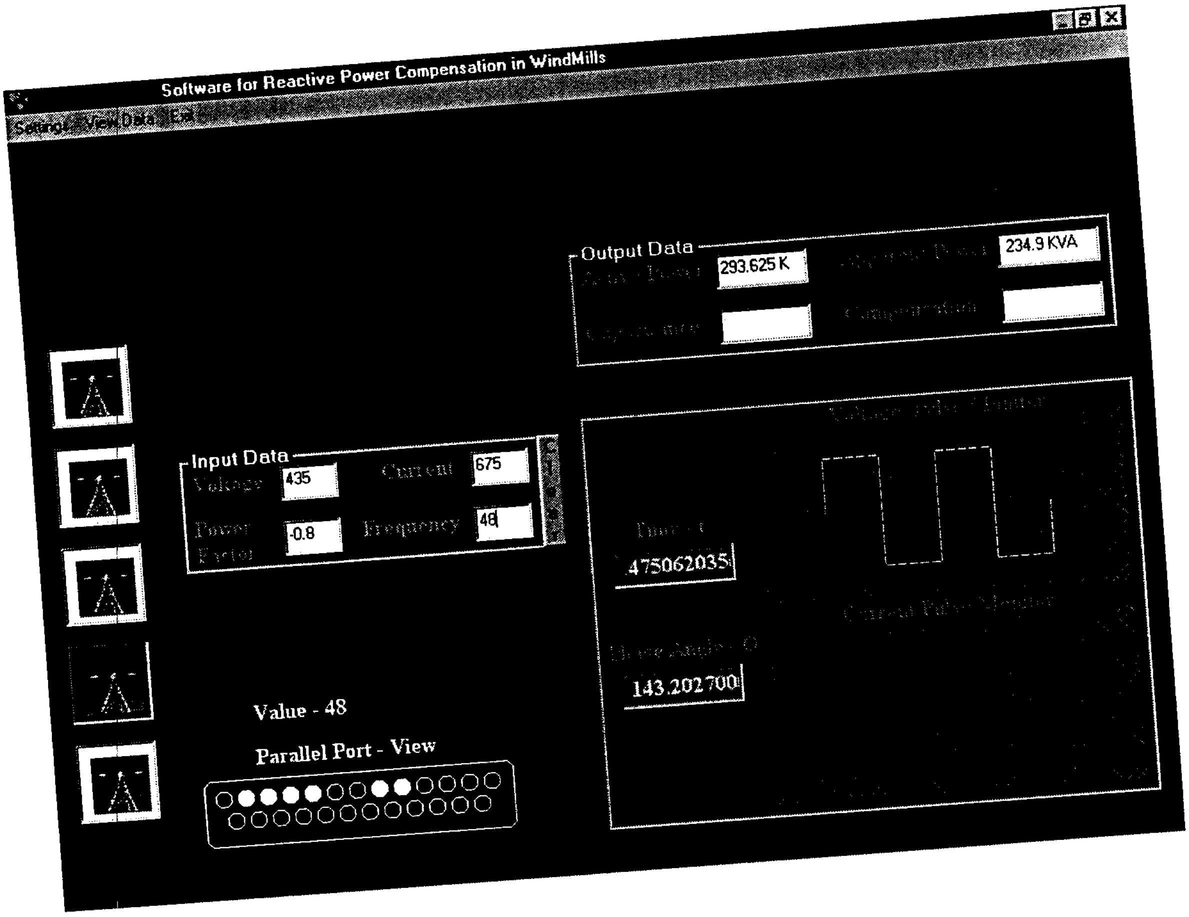


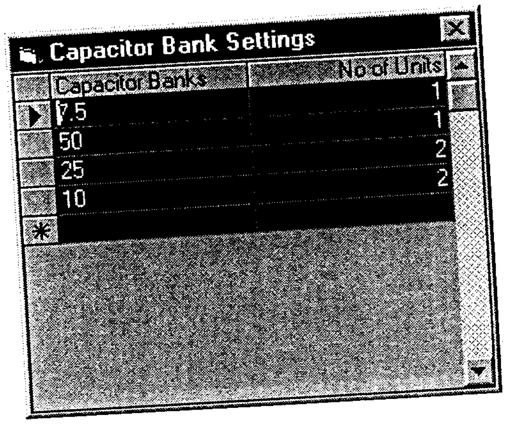
Software for Reactive Power Compensation in WindMills
Settings
WindMill
Capacitor Bank
PF Improvement
Output Data
Input Data
Voltage
Current
Power Factor
Frequency
Value - 2
Parallel Port - View


Software for Reactive Power Compensation in WindMills
Output Data
260 KW
208 KVA
3.1668 F
109.2 KVAR
Input Data
400
Current
650
Power Factor
0.8
Frequency
49
.119877156
36.8885985
Value - 2
Parallel Port - View



Software for Reactive Power Compensation in WindMills
WindMill
4
Output Data
260 KW
208 KVA
3.1668 F
109.2 KVAR
Input Data
400
Current
650
0.8
Frequency
49
.119877156
36.8885985
Value - 4
Parallel Port - View

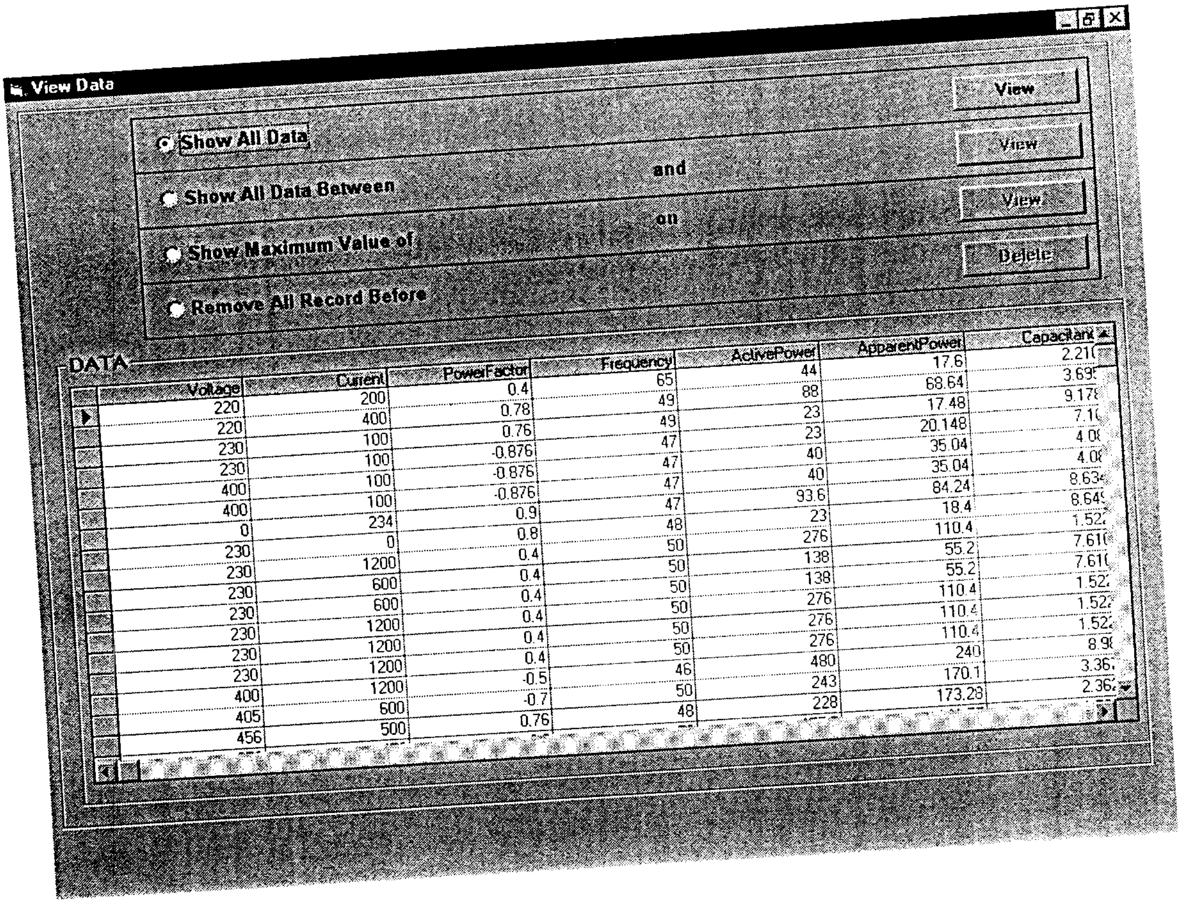

Software for Reactive Power Compensation in WindMills
Output Data
293.625 K
234.9 KVA
Input Data
435
Current
675
-0.8
Frequency
48
475062035
143.202700
Value - 48
Parallel Port - View

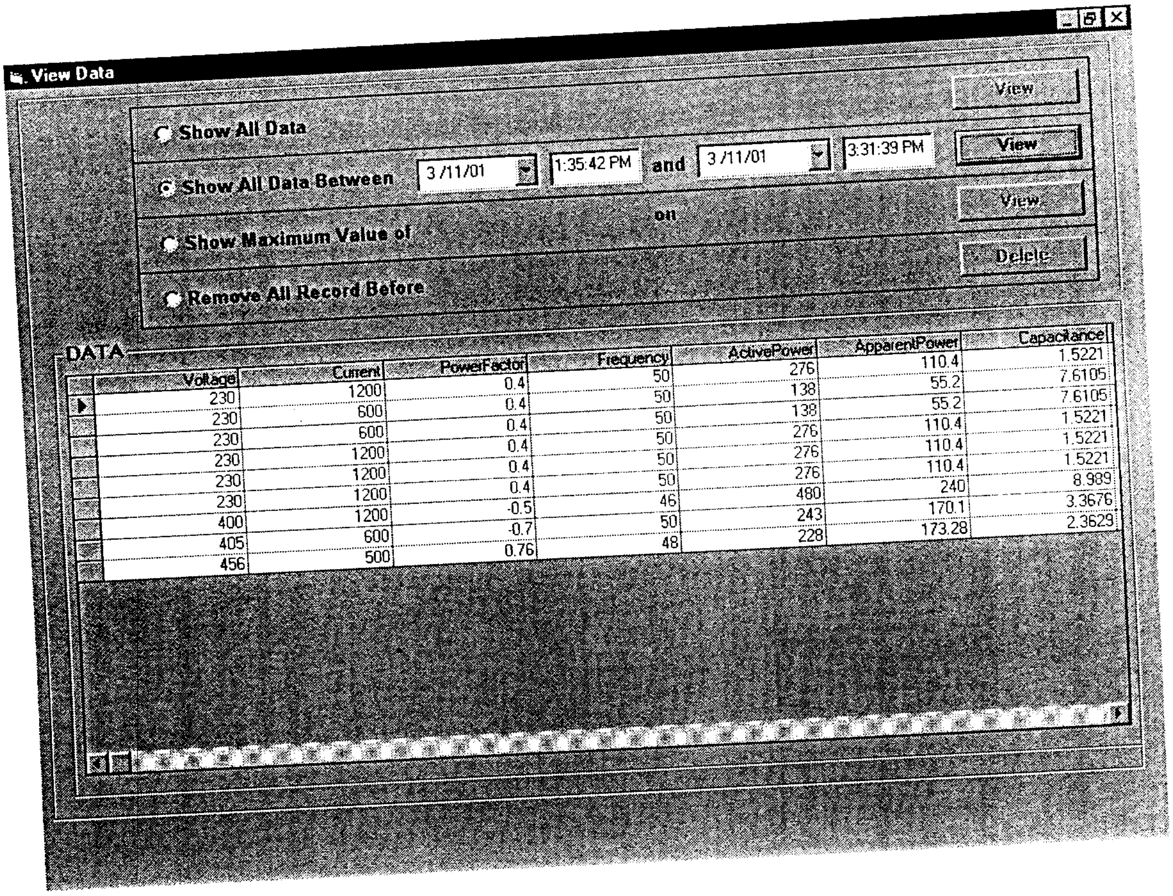

Capacitor Bank Settings
Capacitor Banks
No of Units
7.5
1
50
1
25
2
10
2

Power Factor Improvement Table

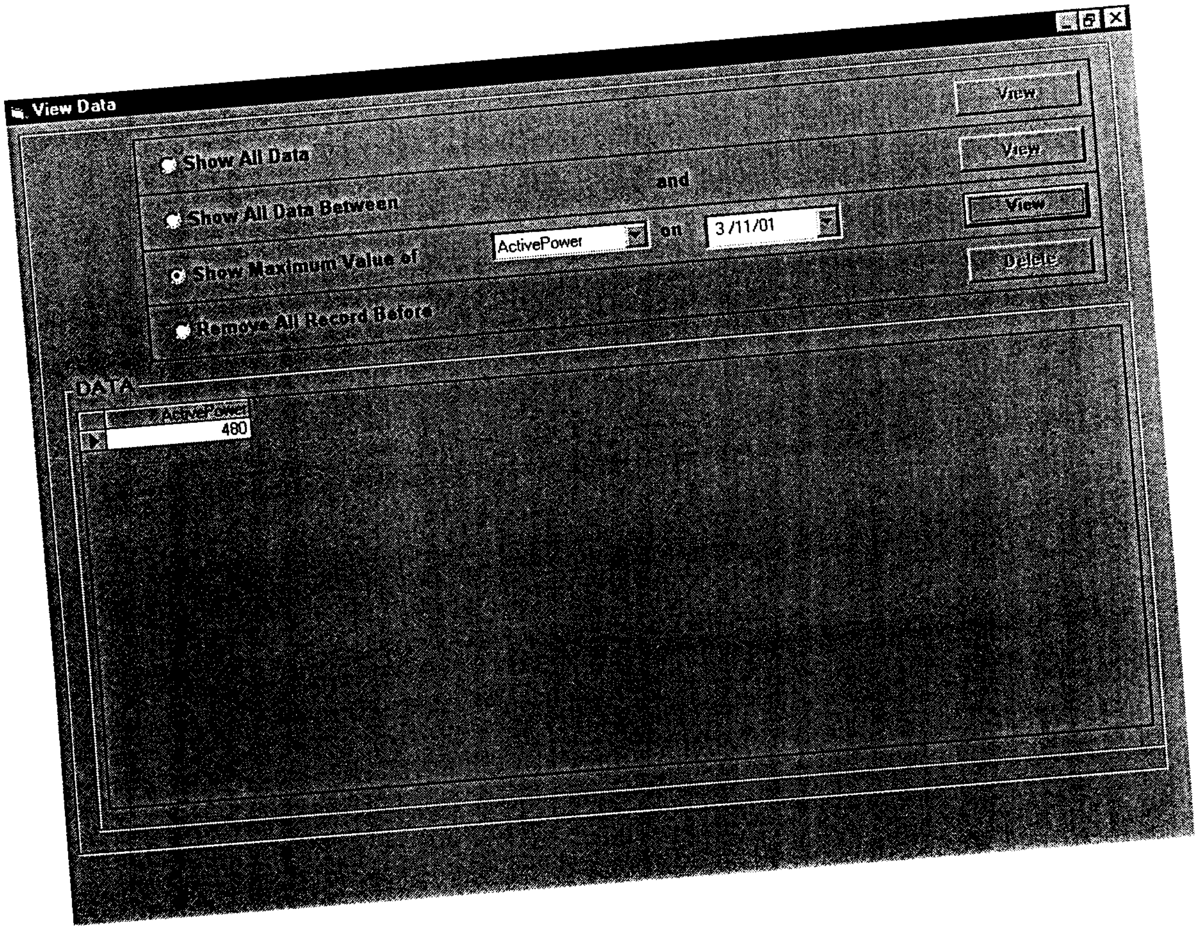
PF	0.85	0.90	0.95	0.98	1.0
0.3	1.9	2.23	2.42	2.56	2.78
0.35	1.78	2.05	2.28	2.39	2.57
0.4	1.67	1.8	1.96	2.08	2.29
0.45	1.36	1.5	1.66	1.78	1.99
0.5	1.11	1.25	1.4	1.53	1.73
0.55	0.9	1.03	1.19	1.32	1.52
0.6	0.71	0.85	1	1.13	1.33
0.65	0.55	0.68	0.84	0.97	1.17
0.7	0.4	0.54	0.69	0.81	1.02
0.75	0.26	0.4	0.55	0.67	0.88
0.8	0.13	0.27	0.42	0.54	0.75
0.85	0	0.14	0.29	0.42	0.62
0.9	0	0	0.15	0.28	0.48

Click Column To Select Capacitor To Improve Power Factor


View Data
Show All Data
Show All Data Between
and
Show Maximum Value of
on
Remove All Record Before
View
View
View
Delete
DATA
Voltage Current PowerFactor Frequency ActivePower ApparentPower Capacitan
220 200 0.4 65 44 17.6 2.21
220 400 0.78 49 88 68.64 3.69
230 100 0.76 49 23 17.48 9.17
230 100 -0.876 47 23 20.148 7.1
400 100 -0.876 47 40 35.04 4.0
400 100 -0.876 47 40 35.04 4.0
0 234 0.9 47 93.6 84.24 8.63
230 0 0.8 48 23 18.4 8.64
230 1200 0.4 50 276 110.4 1.52
230 600 0.4 50 138 55.2 7.61
230 600 0.4 50 138 55.2 7.61
230 1200 0.4 50 276 110.4 1.52
230 1200 0.4 50 276 110.4 1.52
230 1200 0.4 50 276 110.4 1.52
400 1200 0.4 50 480 240 8.9
405 600 -0.5 46 243 170.1 3.36
456 500 -0.7 50 228 173.28 2.36



Voltage	Current	PowerFactor	Frequency	ActivePower	ApparentPower	Capacitance
230	1200	0.4	50	276	110.4	1.5221
230	600	0.4	50	138	55.2	7.6105
230	600	0.4	50	138	55.2	7.6105
230	1200	0.4	50	276	110.4	1.5221
230	1200	0.4	50	276	110.4	1.5221
230	1200	0.4	50	276	110.4	1.5221
400	1200	-0.5	46	480	240	8.989
405	600	-0.7	50	243	170.1	3.3676
456	500	0.76	48	228	173.28	2.3629


View Data
View
View
View
Delete
Show All Data
Show All Data Between
and
Show Maximum Value of
ActivePower
on
3/11/01
Remove All Record Before
DATA
ActivePower
480

SAMPLE CODE

Front screen

```
Dim flag As Boolean
Private Sub Form_Load()
Form2.WindowState = 2
Vi = True
End Sub

Private Sub Picture1_DblClick()
Form2.Hide
Form3.Show
End Sub

Private Sub Timer1_Timer()
If flag = True Then
Heading.FontBold = True
flag = False
Else
flag = True
Heading.FontBold = False
End If
End Sub
```

Login Screen

```
Dim res As VbMsgBoxResult
Private Sub Command1_Click()
If Text1.Text = "Windmills" Then
  If Text2.Text = "power" Then
    Form3.Hide
    Rpc.Show
  Else
    MsgBox ("Invalid Password!")
  End If
Else
  MsgBox ("Invalid User entry!")
End If
End Sub

Private Sub Command2_Click()
res = MsgBox("Do you want to quit the system?", vbOKCancel, "Exit system")
If res = vbOK Then
  End
End If
End Sub

Private Sub Command3_Click()
Form3.Hide
Form2.Show
End Sub

Private Sub Form_Load()
Form3.WindowState = 2
End Sub

Private Sub Picture1_Click()
Form3.Hide
Form2.Show
End Sub

Private Sub Picture2_Click()
Form3.Hide
Form2.Show
End Sub
```

Reactive Power Compensation

```
Private Declare Function SetPixel Lib "gdi32" (ByVal hdc As Long, ByVal X As
Long, ByVal Y As Long, ByVal crColor As Long) As Long
Private Declare Sub Sleep Lib "kernel32" (ByVal dwMilliseconds As Long)
Dim WmId As Long
Dim BArr(15) As Long
Dim Wp As Long
Dim Wpt As Long
Dim PffG As String
Dim Vc As Long
Dim Ic As Long
Dim Sp As Long
Dim wi, hi As Long
Dim Xc As Long
Dim Yc As Long
Dim w, h As Long
Dim wi1, hi1 As Long
Dim Xc1 As Long
Dim Yc1 As Long
Dim w1, h1 As Long
Dim Cap(228) As String
Dim Ci As Long
Dim Sc As Long
Dim Tleft As Double
Dim Ttop As Double
Dim Tleft1 As Double
Dim Ttop1 As Double
Dim db As Database
Dim rs As Recordset
Dim db1 As Database
Dim rs1 As Recordset


Private Sub Command1_Click()
Picture1.Picture = LoadPicture()
Picture1.Refresh
Picture2.Picture = LoadPicture()
Picture2.Refresh
If Mid$(Text1(2).Text, 1, 1) = "-" Then
If Wpt <> 0 Then Label10.Caption = "Leading Power Factor": Label10.Refresh ':
Label16.Caption = "Capacitor Disconnect": Label16.Refresh
Picture1.Left = Tleft1
Picture1.Top = Ttop1
Picture2.Left = Tleft
Picture2.Top = Ttop
Else
```

```
Label10.Caption = "Lagging Power Factor": Label10.Refresh ': Label16.Caption =
"Capacitor Connect": Label16.Refresh
Picture1.Left = Tleft
Picture1.Top = Ttop
Picture2.Left = Tleft1
Picture2.Top = Ttop1
End If
Xc = 1
wi = 40
hi = 81
lw = wi
'lh = hi
lh = 64
Xc1 = 1
wi1 = 40
hi1 = 81
lw1 = wi1 + (Wpt * 4)
'lh1 = hi1
lh1 = 64

Do While (Xc <= 9)
If Xc = 1 Then
    w = lw
    h = lh
    For i = 1 To hi - 40
        For j = 0 To 30000: Next j
        lh = h - i
        SetPixel Picture1.hdc, lw, lh, vbBlack
        Picture1.Refresh
    Next i
    Xc = Xc + 1
  End If
    If Xc1 = 1 Then
        w1 = lw1
        h1 = lh1
        For i = 1 To hi1 - 40
            For j = 0 To 30000: Next j
            lh1 = h1 - i
            SetPixel Picture2.hdc, lw1, lh1, vbWhite
            Picture2.Refresh
        Next i
        Xc1 = Xc1 + 1
    End If
  If Xc = 2 Then
      w = lw
      h = lh
      For i = 1 To wi
          For j = 0 To 30000: Next j
          lw = w + i
          SetPixel Picture1.hdc, lw, lh, vbBlack
```

```
        Picture1.Refresh
    Next i
    Xc = Xc + 1
End If
    If Xc1 = 2 Then
        w1 = lw1
        h1 = lh1
        For i = 1 To wi1
            For j = 0 To 30000: Next j
            lw1 = w1 + i
            SetPixel Picture2.hdc, lw1, lh1, vbWhite
            Picture2.Refresh
        Next i
        Xc1 = Xc1 + 1
    End If
If Xc = 3 Then
    w = lw
    h = lh
    For i = 1 To 2 * wi
        For j = 0 To 30000: Next j
        lh = h + i
        SetPixel Picture1.hdc, lw, lh, vbBlack
        Picture1.Refresh
    Next i
    Xc = Xc + 1
End If
If Xc1 = 3 Then
        w1 = lw1
        h1 = lh1
        For i = 1 To 2 * wi1
            For j = 0 To 30000: Next j
            lh1 = h1 + i
            SetPixel Picture2.hdc, lw1, lh1, vbWhite
            Picture2.Refresh
        Next i
        Xc1 = Xc1 + 1
    End If
If Xc = 4 Then
    w = lw
    h = lh
    For i = 1 To wi
        For j = 0 To 30000: Next j
        lw = w + i
        SetPixel Picture1.hdc, lw, lh, vbBlack
        Picture1.Refresh
    Next i
    Xc = Xc + 1
End If
    If Xc1 = 4 Then
        w1 = lw1
```

```
        h1 = lh1
        For i = 1 To wi1
            For j = 0 To 30000: Next j
            lw1 = w1 + i
            SetPixel Picture2.hdc, lw1, lh1, vbWhite
            Picture2.Refresh
        Next i
        Xc1 = Xc1 + 1
    End If
If Xc = 5 Then
    w = lw
    h = lh
    For i = 1 To 2 * wi
        For j = 0 To 30000: Next j
        lh = h - i
        SetPixel Picture1.hdc, lw, lh, vbBlack
        Picture1.Refresh
    Next i
    Xc = Xc + 1
End If
If Xc1 = 5 Then
        w1 = lw1
        h1 = lh1
        For i = 1 To 2 * wi1
            For j = 0 To 30000: Next j
            lh1 = h1 - i
            SetPixel Picture2.hdc, lw1, lh1, vbWhite
            Picture2.Refresh
        Next i
        Xc1 = Xc1 + 1
    End If
If Xc = 6 Then
    w = lw
    h = lh
    For i = 1 To wi
        For j = 0 To 30000: Next j
        lw = w + i
        SetPixel Picture1.hdc, lw, lh, vbBlack
        Picture1.Refresh
    Next i
    Xc = Xc + 1
End If
    If Xc1 = 6 Then
        w1 = lw1
        h1 = lh1
        For i = 1 To wi1
            For j = 0 To 30000: Next j
            lw1 = w1 + i
            SetPixel Picture2.hdc, lw1, lh1, vbWhite
            Picture2.Refresh
```

```
        Next i
        Xc1 = Xc1 + 1
    End If
If Xc = 7 Then
    w = lw
    h = lh
    For i = 1 To 2 * wi
        For j = 0 To 30000: Next j
        lh = h + i
        SetPixel Picture1.hdc, lw, lh, vbBlack
        Picture1.Refresh
    Next i
    Xc = Xc + 1
End If
    If Xc1 = 7 Then
        w1 = lw1
        h1 = lh1
        For i = 1 To 2 * wi1
            For j = 0 To 30000: Next j
            lh1 = h1 + i
            SetPixel Picture2.hdc, lw1, lh1, vbWhite
            Picture2.Refresh
        Next i
        Xc1 = Xc1 + 1
    End If
If Xc = 8 Then
    w = lw
    h = lh
    For i = 1 To wi
        For j = 0 To 30000: Next j
        lw = w + i
        SetPixel Picture1.hdc, lw, lh, vbBlack
        Picture1.Refresh
    Next i
    Xc = Xc + 1
End If
    If Xc1 = 8 Then
        w1 = lw1
        h1 = lh1
        For i = 1 To wi1
            For j = 0 To 30000: Next j
            lw1 = w1 + i
            SetPixel Picture2.hdc, lw1, lh1, vbWhite
            Picture2.Refresh
        Next i
        Xc1 = Xc1 + 1
    End If
If Xc = 9 Then
    w = lw
    h = lh
```

```
For i = 1 To wi
    For j = 0 To 30000: Next j
    lh = h - i
    SetPixel Picture1.hdc, lw, lh, vbBlack
    Picture1.Refresh
  Next i
  Xc = Xc + 1
End If
  If Xc1 = 9 Then
      w1 = lw1
      h1 = lh1
      For i = 1 To wi1
          For j = 0 To 30000: Next j
          lh1 = h1 - i
          SetPixel Picture2.hdc, lw1, lh1, vbWhite
          Picture2.Refresh
      Next i
      Xc1 = Xc1 + 1
  End If
Loop
Picture1.Refresh
Label16.Caption = ""
End Sub

Private Sub Command2_Click()
For i = 0 To 3
Text1(i).Text = ""
Text4(i).Text = ""
Next
End Sub

Private Sub Form_Click()
If Option1(0).Value = True Then Timer2.Enabled = True
End Sub

Private Sub Form_Load()
Dim i As Long
Ci = 0
Sc = -1
Rpc.Show
For i = 1 To 53
Cap(i) = Mid$(Rpc.Caption, i, 1)
Next i
For i = 54 To 228
Cap(i) = " "
Next i
WmId = 0
'Line1.BorderColor = vbwhite
Option1(0).Value = True
Tleft = Picture1.Left
```

```
Ttop = Picture1.Top
Tleft1 = Picture2.Left
Ttop1 = Picture2.Top
PFImp = 0.95
ArBid = Bank.Data1.Recordset.RecordCount
'ReDim ArB(ArBid, 2) As Double
i = 1
Do While Not Bank.Data1.Recordset.EOF
    ArB(i, 0) = Val(Bank.Data1.Recordset.Fields(0))
    ArB(i, 1) = Val(Bank.Data1.Recordset.Fields(1))
    Bank.Data1.Recordset.MoveNext
    i = i + 1
Loop
Set db1 = OpenDatabase(App.Path & "\cap.mdb")
Set rs1 = db1.OpenRecordset("select * from data")
If rs1.RecordCount > 0 Then
rs1.MoveLast
End If
End Sub

Private Sub MnuCB_Click()
Bank.Show vbModal, Me
End Sub

Private Sub MnuE_Click()
End
End Sub

Private Sub MnuPFI_Click()
RpcPFdb.Show vbModal, Me
End Sub

Private Sub MnuWM_Click()
Frame3.Visible = True
End Sub

Private Sub Option1_Click(Index As Integer)
If Index = 1 Then
Timer2.Enabled = False
Text3.Enabled = True
Text3.Text = ""
Label9.Enabled = True
Else
Timer2.Enabled = True
Text3.Text = ""
Text3.Enabled = False
Label9.Enabled = False
Frame3.Visible = False
End If
End Sub
```

```
Private Sub Option1_GotFocus(Index As Integer)
If Index = 0 And Option1(0).Value = True Then Frame3.Visible = False
End Sub

Private Sub Text1_Click(Index As Integer)
If Option1(0).Value = True Then Timer2.Enabled = False
End Sub

Private Sub Text1_KeyPress(Index As Integer, KeyAscii As Integer)
If KeyAscii = 13 Then
    If Index <> 3 Then
        Text1(Index + 1).SetFocus
    End If
End If
If Index = 3 And KeyAscii = 13 Then
 If Not (Val(Text1(0).Text) > 324 And Val(Text1(0).Text) < 451) Then MsgBox
"Voltage Should be between the range 325 and 450.": Exit Sub
 If Not (Val(Text1(1).Text) > 399 And Val(Text1(1).Text) < 701) Then MsgBox
"Current Should be between the range 400 and 700.": Exit Sub
 If Not (Val(Text1(2).Text) > -1 And Val(Text1(2).Text) < 1) Then MsgBox "Power
Factor Should be between the range -1 and 1": Exit Sub
 If Not (Val(Text1(3).Text) > 46 And Val(Text1(3).Text) < 52) Then MsgBox
"Frequency should be between the range 47 and 51.": Exit Sub

 Label14.Caption = "Value - " & Text1(Index).Text
 Label14.Refresh
 Call address_cal(Val(Text1(Index).Text))
 Call calculation
 Exit Sub
 End If
 If KeyAscii = 45 Then
 If Not (Len(Trim(Text1(Index))) = 0 And KeyAscii = 45 And Index = 2) Then
 KeyAscii = 0
 Exit Sub
 End If

 If InStr(1, Text1(Index).Text, ".") > 0 And KeyAscii = 46 Then KeyAscii = 0: Exit
 Sub
 If Not ((KeyAscii >= 48 And KeyAscii <= 57) Or KeyAscii = 8 Or KeyAscii = 46 Or
 KeyAscii = 13) Then
 KeyAscii = 0
 MsgBox "Invalid Entry", vbInformation, "Rpc"
 End If
 If Len(Trim(Text1(Index).Text)) > 0 And KeyAscii = 13 Then
     If Index = 2 Then: Label14.Caption = "Value - " & Text1(Index).Text:
 Label14.Refresh: Call address_cal(Val(Text1(Index).Text) * 100): Exit Sub
     Label14.Caption = "Value - " & Text1(Index).Text
     Label14.Refresh
     Call address_cal(Val(Text1(Index).Text))
```

```
End If
End Sub

Private Sub calculation()
Dim X As Double
For i = 0 To 3
If Len(Trim(Text1(i).Text)) = 0 Then MsgBox "Enter All Values.": Exit Sub
Next i
If Val(Trim(Text1(2).Text)) > 1 Then: MsgBox "Invalid Data": Exit Sub
If Val(Trim(Text1(2).Text)) = 1 Then
Wpt = 0
Text2(1).Text = Str((180 * (Atn(-X / Sqr(-X * X + 1)) + 2 * Atn(1))) / 3.14)
Text2(0).Text = Str(CDbl(Text2(1).Text) / (2 * 3.14 * CDbl(Text1(3).Text)))
Text2(0).Refresh
Text2(1).Refresh
Label10.Caption = "Unity Power Factor"
Call Command1_Click
Output_Data
Label10.Caption = ""
If Option1(0).Value = True Then Timer2.Enabled = True
GoTo 40
End If
If InStr(1, Text1(2).Text, ".") > 0 Then
PffG = Mid$(Text1(2).Text, InStr(1, Text1(2).Text, ".") + 1, 1)
Wpt = 10 - Val(PffG)
X = CDbl(Text1(2).Text)
Text2(1).Text = Str((180 * (Atn(-X / Sqr(-X * X + 1)) + 2 * Atn(1))) / 3.14)
Text2(0).Text = Str(CDbl(Text2(1).Text) / (2 * 3.14 * CDbl(Text1(3).Text)))
Text2(0).Refresh
Text2(1).Refresh
Call Command1_Click
Label10.Caption = ""
Output_Data
If Option1(0).Value = True Then Timer2.Enabled = True
'For I = 0 To 5
'Shape2(I).Left = 40 + (Wpt * 4)
'Next I
'Shape1(0).Visible = True
'Timer1.Enabled = True
'Vc = 0
'Ic = -1
End If
40:
End Sub

Private Sub Text3_KeyPress(KeyAscii As Integer)
If KeyAscii = 13 Then
Text1(0).SetFocus
End If
If KeyAscii = 13 And Len(Trim(Text3)) > 0 Then
```

```
For i = 0 To 4
If Val(Text3.Text) - 1 = i Then
    Picture3(i).BackColor = vbRed
Else
    Picture3(i).BackColor = vbWhite
End If
Next i
WmId = Val(Text3.Text)
Label14.Caption = "Value - " & Text3.Text
Label14.Refresh
Call address_cal(Val(Text3.Text))
Frame3.Visible = False
Exit Sub
End If
If Not ((KeyAscii >= 49 And KeyAscii <= 53) Or KeyAscii = 8 Or KeyAscii = 13)
Then
KeyAscii = 0
MsgBox "Invalid Entry", vbInformation, "Rpc"
End If
End Sub
Private Sub address_cal(Tint As Long)
On Error Resume Next
Dim i, j As Long
Dim Quo, Remi As Long
Quo = Tint
If Quo = 0 Then GoTo 10
j = 15
For i = 0 To 15
BArr(i) = 0
Next i
If Quo = 1 Then BArr(15) = 1: GoTo 10
Do While Quo > 1
    BArr(j) = Quo Mod 2
    Quo = Quo \ 2
    j = j - 1
Loop
If Quo = 1 Then BArr(j) = Quo
10: For i = 1 To 8
Shape5(i).FillColor = vbWhite
Shape5(i).Refresh
Next i
For i = 8 To 1 Step -1
   If BArr(7 + i) = 1 Then
        Shape5(9 - i).FillColor = vbRed
   Else
        Shape5(9 - i).FillColor = vbWhite
   End If
   Shape5(i).Refresh
Next i
If Tint < 256 Then Exit Sub
```

```
'---- wait time
Sleep 2000
'----Second 8 bit
 For i = 1 To 8
Shape5(i).FillColor = vbWhite
Shape5(i).Refresh
Next i
 For i = 7 To 0 Step -1
   If BArr(i) = 1 Then
       Shape5(8 - i).FillColor = vbRed
   Else
       Shape5(8 - i).FillColor = vbWhite
   End If
   Shape5(i).Refresh
Next i
End Sub

Private Sub Timer2_Timer()
WmId = WmId + 1
If WmId > 5 Then WmId = 1
For i = 0 To 4
If WmId - 1 = i Then
Picture3(i).BackColor = vbRed
Else
Picture3(i).BackColor = vbWhite
End If
Next i
Label14.Caption = "Value - " & WmId
Label14.Refresh
Call address_cal(WmId)
End Sub
Private Sub Timer4_Timer()
Dim Tc As String
Dim tc1 As String
Dim j As Long
Ci = Ci + 1
If Ci > 228 Then Ci = 0: Exit Sub
If Ci <= 53 Then
    For j = Ci To 53
        Tc = Tc + Cap(j)
    Next j
    Rpc.Caption = Tc

End If
If Ci > 53 Then
    For j = 0 To 228 - Ci
    tc1 = tc1 + " "
    Next j
    For j = 1 To IIf((Ci > 100), 53, Ci - 53)
    Tc = Tc + Cap(j)
```

```
Next j
Rpc.Caption = tc1
Rpc.Caption = Rpc.Caption + Tc
End If
End Sub
Private Sub Output_Data()
Dim cn As Long
Dim D As Double
Dim C As Double
Dim Tpf As Double
Text4(0).Text = (Val(Text1(0).Text) * Val(Text1(1).Text)) / 1000
Text4(1).Text = Val(Text4(0).Text) * Val(Text1(2).Text)
Text4(2).Text = (Val(Text1(1).Text) / (2 * 3.14159 * Val(Text1(3).Text) *
Val(Text1(0).Text))) * Sqr(1 - (Val(Text1(2).Text) * Val(Text1(2).Text)))
Ic = Val(Text1(1).Text) * (Sqr(1 - (Val(Text1(2).Text) * Val(Text1(2).Text))))
Text4(0).Text = Text4(0).Text & " KW"
Text4(1).Text = Str(Abs(Val(Text4(1).Text))) & " KVA"
Text4(2).Text = Mid$(Text4(2).Text, 1, 6) & " F"
Tpf = Val(Text1(2).Text)
If Mid$(Text1(2).Text, 1, 1) = "-" Then
Label16.Caption = "Capacitor Disconnect": Label16.Refresh
Text4(2).Text = ""
Text4(2).Refresh
address_cal 0
Sleep 2000
Label16.Caption = ""
Exit Sub
Else
Label16.Caption = "Capacitor Connect": Label16.Refresh
address_cal 65535
End If

If Abs(Tpf) < 0.3 Then
    Label13.Caption = "Advisible To disconnect The WindMill " & WmId & " (Low
PF)"
    Sleep 300
    Label13.Caption = ""
    Sleep 300
    Label13.Caption = "Advisible To disconnect The WindMill " & WmId & " (Low
PF)"
    Sleep 300
    Label13.Caption = ""
    Sleep 300
    Label13.Caption = "Advisible To disconnect The WindMill " & WmId & " (Low
PF)"
    Sleep 400
    Label13.Caption = ""
    Sleep 300
    Label13.Caption = "Advisible To disconnect The WindMill " & WmId & " (Low
PF)"
```

```
    Sleep 400
    Label13.Caption = ""
    Exit Sub
End If
If Abs(Tpf) >= PFImp Then
Label13.Caption = "No compensation Required For WindMill " & WmId
    Sleep 300
    Label13.Caption = ""
    Sleep 300
    Label13.Caption = "No compensation Required For WindMill " & WmId
    Sleep 300
    Label13.Caption = ""
    Sleep 300
    Label13.Caption = "No compensation Required For WindMill " & WmId
    Sleep 400
    Label13.Caption = ""
    Sleep 300
    Label13.Caption = "No compensation Required For WindMill " & WmId
    Sleep 400
    Label13.Caption = ""
    Exit Sub
End If
Set db = OpenDatabase(App.Path & "\cap.mdb")
Set rs = db.OpenRecordset("select * from capacitor")
If PFImp = 0.85 Then cn = 1
If PFImp = 0.9 Then cn = 2
If PFImp = 0.95 Then cn = 3
If PFImp = 0.98 Then cn = 4
If PFImp = 1 Then cn = 5
rs.MoveFirst
D = Abs(rs.Fields(0) - Tpf)
C = rs.Fields(cn)
Do While Not rs.EOF
    If D > Abs(rs.Fields(0) - Tpf) Then
        C = rs.Fields(cn)
        D = Abs(rs.Fields(0) - Tpf)
    End If
rs.MoveNext
Loop
Text4(3).Text = C * Val(Text4(0).Text)
Text4(3).Text = Mid$(Text4(3).Text, 1, 6) & " KVAR"
'-------storing records-----
rs1.AddNew
For i = 0 To 3
rs1.Fields(i) = Val(Text1(i).Text)
Next i
'MsgBox (Text4(2).Text)
rs1.Fields(4) = Val(Text4(0).Text)
rs1.Fields(5) = Val(Text4(1).Text)
rs1.Fields(6) = Val(Text4(2).Text)
```

```
rs1.Fields(7) = Val(Text4(3).Text)
rs1.Fields(8) = Format(Now, "mm/dd/yy hh:mm:ss AMPM")
rs1.Update
'-------storing records-----
Call Bank_Cal
Label16.Caption = ""
End Sub
Private Sub Bank_Cal()
Dim Tcv As Double
Dim i, j, k As Long
Tcv = CInt(Val(Text4(3).Text))
Bank.Data1.RecordSource = "SELECT * from bank order by [capacitor banks]
desc"
Bank.Data1.Refresh
If Tcv < Bank.Data1.Recordset.Fields(0) Then
   Bpa(1, 0) = Bank.Data1.Recordset.Fields(0)
   Bpa(1, 1) = 1
   Call bank_cal_low
   Bpaid = 1
   GoTo 20
End If
'MsgBox Text4(3).Text
For i = 1 To ArBid
For j = 1 To ArB(i, 1)
If ArB(i, 0) * 1 < Tcv Then
   Bpa(i, 0) = ArB(i, 0)
   Bpa(i, 1) = j
   Tcv = Tcv - ArB(i, 0) * 1
ElseIf ArB(i, 0) * 1 = Tcv Then
   Bpa(i, 0) = ArB(i, 0)
   Bpa(i, 1) = j
   GoTo 10
ElseIf ArB(i, 0) * 1 > Tcv Then
   Bpa(i, 0) = ArB(i, 0)
   Bpa(i, 1) = j
   GoTo 10
End If
Next j
Next i
10:  If i > ArBid Then
   Bpaid = i - 1
Else
   Bpaid = i
End If
20: Select Case WmId

Case 1: k = 100
        For i = 1 To Bpaid
            For j = 1 To Bpa(i, 1)
                k = k + 1
```

```
            Label15.Caption = "Capacitor Bank " & Bpa(i, 0) & "KVAR"
            Label15.Refresh
            Label14.Caption = "Value - " & k
            Label14.Refresh
            Call address_cal(k)
            Sleep 1000
        Next j
    Next i
Case 2: k = 200
    For i = 1 To Bpaid
        For j = 1 To Bpa(i, 1)
            k = k + 1
            Label15.Caption = "Capacitor Bank " & Bpa(i, 0) & "KVAR"
            Label15.Refresh
            Label14.Caption = "Value - " & k
            Label14.Refresh
            Call address_cal(k)
            Sleep 1000
        Next j
    Next i
Case 3: k = 300
    For i = 1 To Bpaid
        For j = 1 To Bpa(i, 1)
            k = k + 1
            Label15.Caption = "Capacitor Bank " & Bpa(i, 0) & "KVAR"
            Label15.Refresh
            Label14.Caption = "Value - " & k
            Label14.Refresh
            Call address_cal(k)
            Sleep 1000
        Next j
    Next i
Case 4: k = 400
    For i = 1 To Bpaid
        For j = 1 To Bpa(i, 1)
            k = k + 1
            Label15.Caption = "Capacitor Bank " & Bpa(i, 0) & "KVAR"
            Label15.Refresh
            Label14.Caption = "Value - " & k
            Label14.Refresh
            Call address_cal(k)
            Sleep 1000
        Next j
    Next i
Case 5: k = 500
    For i = 1 To Bpaid
        For j = 1 To Bpa(i, 1)
            k = k + 1
            Label15.Caption = "Capacitor Bank " & Bpa(i, 0) & "KVAR"
            Label15.Refresh
```

```
            Label14.Caption = "Value - " & k
            Label14.Refresh
            Call address_cal(k)
            Sleep 1000
        Next j
    Next i
End Select
For i = 1 To 20
Bpa(i, 0) = 0
Bpa(i, 1) = 0
Next i
Label15.Caption = ""
End Sub
Private Sub bank_cal_low()
Dim i, j, k As Long
Tcv = CInt(Val(Text4(3).Text))
Bank.Data1.RecordSource = "SELECT * from bank order by [capacitor banks]
asc"
Bank.Data1.Refresh
Do While Not Bank.Data1.Recordset.EOF
   If Tcv <= Bank.Data1.Recordset.Fields(0) Then
   GoTo 100
   End If
Bank.Data1.Recordset.MoveNext
Loop
Exit Sub
100:
Bpa(1, 0) = Bank.Data1.Recordset.Fields(0)
Bpa(1, 1) = 1
End Sub

Private Sub Vdata_Click()
Form1.Show vbModal, Me
End Sub
```

Capacitor Bank

```
Private Sub Form_Load()
Data1.DatabaseName = App.Path & "\cap.mdb"
Data1.RecordSource = "Bank"
Data1.Refresh
DBGrid1.Refresh
End Sub

Private Sub Form_Unload(Cancel As Integer)
Dim i As Long
ArBid = Data1.Recordset.RecordCount
'ReDim ArB(ArBid, 2) As Double
i = 1
If Data1.Recordset.RecordCount > 0 Then Data1.Recordset.MoveFirst
Do While Not Data1.Recordset.EOF
    ArB(i, 0) = Val(Data1.Recordset.Fields(0))
    ArB(i, 1) = Val(Data1.Recordset.Fields(1))
    Data1.Recordset.MoveNext
    i = i + 1
Loop
End Sub
```

Improvement Table

```
Dim Vi As Boolean

Private Sub DBGrid1_HeadClick(ByVal ColIndex As Integer)
If ColIndex <> 0 Then
PFImp = Val(DBGrid1.Columns(ColIndex).Caption)
Rpc.MnuPFI.Caption = "PF Improvement - " & PFImp
End If
'MsgBox PFImp
End Sub

Private Sub Form_Load()
Data1.DatabaseName = App.Path & "\cap.mdb"
Data1.RecordSource = "capacitor"
Data1.Refresh
DBGrid1.Width = 9350
DBGrid1.Height = 3820
For i = 1 To 5
DBGrid1.Columns(i).AllowSizing = False
If i < 5 Then
DBGrid1.Columns(i).Caption = "0." & Mid$(Data1.Recordset.Fields(i).Name, 4,
2)
End If
If i = 5 Then DBGrid1.Columns(5).Caption = "1.0"
Next i
RpcPFdb.Width = DBGrid1.Width + 100
RpcPFdb.Height = DBGrid1.Height + 700 + 160
Label1.Top = DBGrid1.Height + 70
Vi = False
End Sub

Private Sub Timer1_Timer()
If Vi = False Then
Label1.Caption = ""
Vi = True
Else
Vi = False
Label1.Caption = "                              Click Column To Select Capacitor To
Improve Power Factor"
End If
End Sub
```

View Data

```
Private Sub Command1_Click()
Data1.RecordSource = "select * from data"
Data1.Refresh
DBGrid1.Refresh
End Sub

Private Sub Command2_Click()
Data1.RecordSource = "select * from data where rdate >=#" &
Format(DTPicker1.Value, "mm/dd/yy") & " " & Text1.Text & "# and rdate <=#" &
Format(DTPicker2.Value, "mm/dd/yy") & " " & Text2.Text & "#"
Data1.Refresh
DBGrid1.Refresh
End Sub

Private Sub Command3_Click()
Data1.RecordSource = "select max(" & Combo1.Text & ") from data where
rdate>=#" & Format(DTPicker3.Value, "mm/dd/yy") & "# and rdate <=#" &
Format(DTPicker3.Value, "mm/dd/yy") & " 11:59:00 PM#"
Data1.Refresh
DBGrid1.Refresh
DBGrid1.Columns(0).Caption = Combo1.Text
End Sub

Private Sub Command4_Click()
Dim db2 As Database
Set db2 = OpenDatabase(App.Path & "\cap.mdb")
db2.Execute "delete from data where rdate<=#" & Format(DTPicker4.Value,
"mm/dd/yy hh:mm:ss AMPM") & "#"
Data1.Refresh
DBGrid1.Refresh
End Sub

Private Sub Form_Load()
Data1.DatabaseName = App.Path & "\cap.mdb"
Data1.RecordSource = "select * from data"
Data1.Refresh
DBGrid1.Refresh
Option1(0).Value = True
Combo1.AddItem "Voltage", 0
Combo1.AddItem "Current", 1
Combo1.AddItem "PowerFactor", 2
Combo1.AddItem "Frequency", 3
Combo1.AddItem "ActivePower", 4
Combo1.AddItem "ApparentPower", 5
Combo1.AddItem "Capacitance", 6
Combo1.AddItem "Compensation", 7
Command1.Enabled = True
```

```
Command2.Enabled = False
Command3.Enabled = False
Command4.Enabled = False
Combo1.Visible = False
DTPicker1.Visible = False
DTPicker2.Visible = False
DTPicker3.Visible = False
DTPicker4.Visible = False
Text1.Visible = False
Text2.Visible = False
End Sub

Private Sub Option1_Click(Index As Integer)
If Option1(0).Enabled = True Then
    Option1(0).Value = True
    Command1.Enabled = True
    Command2.Enabled = False
    Command3.Enabled = False
    Command4.Enabled = False
    Combo1.Visible = False
    DTPicker1.Visible = False
    DTPicker2.Visible = False
    DTPicker3.Visible = False
    DTPicker4.Visible = False
    Text1.Visible = False
    Text2.Visible = False
End If
End Sub

Private Sub Option3_Click()
If Option3.Enabled = True Then
    Option3.Value = True
    Command1.Enabled = False
    Command2.Enabled = True
    Command3.Enabled = False
    Command4.Enabled = False
    DTPicker1.Visible = True
    DTPicker2.Visible = True
    Text1.Visible = True
    Text2.Visible = True
    Combo1.Visible = False
    DTPicker3.Visible = False
    DTPicker4.Visible = False
End If
End Sub

Private Sub Option2_Click()
If Option2.Enabled = True Then
    Option2.Value = True
```

```
   Command1.Enabled = False
   Command2.Enabled = False
   Command3.Enabled = False
   Command4.Enabled = True
   DTPicker4.Visible = True
   DTPicker1.Visible = False
   DTPicker2.Visible = False
   Text1.Visible = False
   Text2.Visible = False
   Combo1.Visible = False
   DTPicker3.Visible = False
End If
End Sub

Private Sub Option4_Click()
If Option4.Enabled = True Then
   Option4.Value = True
   Command1.Enabled = False
   Command3.Enabled = True
   Command2.Enabled = False
   Command4.Enabled = False
   Combo1.Visible = True
   DTPicker3.Visible = True
   DTPicker1.Visible = False
   DTPicker2.Visible = False
   DTPicker4.Visible = False
   Text1.Visible = False
   Text2.Visible = False
End If
End Sub

Private Sub Text1_Change()
Text1.Text = UCase(Text1.Text)
End Sub

Private Sub Text2_Change()
Text2.Text = UCase(Text2.Text)
End Sub

Private Sub Text3_Change()
Text3.Text = UCase(Text3.Text)
End Sub
```

DLL

```
Private Declare Function GetIn Lib "Rpc32" () As Long
Private Declare Function SetOut Lib "Rpc32" (ByVal X As Long) As Long

Private Sub main()
If Text = "in" Then
    For i = 0 To 5
        a(i) = GetIn()
    Next i
Else
    For i = 0 To Tnum
        Call SetOut(Bpa(i, 1))
    Next i
End If
End Sub
Private Sub Form_Load()
Call main
End Sub
```

CHAPTER 7

CONCLUSION

Wind has thus become one of the major non-conventional source from which maximum amount of power is being generated. A detailed study about the power generation in windmills have made us conclude that apart from the reactive power consumed, the wind does not pose any other problems like pollution.

This project aims to study the burden on the grid due to GCIG and to provide a better solution for compensation of reactive power by the induction generator from the grid. At present, switched capacitors are widely used in WEGs for compensating the reactive power. Microprocessor based controllers realize the cut-in and cutout of capacitors. The cut-in and cutout of capacitors of larger value are done in smaller number of steps. In this scheme, the intermediate values of reactive power are left uncompensated, which results in ineffective or poor compensation.

This project provides a better solution for handling past records, which is done by means of database. Also the reactive power can be compensated for more a single windmill by incorporating time-sharing techniques. The hardware part can be established only with the help of data acquisition systems and coprocessor unit. Even the actual position of current and voltage pulses can be seen in our software. We have also given due importance to take into account the maximum amount of reactive power consumed for a particular period of time

FUTURE DEVELOPMENTS TO BE MADE IN OUR PROJECT

- The software coding can be installed in the system and the system can be operated through the network.

- Along with the hardware section the proposed system can replace all existing system.

- Even provision can be included for operating the windmill automatically including replacement of Thyristor switch at the time of start.

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