INTELLIGENT LOAD MANAGEMENT SYSTEM USING MONITORING AND CONTROL SYSTEM FOR INDUSTRIAL FACILITIES

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ABSTRACT

Intelligent Load Management System Using Monitoring and Control System for Industrial Facilities

The subject of this thesis is studying voltage and frequency instability problems and management the power consumption for industrial facility. The presented work suggests monitoring and controlling system which will introduce (monitoring, alarming, controlling, and power quality improvement) based on data collected from the system. The system can afford the following features:

- Complete information about the plant (circuit breakers status, source of feeding, and level of the consumed power).

- Information about the operating values of the voltage, operating values of the frequency and the total power consumption. These values will assist in getting any action to return the plant to its normal operation by minimum costs.

- Recorded information such case voltage spike, frequency spike and total power consumption.

- Apply load shedding when voltage, frequency changes its set value according to NEMA standard margin value.

- Apply load shedding when the power consumption exceeds its contracted value.

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LIST OF ABBREVIATIONS

AUFLS	Adaptive Under Frequency Load Shedding
PMU	Phasor Measurement Unit
GPS	Global Positioning Satellite
WECC	Western Electricity Coordinating Council
UFLS	Under Frequency Load Shedding
SCADA	Supervisory Control And Data Acquisition
EMS	Energy Management System
ASD	Adjustable Speed Drives
NERC	North American Electric Reliability Council
WSCC	Western Systems Coordinating Council
DC	Direct Current
PI	Proportional Integral
kVAR	Kilovolt Ampere Reactive Power
kWh	Kilowatt hour
LAN	Local Area Network
ANSI	American National Standards Institute
PLC	Programmable Logic Controller
NEMA	National Electrical Manufacturers Association
DDC	Direct Digital Controls
MMI	Man-Machine Interface

CHAPTER ONE

1.1 Introduction

With the increasing demand for electrical power and due to economic and environmental constraints, power systems are currently being operated over its limits than they were previously. This has led to an ever-increasing risk of voltage instability and frequency instability; voltage and frequency are the most important limiting factors for power among different countermeasures for the prevention of the voltage and frequency instability.

The result of increased demand and expansion of industrial cities and the rareness of the necessary raw material required producing electricity which led to rising increase in the cost and the energy bill, studying power efficiency became inevitable to manage these industrial enterprises especially in the private sector.
And according to that, reducing power consumption without affecting production levels turns into a research and development (R&D) target.

Also, the quality of the electrical power in industrial facilities is in focus these days due to its relation with energy bill, Also the productivity and quality of the manufactured products are depending on the electrical power quality. Research and development to improve power quality depends on collecting accurate data from different resources and different processes all over the facility, then these collected data goes throw a comparing process to evaluate its validity with the upper and lower limits stated in the international and local codes and regulations.

Load-management procedures involve changes to equipment and/or consumption patterns on the customer side. There are many methods of load management which can be followed by an industry or a utility, such as load shedding and restoring, load shifting, installing energy-efficient processes and equipment, energy storage devices such as (capacitors-batteries), co-generation, non-conventional sources of energy, and reactive power control. Meeting the peak demand is one of the major problems now facing the electric utilities. With the existing generating capacity being unmanageable, authorities are forced to implement load shedding in various sectors during most of the seasons. Load shifting will be a better option for most industries. Load shifting basically means scheduling the load in such a way that loads are diverted from peak period to off peak periods, thereby shaving the peak and filling the valley of the load curve.

To encourage load shifting in industries, and thereby to reduce peak demand automatically, atechnology such as introduced here will be extended.

1.2 Outlines of the Thesis.

The thesis contains five chapters and appendixes in addition to the references.

Chapter 1 includes an introduction and the thesis outlines.

Chapter 2 includes Literature review.

Chapter 3 includes an analytical study discuss the problem of instability in voltage and frequency due to unbalance of the electric power and the effect of both on loads. Also, the electric power Tariffs for large industrial facility will be discussed and how to calculate and manage the electric loads to minimize the cost as much as possible, detailed study on how to control the consumed electric power will be elaborated in the following chapter so that; the consumed electric power does not exceed the value in the contract and how to maintain it in a suitable slide.

Traditional Methods used in load shedding systems was considered and thesis suggested a new approach using PLC and SCADA systems.

Chapter 4 includes a case study on the Egyptian Iron and Steel Company in Tebbien district external and internal networks has been studied.

All electrical loads in the company was calculated, by design both the PLC and SCADA software programs and embedded the proposed load shedding system in both software so that, it would be easy to apply this easy, smart and efficient solution to avoid any complications that might appear due to instability in voltage or frequency.

Finally thesis considered minimizing the cost of the electric power consumption by using load shedding priorities.

The calculated final results show that the monthly savings would be around 3Million L.E. ≈ 15 %(from total electricity bill) in case studies.

Chapter 5 summarizes the conclusions and gives suggestions for future works.

CHAPTER TWO
LITERATURE REVIEW

CHAPTER TWO

Literature Review of Energy Management and Problems of Instability in Voltage and Frequency on Induction Motors

Power systems are being operated closer to the stability limit nowadays as deregulation introduces many economic objectives for operation. As the system becomes more interconnected, weak connections, unexpected events, hidden failure in protection systems (A Hidden Failure is defined to be a permanent defect that will cause a relay or a relay system to incorrectly and inappropriately remove a circuit element(s) as a direct consequence of another switching event.”) [1], human errors and other reasons may cause the system to lose balance and even lead to catastrophic failures. In most of the recent blackouts in the world, the time period from the occurrence of dominating disturbance to the complete blackout is usually in the order of minutes and involves several stability problems, such as frequency stability, voltage stability and transient stability Compared with the others.
Without system frequency and voltage stability, reactive power balance and voltage profile cannot be held and the overall system may crash quickly.
Momentary voltage and frequency fluctuations can disastrously impact production.

This chapter reviews Energy management and problems of instability in voltage and frequency due to unbalance of the electric power and the effect of both of them on loads.

2.1 Energy management and control system (EMCS).

Energy management and control system (EMCS) technology has evolved over the past 3 decades from pneumatic and mechanical devices to direct digital controls (DDC) or computer based controllers and systems. Today's EMCS systems consist of electronic devices with microprocessors and communication capabilities. Widespread use of powerful, low-cost microprocessors, use of standard cabling, and the adoption of standard communication protocols (such as BACnet, LonWorks, and MODBUS) have led to today's improved EMCS systems. Most modern EMCS systems have powerful microprocessors in the field panels and controllers that will soon be embedded in sensors as well. Therefore, in addition to providing better functionality at a lower cost, these EMCS systems also allow for distributing the processing and control functions to the field panels and controllers without having to rely on a central supervisory controller for all functions.

Protective relays are an absolute necessity in all power management systems. These relays are, therefore, a logical base of electronic devices upon which a complete power management system can be built. Modern protective relaying devices offer all the I/O, programmability, data collection, metering, and power system diagnostics that previously required the integration of Remote Terminal Units (RTUs), PLCs (Programmable Logic Controllers), DFRs (Digital Fault Recorders), transducers, meters, and multiple single-function protective relays. By reducing device counts, these modern, multifunction protective devices have significantly reduced the price and greatly increased the reliability of automatically protecting and controlling modern power systems. Modern power management systems are a complete integration of an installed base of protective relays, remote I/O modules, wide area control systems, communications, monitoring, and engineering toolsets. Figure 2.1 shows all the major components of these systems [2].

2.2 Energy Management System Structure

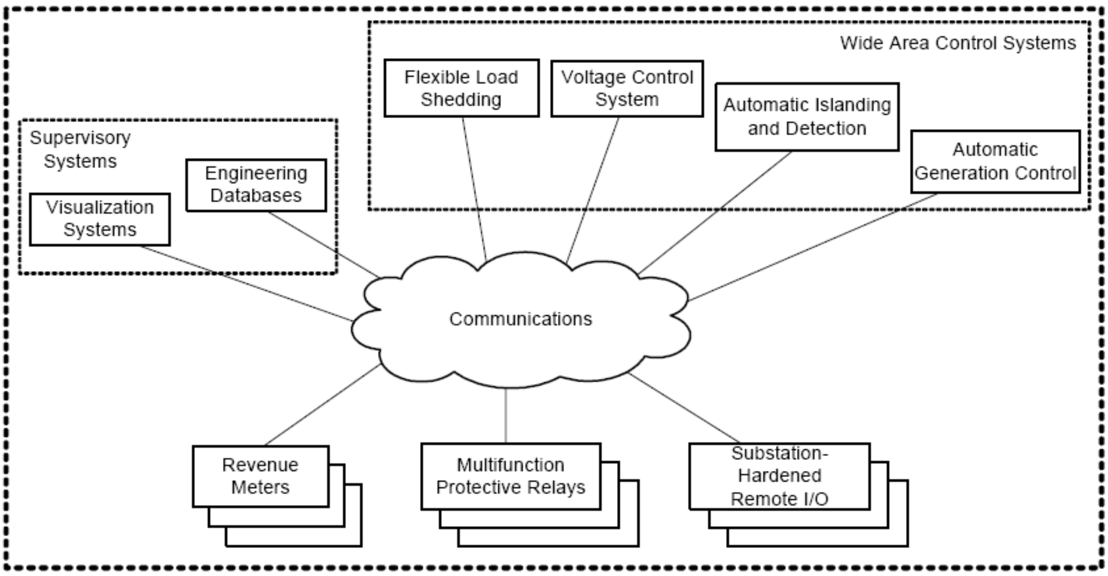

Figure 2.1Architecture of present P.M.S

Energy management and control functions can be broadly classified into three groups: basic, intermediate, and advanced Basic and intermediate functions seek measuring and control energy in simple way. It varies from using sensors, energy metering, alarm settings, scheduling and load shifting. It follows a simple process, from data collected by sensors, which gives signals for controllers that takes decision according to the signal given. Advanced functions could be identified as “intelligent” energy management systems.

2.3 Methods of EMS (Energy Management System) are:

A- Time-of-use management:

With this approach, often called “load shifting,” savings come from managing operations to shift power usage to nonpeak times.

B- Real-time pricing (RTP) optimization:

This method is based on the change of tariff rates based on the market price of electricity by giving time period ranging from 10 minutes to 24 hours. The government clear to customers a statement of tariff every 1 hour, electricity tariffs depending on the peak periods shall be within the periods of peak tariff is high and away from peak period’s tariffs are low.

C- Demand response:

In this method of ways Energy Management System There is agreement between both the company distributed electricity and customers to shed the loads by customers during peak periods and in specific time and specific amount of loads, distributor of electricity Specifies that and notify customers. All this in return for reducing electricity tariff during this period the peak periods typically ranging from 2 hours to 4 hours per day

In this thesis the first method (Time-of-use management) will be applied as in Egypt.

2.4 Previous Literature Survey on Load Management and Voltage, Frequency Instability.

Electrical power considered to be one of the main critical issues to achieve a sustainable growth rate and prosperity not only in the developed countries but also in the currently developing countries, in manufacturing facilities the elevated need to increase production is crucial specially that electrical power in these manufacturing facilities is consuming a lot of subsidies due to oil prices.Studying power efficiency to minimize consumption was not a priority till a few years ago.

The idea of "Load Management System" itself is not new; Reference [3] study the concept of peak shaving and the study of demand, how to reduce costs by shedding some of the auxiliary devices like Air conditioners and lighting without any effects on productivity.Reference [4] study the problems related to demand side loads in commercial (trade), residential and industrial buildings and how to enhance electrical power using power factor and load shedding.Reference [5] study the electric tariff and its effect on industrial buildings and factories especially with its constantly increased value and how that is going to affect production.The paper illustrated some effective methods to reduce the consumed power in rush hours and how to handle and distribute their needs all over the day so that, it could reduce the energy cost.These suggested methods were put to test in the fields of food, plastic and cement industries in France and Italy.
Reference [6] study introduces a wide view on the efficient use of electrical power in the industrial city of TIMA; in addition to that, the report shows the inhabitant factors that prevent increasing electrical power efficiency in TIMA city.Reference [7] introduced data analysis on the demand of the electrical power and how to distribute it miserly to avoid rush hours and the study of the other alternatives like load shedding in rush hours and how to compensate it by aback up generators in service during this period. This research refers also to the possibility of using renewable energy.Reference [8] study the power losses in three phase induction motors and power transformers and how to reduce these losses by improving the power factor.
Reference [9] discussed the issue of load management from both sides. The supply side or the demand side and the generation or distribution of loads side and discussed three ways in the supply side:
Direct load control-interruptible load control and time of use (TOU).

A- Direct load control

Shed loads directly on the customer when needed