Automatic Reactive Power Flow Control in 100MW Turbo Generator

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Abstract: ***Reactive power (vars) is required to maintain the voltage to deliver active power(watts) through transmission lines. Motor loads and other loads require reactive power to convert the flow of electrons into useful work. When there is not enough reactive power, the voltage sags down and it is not possible to push the power demanded by loads through the lines. Synchronous generators are rated in terms of the maximum MVA output at a specified voltage and power factor (usually 085 or 0.9 lagging) which they can carry continuously without overheating. The active power output is limited by the prime mover capability to a value within the MVA rating. Thecontinuous reactive power output capability is limited by three considerations: armature current limit, field current limit, and end region heating limit. During the daily operation, power systems may experience both over-voltage and under-voltage violations that can be overcome by voltage/Var control generators can generate or absorb reactive power depending on the excitation. When overexcited they supply the reactive power, and when under excited they absorb. Here we are using a single microcontroller for automatic controlling of reactive power (MVAR) flow and maintain a terminal voltage in 230 KV transmission line.***

Keywords: Active power,Apparentpower, Efficiency, Power factor, Reactive power

1. Introduction

During the daily operation, power systems may experience both over-voltage and under-voltage violations that can be overcome by voltage/Var[1] control. Through controlling the production, adsorption, and flow of reactive power at all levels in the system, voltage/Var control can maintain the voltage profile within acceptable limit and reduce the transmission [4] losses. In the last 20 years, this problem has attracted the interest from both academia and industry and this has produced many special devices and algorithms. Some countries have adopted some of these in their real power networks and achieved reasonably successful results.

2. Reactive Power

Active power is the energy supplied to run a motor, heat a home, or illuminate an electric light bulb, while reactive power provides the important function of regulating voltage. Reactive power is used to provide the voltage levels necessary for active power to do useful work. Reactive power is essential to move active power through the transmission and distribution system to the customer.This paper first introduces reactive power sources and control devices for them.Voltages are controlled by providing sufficient reactive power control margin to "modulate" and supply.

Voltages are controlled [5] by predicting and correcting reactive power demand from loads. The reactive sources must be coordinated to ensure that adequate voltages are maintained everywhere on the interconnected system during all possible system conditions. Maintaining acceptable system voltages involves the coordination of sources and sinks. Load shedding schemes must be implemented as a "resort" to maintain acceptable voltages in Generating Station.

Generators can generate or absorb reactive power depending on the excitation. When overexcited they supply the reactive power, and when under excited they absorb reactive power. The automatic voltage regulators of generators can continually adjust the excitation.

Power factor is defined as the ratio of real power to apparent power. This definition is often mathematically represented as kW/kVA, where the numerator is the active (real) power and the denominator is the (active+ reactive) or apparent power. Though the definition is very simple, the concept of reactive power is vague or confusing even too many of those who are technically knowledgeable.

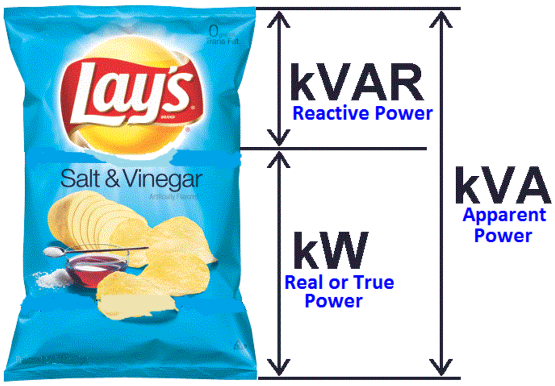

Figure 1: Analogy of Reactive Power

Explanation for reactive power says that in an alternating current system, when the voltage and current go up and down at the same time, only real power is transmitted and when there is a time shift between voltage and current both active and reactive power are transmitted. But, when the average in time is calculated, the average active power exists causing a net flow of energy from one point to another, whereas average reactive power is zero, irrespective of the network or state of the system. In the case of reactive power, the amount of energy flowing in one direction is equal to the amount of energy flowing in the opposite direction (or different parts -capacitors, inductors, etc. - of a network, exchange the reactive power). That means reactive power is neither produced nor consumed. But, in reality we measure reactive power losses, introduce so many equipment's for reactive power compensation to reduce electricity consumption and cost.

The purposes of generators are to supply the active power, to provide the primary voltage control of the power system and to bring about, or at least contribute to, the desired reactive power balance in the areas adjacent to the generating stations. A generator absorbs reactive power when under excited and it produces reactive power when overexcited. The reactive power output is continuously controllable through varying the excitation current. The allowable reactive power absorption or production is dependent on the active power output as illustrated by the power charts. For short-term operation the thermal limits are usually allowed to be overridden.

The step-response time in voltage control is from several tenths of a second and upwards. The rated power factor of generators usually lies within the range 0.80 to 0.95.

Generators installed remotely from load centers usually have a high rated power factor [3]; this is often the case with large hydro-turbine generators. Generators installed close to load centers usually have a lower rated power factor. In some cases of large steam-turbine generators the rated power factor may have been selected at the lower end of the above range in order to ensure reactive power reserve for severe forced outage conditions of the power system.

Large generators are usually connected direct to transmission networks via step-up transformers. The terminal voltage of a large generator is usually allowed to be controlled within a ± 5% range around the nominal voltage, at rated load. In most countries the generator step-up transformers are usually not equipped with on-load tap changers.

The MVAR output of a generator is dependent on its excitation. The MVAR is generated during over excitation and is absorbed during under excitation. The rotor current depends on the excitation. The rotor winding temperature, the air gap temperature and the machine temperature increase during over excitation. The winding temperature is limited to about 90oC during normal loading. It increases to 100 – 105oC during over loading. The machine which is already over heated due to MVAR generation cannot take MW load to its full capacity. Hence MW load is to be compromised when the unit is excited beyond its normal limits.

When the unit generates MVAR and supplies to the system, the system voltage profile around the generating station increases. This increase in voltage is more in first neighborhood. The load end voltages which are beyond, say second neighborhood will not get affected because of this unit excitation. Hence the influence of a unit on voltage profile in the system is local in nature. The load end voltages cannot be controlled by the generating units[2].

However depending on the capability curve of the generating unit and as long as margin is available in the unit, it can be used to control the system voltages in its vicinity.

The change in the voltage DV in the first neighborhood of the generating station depends on the
Relation DV = DQ/S in p.u.
Where DV = change in bus voltage in p.u.
DQ = Amount of Q supplied through over excitation in p.u.
S = Fault level of the system at first neighborhood in p.u..

3. Architecture of Reactive Power Flow Control

The existing system of protection in turbine generator system is relay and hard wired system. The existing system has lot of disadvantages such as high power consumption, slower operation rate, high maintenance cost, consists of so much of wires, improper operation at critical stage, is not safer, since using of dc supply.These drawbacks have lead us to the protection of turbine by using PIC controller.

PIC 16F877A is a controller which is used for the protection of turbine generator system.PIC controller operates at very low voltage and it consumes very less power.PIC controller uses a simple user friendly programming and requires less hardware components. Program used in the PIC can be easily altered and effectively controlled.PIC IC is used for real time monitoring of data that can be done in relay system. There are several advantages by using this PIC controller. Such as it is cost effective since we do not use any cables for data sharing, overall installation expenses and life cycle cost can be significantly lowered.

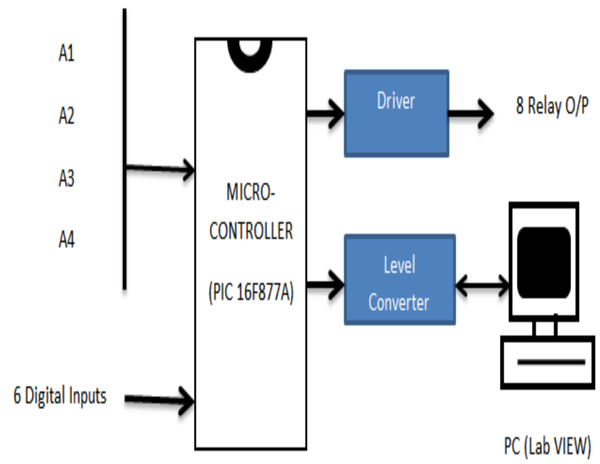

Figure 2: Architecture of Reactive Power Flow Control

The architecture mainly consists of PIC 16F877A, driver IC, level converter and relay outputs. The PIC 16F877A IC works at 5V so in order toprovide the sufficient voltage for the operation of PIC we are using IC 7805.Two capacitors are connected to the IC 7805 for regulator stability. We have 4 analog inputs and 6 digital inputs given to the PIC controller. The PIC controller follows CMOS logic while the PC follows TTL logic, in order to combine the logics we use level converter. The level converter used here is MAX232.The output from the level converter is being monitored by the PC by using Lab VIEW. In the Lab VIEW software we would have drawn a block diagram to control the various parameters that affect the generating power which in turn affects the efficiency of the whole power plant.While we use MP LAB software for controlling the PIC controller and engages its operation in the reactive power flow control.

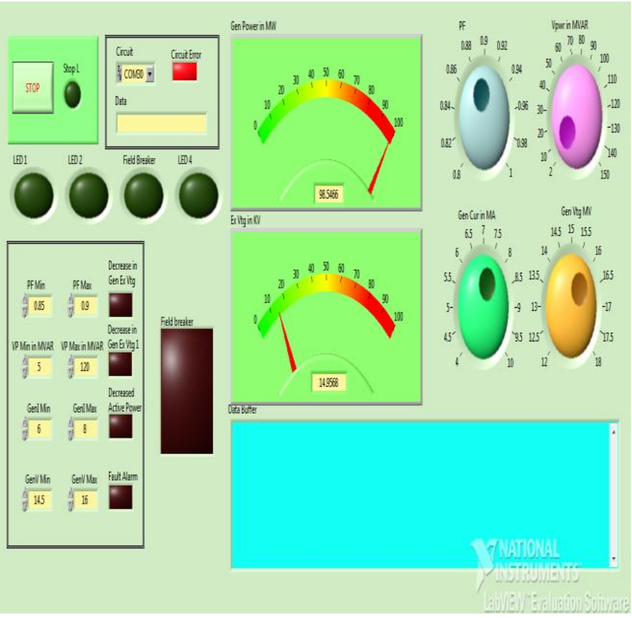

Figure 3: Front panel of Reactive Power Flow Control Model in Lab VIEW

There are four major parameters in the front panel which improves the efficiency [6] of the power plant.The parameters are PF (power factor),Vpwr in MVAR, Generating current in MA and Generating voltage in MV. The power factor plays a vital role in the efficiency of the plant. Improvement in power factor reduces the electricity consumption. For a 100MW turbo generator the power factor should be maintained at a range of 0.8 to 0.9.The Vpwr should be maintained at a very low range. Lower the Reactive power more will be the Generating power. Similarly the generating current and generating voltage should be maintained in the ranges specified. More the Generating current more will be the generating powersame is the case with generating voltage. By maintaining the values in the above mentioned parameters we can get an efficiency of 98% (approx.).If the values of the above mentioned parameters exceed or go below the ranges specified a fault alarm is being produced in order to alert the officials in work in the power plant to maintain the desired parameter in the specified range.

4. Simulation and Result Analysis

On comparing the efficiency of the present system with that of the earlier system, we can see that the efficiency is increased for the proposed one. The approximate efficiency comparison graph can be depicted as below:

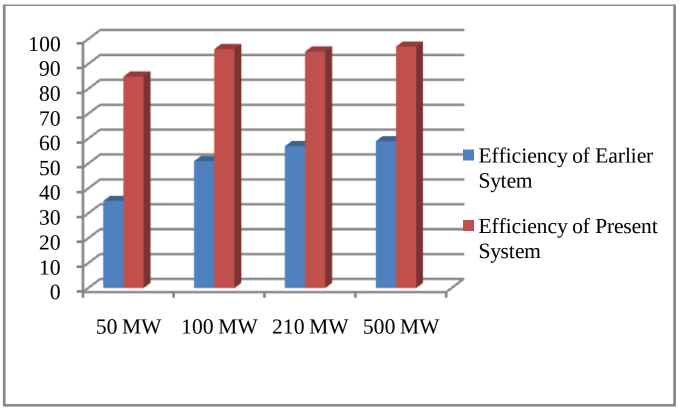

Figure 2: Efficiency comparison graph

The Reactive Power flow control using the LabVIEW Software provides the required result. In the earlier system the power being generated from the power plant had an efficiency of 35 – 55 % while in this system we can get an efficiency of 96-98%.The generated current is transmitted and distributed with minimal losses to the consumer due to the reduction in reactive power thus it increases the overall efficiency.

5. Conclusion and Future Scope

In this paper, several representative techniques of voltage/Var control, Rotor Excitation control, Active Power Control (MW) and Generator Load control are reviewed by using MPLAB software and Lab VIEW. We come to know that on reducing the reactive power we can increase the efficiency and reduce the transmission and distribution losses to a certain limit. Their advantages and disadvantages are analyzed.

The future challenge is to how to efficiently and accurately solve the problem taking into consideration the dynamic nature of power systems.

6. Acknowledgement

We thank our parents for being a spearhead for the paper and for giving instructions to complete the same. We also thank our professors for giving us the necessary guidelines to write this paper.

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