

# Chapter 18

## Nonlinear Dynamics of Voltage Fluctuation in Power Plants for Strategic Decisions

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### ABSTRACT

*The stability of output of a power station is an important criterion for power supply. It is always desired that the voltage and frequency of output of any power plant should be stable. The nature of fluctuations, if any, in the output, needs thorough investigation. If the fluctuation has high degree of chaos as revealed by the time series representing the voltage, then such fluctuation may be controlled by introducing unconventional sources of power like hydro, wind, et cetera in the grid. The authors have analyzed the daily voltage output from five different thermal power stations in Eastern India. To analyze the dynamics of the time series the authors have used the techniques from nonlinear dynamics Delay Embedded Phase Reconstruction and Empirical Mode Decomposition. The studies show that the dynamics of the time path of voltage output of Biharshariff, Maithon, and Jeypore power plants are more or less chaotic in nature. Therefore, it may be inferred that in those particular grids other sources of power generation may be introduced.*

### INTRODUCTION

The stability of output of a power station is an important criterion for power supply. It is always desired that the voltage and frequency of output of any power plant should be stable meaning the

fluctuations, if any, should be within a given small range. Essentially, the time series describing the daily voltage output of any power plant should be of stable nature. This cannot be achieved through operational or tactical decisions and actions. Rather it calls for the need of engaging in strategic

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planning and implementation for reasons elaborated in the following paragraph. For an emerging country, this strategic decision becomes one of national importance. The recent developments in the field of nonlinear dynamics and chaos enable us to analyse the voltage output in detail. This, in turn, forms a strong information base and analytic framework for taking a strategic decision at the national power grid level. To examine this, for our analysis we have selected the daily voltage output data from five thermal power stations in eastern India from March 2004 to April 2007.

### **Motivation of Study: Strategic Decision in Power Grid**

The motivation of this study lay in the fact that if any time series reveals erratic behaviour, then such power plant may be identified and the resultant output voltage of the grid may be affected by introducing alternate sources of power such as hydel, wind etc. The hydro or wind based units are capable of quick start-up and generation escalation helping to mitigate such voltage fluctuations. This decision can only be taken by the Power Grid corporations and not by the individual power plants at the operational level. The nature of this decision is complex and involves high level strategic inputs. For a power grid corporation to be able to decide on selection of power generation technology and mode it needs exhaustive input that enables proper decision making. The large scale impact and resource involvement of such decision makes it vulnerable to the quality of analytical input that leads to the decision. Specially, in an emerging economy like that of India, any strategic decision regarding introduction of new technology and building new system calls for utmost care and deep insight before coming to any conclusion. The analysis of the time series representing the daily voltage output thus has to be able to bring out clearly the level and nature of instability in the voltage. A simple statistical analysis does

not reveal a picture clear enough to aid the grid authorities to take a strategic decision. A deeper study analysing the nonlinear dynamics and chaos of the time series representing the voltage output of the power plants needs to be undertaken. Keeping this in mind, to analyze the behaviour of time series, we have used certain techniques evolved out of nonlinear dynamics. These techniques are very effective tools of analyzing any nonlinear time series. These tools effectively reveal whether the time series shows any degree of chaos or not. Such behaviours are not revealed by standard statistical tools. The analysis of the nonlinear dynamics of the time series clearly shows the gravity and impact of the problem which calls for classifying the same as a strategic problem. The analysis has been carried out extensively much for the appreciation about the dimensional complexity of the operations management problem besides developing an insight about nature and consequences of the fluctuations.

### **ERLDC: A SNAPSHOT**

Our analysis is based on daily voltage data of Rourkela, Biharshariff, Durgapur, Maithon & Jeyore Thermal Power Stations all situated in eastern India.

The data have been collected from database of Eastern Regional Load Despatch Centre (ERLDC), Power Grid Corporation of India Limited, The Central Transmission Utility of India, available at their official website [www.erldc.com](http://www.erldc.com) for the period March 2004 to April 2007 (both month inclusive).

According to West Bengal Power Board, the Eastern Regional Power System of India comprise of state of West Bengal, Bihar, Orissa and Sskim. The Grid is responsible for reliable and economic power system operation by running the entire grid in an interconnected mode. The same website (<http://wbpower.nic.in/erldc.htm>) lists the

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