A novel approach for UI charge reduction using AMI based load prioritization in smart grid

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Abstract

System frequency is vital part for power system balance. As per India Electricity Grid code frequency should be in the range of 49.5 Hz–50.5 Hz. Deviation from above mentioned range is charged as Unscheduled Interchange (UI) charge. This paper proposes a new method for load and frequency control based on control of third parameter of three-part Availability Based Tariff (ABT) i.e. Unscheduled Interchange charges. New circuit is designed considering prioritization of load and using Advanced Metering Infrastructure (AMI) under Smart Grid environment.

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Keywords: Unscheduled interchange; Availability based tariff; Advanced metering infrastructure; Smart grid

1. Introduction

Grid management in India is carried out on regional basis. Five regions namely Northern, Eastern, western, north-eastern and southern. On 31st December, 2013 the southern grid is connected synchronously with rest all regions and India has achieved one nation, one grid and one frequency mission. To maintain discipline of grid Central Electricity Regulatory Commission CERC has introduced Availability Based Tariff, ABT based on financial principles. Where in all the central section generators and beneficiaries must declare a schedule for dispatch and drawl for every 15-min time block, one day in advance. Any deviation from the schedule is charged at Unscheduled Interchange rates, which are frequency dependent. System frequency is a major indicator of the power balance in the system; frequency is closely related to real power balance in the system. As per Indian Electricity Grid Code, frequency limit is 49.5 Hz–50.5 Hz. Frequency instability leads to massive and cascade blackout in the power system. Restoration after blackout takes time, its essential task to timely recover the system back to normal.

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There are three components of ABT fixed cost, variable cost and UI. When there is a deviation from actual generation and deviation of frequency the third component of ABT comes into the picture. ABT metering which is one of the components of Advanced Metering Infrastructure (AMI) gives real-time monitoring of control of frequency. AMI of smart grid technology makes it possible to work traditional grid in smarter way by better utilization of information and communication technology. This paper proposes the idea of control of frequency considering load prioritization to reduce Unscheduled Interchange charges penalties currently being paid by state utility to central utility. Paper is written to provide answers to following research questions.

1) How to eliminate or minimize the Unscheduled Interchange (UI) charges to avoid penalty paid by state utility?
2) How to design a load management scheme to control frequency deviation considering prioritization of loads?

1.1. Review of literature

The literature survey has been done considering three aspects.

1) Smart grid overview and development in India
2) Smart grid communication technology and Advanced Metering Infrastructure (AMI)
3) Availability Based Tariff and UI mechanism

Paper Mukhopadhyay et al. (1892) is about drivers of smart grid. Drivers for the smart grid, Advanced Metering Infrastructure, network reliability and security and integration of renewable energy are described. Ma et al. (2013) have explained the comparison of smart grid and conventional grid, communication networks in smart transmission and distribution grid, communication security and challenges and opportunities in communication. In paper Ma et al. (2016) smart grid communication infrastructure and technologies, technical challenges in communication and security are given. Sabbah et al. (2013) have done survey on protocols used in smart grid. Paper Holmukhbea et al. (2010) is the review paper of ABT and its impact on industry players. In paper Manoj et al. (2016) micro controller based load model is explained. Pre ABT and Post ABT scenario, power exchange and UI mechanism is explained in Vijayapriya et al. (2010). In paper Hou et al. (2014) ABT basic concepts and UI mechanism is explained to understand ABT Issues, its components, mechanism, benefits and the impact of grid on different players like generation utilities, grid operator, consumers involved in power generation, transmission and distribution. This paper describes the basic features of smart grid, comparison of conventional grid and smart grid (Imam Journal Article, 2009) and explains basic components of smart metering. In Paul et al. (2014) overview of India’s power market initiatives taken considering technical and non-technical approaches are explained. Paper Bala et al. (2012) is about Client server communication in Android Based Platform, basic service layers of architecture and polling pushing techniques. In Yang et al. (2013) new features of AMI, relationship of power supply and applications of AMI in smart grid are explained. AMI overall design is explained. Android based client server communication is explained considering TCP IP protocols (Luhua et al., 2010). Paper Truong and Vu (2012) focuses on Pros and cons of existing frequency mechanism is discussed. To maintain real time balance between demand and supply, all generators are compiled to operate under free governor mode of running. Short coming of the method is huge wear and tear losses (Parada et al., 2008). In paper Santosh et al. (2011) working of UI mechanism is explained loss allocation techniques have been developed and implemented for IEEE 30 bus system. Comparison for various methods is explained. Frequency linked pricing as an instrument for Frequency Regulation Market and ABT mechanism is about the role of Regional Load Dispatch Center (RLDC) and economic dispatch as a useful tool for reduction of cost and promoting Merit Order Dispatch (MDO) under ABT regime (Reddy et al., 2006), Paitan kar and Bhidle (2016) fundamental system of power system protection book provides useful information about smart meter. The primer ABC of ABT deals with ABT and UI mechanism basic concepts, scheduling process intrastate trading open access wheeling (ABC of ABT Bhushan Bhanu, 2005). Patki et al. (2005) explains ABT metering communication network and client server communication is explained taking case study of Mumbai network. Intrastate ABT, UI mechanism is explained. Structure and components of ABT is explained by Forum of Indian regulatory commissions. AMR, AMI, Modbus and various protocols of metering are explained to understand ABT metering in paper Pradish et al. (2009). Power system restoration after blackout is explained considering optimal algorithm, learning outcome is power system topology and load prioritization (Recommendations, 2016). White papers from kalkitech (Impact of ABT on different stake holders, 2016; Integrated Availability based Tariff, 2016) provides useful information for impact of ABT on generating utilities, impact on grid operators and impact on consumer. It
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