IFERP
connecting engineers... developing research

International Journal of Engineering Research in Electrical and Electronic Engineering (IJEREEE) Vol 2, Issue 4, April 2016

Unscheduled Interchanges under ABT

[1] Amit Kumar [2] Arvind Dhingra
[1] M.Tech (Student) [2] Assistant Professor
[1] Department of Power Engineering [2] Department of Electrical Engineering
[1] [2] Guru Nanak Dev Engineering College
Ludhiana, India
[1] amitsingla883@gmail.com [2] arvinddhingra@gmail.com

Abstract: **This Paper presents study in terms of profit earned by generating units by increasing or decreasing their generation under ABT. The decision for increasing or decreasing the generation is taken after the comparison between Unscheduled Interchange (UI) rate and incremental marginal cost (IMC) of generators. For this study ABT Based Load Frequency Controller for an isolated area having four generator power systems is used. All the generators are scheduled to generate less than their capacities. So that it can increase their generation in case of increase in sudden load demand. Frequency signal is converted into price by using Matlab function in accordance with the UI rates issued by Central Electricity Regulation Commission (CERC, INDIA) in year 2014. This controller ensures that generators respond to the UI price automatically and in a desirable manner. All the generator models are simulated in Matlab Simulink. The paper is organized as follows. In section I brief introduction is given. In Section II we explain concept of ABT. Section III comprises of details of ABT based load frequency controller. Details of simulation model and results are discussed in section IV. This is followed by conclusions in Section V.**

***Keywords*— Availability based tariff, ABT based automatic generation controller, Central Electricity Regulatory Commission, Incremental marginal cost, Unscheduled interchange rate.**

I. INTRODUCTION

The Indian power system is characterized by low frequency operation due to continuous power deficit situation for majority of time. The financial constraints typical of a developing country with large population and unequal distribution of resources also led to inadequacies of transmission and distribution network with critical line loadings and low voltage profile. The consumer demands far exceed the available generating capacity. The scarcity of power and the commercial mechanism before ABT (based on take-off of power by States rather than schedules from Central pool) led to low frequency operation. The tariff mechanism did not provide any incentive to reduce generation under high frequency or to maximize generation under low frequency. In other words, the tariff mechanism encouraged grid indiscipline [1]. A new commercial mechanism (Availability Based Tariff) was introduced in the country from 1st July, 2002. The commercial mechanism is specifically defined to suit the deficit power systems. The mechanism streamlined the operation of regional grids. Electrical load demand and generation mismatch causes the frequency to deviates from its nominal value. The governors of all the machines sense the frequency and the mechanical power outputs is changed automatically to match the combined generation with the new combined load. This action is called primary regulation. But frequency remains at a new value and set points must be adjusted for frequency restoration. This set point is adjusted by the Automatic Load Frequency controller and this process is called secondary regulation.

Although the underlying principle on which UI mechanism of ABT operates is quite different from the conventional load frequency control mechanism, it can still be viewed as a price based secondary generation control mechanism. Presently, the generators are responding to price signals manually. In this paper, a model for ABT based automatic generation controller is presented. The presented scheme is simulated on a model of an isolated area system having four generators. Profit earned by all the generators by changing (increase/decrease) their scheduled generation in accordance with comparison between UI price and marginal cost is calculated. Also it has been shown here that such control mechanism, if adopted by all generating stations, can improve the control of frequency. All the generator models are simulated in Matlab.

II. AVAILABILITY BASED TARIFF

ABT is a performance based tariff for the supply of electricity by generators owned & controlled by government. It is also a new system of scheduling & dispatch, which requires both generators and beneficiaries to commit to day-ahead schedule. ABT along with the Electricity of Act 2003 is perhaps the most significant & definitive step taken in the Indian power sector. It is a frequency based pricing mechanism applicable in India for unscheduled electric power transactions. The ABT falls under electricity market mechanisms to charge and regulate power to achieve short term and long term network stability by providing incentives and dis-incentives to grid participants against deviations in their committed schedules. The energy actually supplied by the generating station may differ from what was scheduled. If actual energy supplied were higher than scheduled, the generating station would be entitled to receive a payment for the excess energy (the deviation from schedule, technically termed as Unscheduled Interchange (UI) in Availability Tariff terminology) at a rate dependent on frequency at that time. If the energy actually supplied is less than what is scheduled, the generating station shall have to pay back for the energy shortfall, at the same frequency - linked rate. This tariff is linked with frequency, which is the simplest and transparent indicator of generator loading [2]. Prior to the introduction of Availability Tariff, the regional grids had been operating in a very undisciplined and haphazard manner. There were large deviations in frequency from the rated frequency of 50.0 cycles per second (Hz). Low frequency situations result when the total generation available in the grid is less than the total consumer load. These can be curtailed by enhancing generation and/or curtailing consumer load. High frequency is a result of insufficient backing down of generation when the total consumer load has fallen during off-peak hours. The earlier tariff mechanisms did not provide any incentive for either backing down generation during off-peak hours or for reducing consumer load / enhancing generation during peak-load hours. In fact, it was profitable to go on generating at a high level even when the consumer demand had come down. In other words, the earlier tariff mechanisms encouraged grid indiscipline. The Availability Tariff directly addresses these issues. Firstly, by giving incentives for enhancing output capability of power plants, it enables more consumer load to be met during peak load hours. Secondly, backing down during off-peak hours no longer results in financial loss to generating stations and the earlier incentive for not backing down is neutralized. Thirdly, the shares of beneficiaries in the Central generating stations acquire a meaning, which was previously missing. The beneficiaries now have well-defined entitlements, and are able to draw power up to the specified limits at normal rates of the respective power plants. In case of over-drawl, they have to pay at a higher rate during peak load hours, which discourages them from overdrawing further. This payment then goes to beneficiaries who received less energy than was scheduled, and acts as an incentive/compensation for them [3]. ABT has three components-

(a)Capacity Charge: - This component represents the fixed cost and is linked to the availability of the plants. The total amount payable to the generating company over a year towards the fixed cost would depend on the average availability of the plant over the year.

(b) Energy Charge: - This component of ABT comprises of the variable cost, i.e. the fuel cost of the power plant for generating energy as per given schedule for the day. Therefore, this energy charge is not according to the actual generation but only for scheduled generation.

(c) Unscheduled Interchange Charge: - In case there are deviations from schedule, this third component of ABT comes into picture. Deviations from schedule are determined in 15-minute time blocks. They are priced according to the system frequency condition prevailing at that time. As long as the actual generation/withdrawal is according to the given schedule, the third component of ABT is zero. UI rates are calculated from UI rate curve shown in fig.1

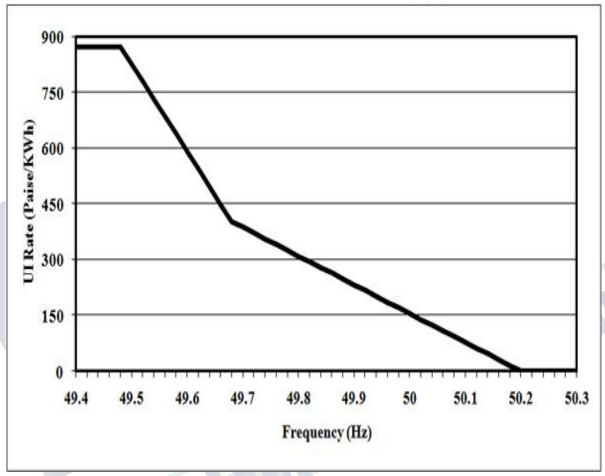

Fig.1. UI rate curve

III. SYSTEM MODELLING

In the Availability based Tariff (ABT) based load frequency controller scheme [4] the primary regulation control loop is the same as in the conventional frequency control, but the secondary loop is changed to incorporate the unscheduled interchange (UI) price signal. The basic block diagram of this control is illustrated in Figure 2. Each generator individually monitors the UI price ρ and compares with its marginal cost γ. It derives an error signal, which is the difference of current UI price and its incremental marginal cost. This error signal, which can be termed as generation control error (GCE), is fed to integral controller. A positive GCE indicates that the generator will profit by increasing generation level. A negative GCE indicates that Generator will profit by decreasing the generation level. Since under ABT, the payments received by generators for UI are separate from the payments for SI, the generators earn profit in both cases. This controller ensures that generators respond to the UI price automatically and in a desirable manner. Also controller ensures that frequency control is as smooth as possible. It is assumed that generators of single area are generating power at scheduled value and frequency of the grid at its scheduled frequency 50Hz. Now for any case, when step load occurs in the system, which results in deviation in the supply frequency.

Item		Generator 1	Generator 2	Generator 3	Generator 4
Capacity		1500	1500	1000	1000
Cost Coefficients	b	800	1000	1600	2000
	c	0.3	0.3	0.4	0.4

Charges for deviation for each 0.01 Hz step is equivalent to 35.60 Paisa/kWh in the frequency range of 50.05-50.00 Hz, and 20.84 Paisa/kWh in frequency range 'below 50 Hz' to 'below 49.70 Hz' [5].

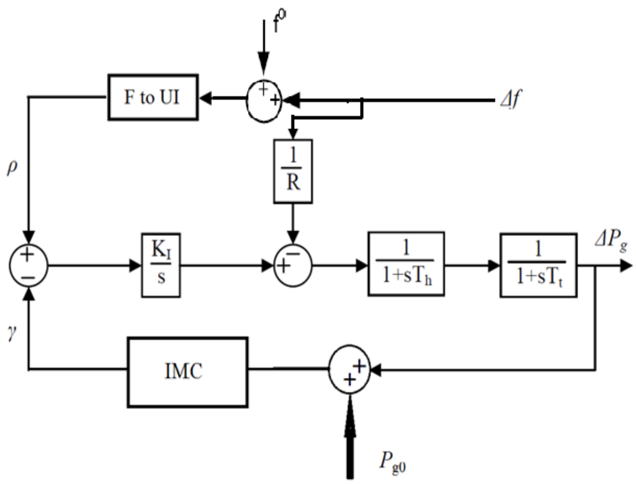

Fig.2. Block diagram of ABT based load frequency controller

IV. SIMULATION AND RESULTS

ABT based load frequency controller has been simulated and tested using an isolated area system having a capacity of 5000 MW supplied by four generating stations [4]. In order to meet the sudden load changes all the generators are scheduled to generate less than their capacities. Hence generator 1, 2, 3 and 4 are scheduled to generate 1400 MWs, 1416.66 MWs, 312.5 MWs and 100 MWs respectively. The relevant data of isolated area and generating stations is given in Table 1 and Table 2 respectively. A step load change of 100MW is applied and changes i.e. frequency deviation, UI rate, change in generation, Incremental Marginal cost are studied.

Table 1 Area data

Capacity	5000MW
f0	50 Hz
D	100Mw/Hz

Table 2 Generator data

All models are created using MATLAB/SIMULINK [6]. Fig. 3 shows the frequency Vs time curve. From curve it is clearly understood that at starting due to sudden increase in load frequency goes down to 49.91 Hz but with time as generators increase their generation frequency increases and settle to final value 49.98 Hz. Fig. 4 shows the UI rate Vs time curve. Due to sudden dip of frequency UI rate increases to very high value more than 2300 INR/MWh but as frequency slowly increases UI rate decreases and finally settles to 1900 INR/MWh. Table 3 shows the profit earned by generators by rescheduling their dispatch in accordance with difference between UI rate and Incremental Marginal Cost.

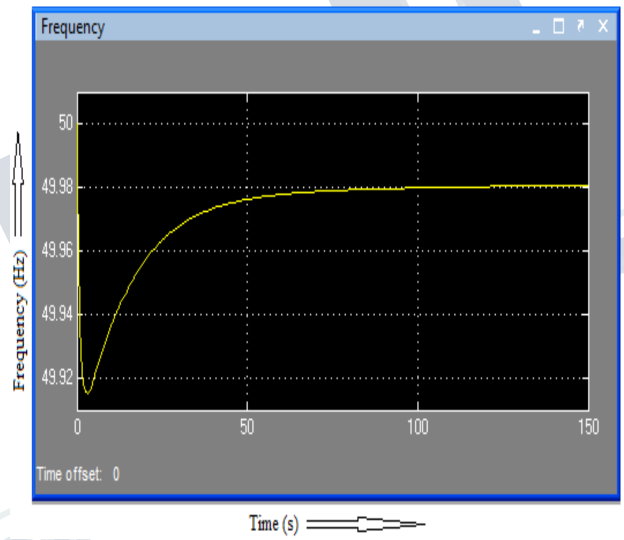

Fig.3. Frequency Vs time curve

UI Rate (INR/MWh)	IMC (INR/MWh)	Scheduled Generation Pg_0 (MW)	Actual Generation Pg(MW)	Unscheduled Interchange ΔPg(MW)	Profit (INR)
1900	1692	1400	1487	87	18096
1900	1868	1416.66	1446	29.34	938.88
1900	1872	312.5	340	27.5	770
1900	2029	100	36.87	-63.13	8143.77

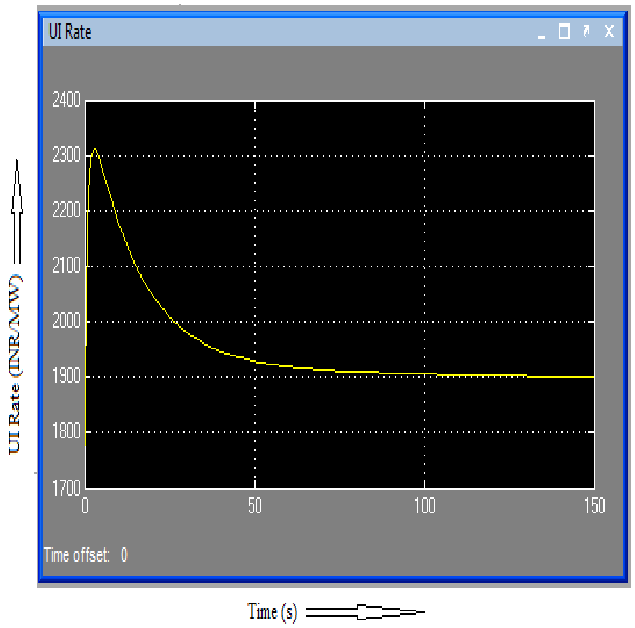

Fig.4. UI Vs time curve

Following results are obtained from simulation-

1) UI price of Generator 1 is 1900 INR/MWh and Incremental Marginal price is 1692 INR/MWh. So there is profit in increasing generation. ABT based control mechanism of Generator 1 sensed it and raised generation to 1487 MW. Thus Generator 1 earns profit of 18096 INR/h by increasing generation.

2) UI price of Generator 2 is 1900 INR/MWh and Incremental Marginal price is 1868 INR/MWh. So there is profit in increasing generation. ABT based control mechanism of Generator 2 sensed it and raised generation to1446 MW. Thus Generator 2 earns profit of 938.88 INR/h by increasing generation.

3) UI price of Generator 3 is 1900 INR/MWh and Incremental Marginal price is 1872 INR/MWh. So there is profit in increasing generation. ABT based control mechanism of Generator 3 sensed it and raised generation to 340 MW. Thus Generator 3 earns profit of 770 INR/h by increasing generation.

4) UI price of Generator 4 is 1900 INR/MWh and Incremental Marginal price is 2029 INR/MWh. Here Incremental Marginal Cost is more than UI price so there is profit in decreasing generation. ABT based control mechanism of Generator 4 sensed it and decreased generation to 37 MW. Thus Generator 4 earns profit of 8143.77 INR/h by decreasing generation.

Table 3- Profit earned by Generators

V. CONCLUSIONS

The major thrust of ABT is to improve the reliability and quality of the power grid. The UI mechanism has reduced the problems faced by the Indian power sector in the field of grid management and discipline. Huge resources of developing India are saved by this mechanism, supporting both over injection as well as under injection depending on the conditions prevailing in the system. When UI price is higher than marginal price, the generator can earn profit by increasing its generation and when UI price is lower than incremental marginal cost the generator can earn profit by decreasing its generation and still getting paid for its availability. Also the ABT based load frequency controller has done the re-dispatching process automatic and helping in reducing frequency fluctuations after sudden load changes. From frequency to price conversion real time price signal is always available to generating stations. In this paper, ABT based load frequency controller is applied to an isolated area test system. In future study of multi-area systems can be done for unscheduled interchanges under ABT.

REFERENCES

[1] NPTEL, Reforms in Indian power sector, Course Coordinated by IIT Delhi.

[2] Mrs Surekha R Deshmukh, Dr Dattatray J Doke and Dr Yogesh P Nerkar "Optimum Generation Scheduling with Purchase of Power from Market and Grid", *TENCON 2009 IEEE Power India Conference*.

[3] Bhanu Bhushan, "ABC of ABT_A Primer on Availability Tariff", 2005 Available online: http://www.nrldc.org/docs/abc_abt.pdf

[4] S. Chanana and A. Kumar, "A Price Based Automatic Generation Control Using Unscheduled Interchange Price Signals in Indian Electricity System", International Journal of Engineering, Science and Technology, 2(2), pp. 23-30.

[5] Central Electricity Regulatory Commission, Unscheduled Interchange Charges and Related Matters Regulation, CERC, 2014, New Delhi, India.

[6] HANS-PETTER HALVORSEN, "Introduction to Simulink", Telemark University College Department of Electrical Engineering, IT and Cybernetics 2011.06.06.