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Dynamic distribution of electricity in multiple areas by single power generating unit through simplex method

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ABSTRACT

Dynamic Load sharing in power resources domain provides a dynamic way of handling power shortages. In this paper, we propose simplex method with ratio and proportion, current and electricity formulae and electrical engineering concepts to dynamically share power. The power distribution logically divided into various layers. The resource need is calculated from each layers using three parameters viz., Power Normal Pn, Power Excess Pe, Power Deficient Pd. Two level of repositories viz., Local Repository, Global Repository are used. The function of local repository is to have the threshold value at each layer. The global repository is installed in Grid (thermal power plant) which calculates values from all the level. We introduced threshold calculation, which includes ratio, and proportion functionality at each layer and calculated the values of Pex, Pn, Pd. In which, message transmission is done with the help of message control system between layers using clock triggering pulses. It sends a series of bits to identify whether the need of power is normal, deficient or excess. The load frequency control system maintains load demand and the frequency of machine in the generating power plant.

Introduction

Distribution of appropriate amount of electrical energy to the consumers has always been a challenging task and above all considering where and how much electrical energy needs to be sent for the particular location is of prime importance.

Different domains have been taken into account to solve these problems, which include linear programming[1], Lagrangian relaxation-based algorithms artificial neural networks [2], Genetic algorithms [3].

Automated Load sharing is taken as such to have maximum gain in any domain because it involves sharing of resources efficiently. Development of the system focuses on the automated and dynamic load sharing of power generation. As the consuming capability gets higher, the need for efficient utilization of the power resources becomes a nightmare. The generating cycle of electricity is been lined through grid because grid distributes the resource for all substations that are connected through a particular geographical area. The grid identifies the resource needed and transmits the power according to the need. The power consumption is different from commercial, industries of large scale and small scale, hospitals, and universities etc.

The merits of this system can be summarized as,

- Efficient use of power resources
- Eradicating human errors
- Calculating the need

In efficient usage, the calculation of energy distribution is done on each level. The level of distribution varied from the grid to the end system. The system interacts with the local repository if the need of energy is identified from any of these. The local repository calculates the system with excess power P_e. Once the excess power P_e is identified, they share the resource according to the need for the systems. If there is no excess power in the local repository, it will check for the higher level repository to handle the need. The system we designed is dynamic in load sharing using simplex method. The system is to provide level-by-level load distribution of power resources. The advantage is the burden of the grid is so much reduced from the previous versions.

Related work

In [4] a new robust load frequency controller for two area interconnected power system is presented to quench the deviations in frequency and tie line power due to different load disturbances. The dynamic model of the interconnected power system is developed without the integral control. The area control error is also not included.

In [5] the decentralized load-frequency control (LFC) of a two-area power system. The model of the power system is determined, and is viewed as an interconnected system, for which the methods of the decentralized control are applied; these are based on the matrix, its kernel, and the equivalent system in the operator domain. Based on this, a decentralized control via linear programming methods and with decentralized optimization techniques is determined. Several responses are given and compared.

In [6] presented power system load frequency control by modified dynamic neural networks controller. The controller has dynamic neurons in hidden layer and conventional neurons in other layers. For considering the sensitivity of power system model, the neural network emulator used to identify the model simultaneously with control process.

To have validation of proposed structure of neural network controller the results of simulation demonstrated that the proposed controller offers better performance than conventional neural network controller.

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In [7] hybrid Neuro-Fuzzy (HNF) approach is employed for an Automatic Generation Control (AGC) of interconnected power system with and without generation rate constraint (GRC). The effectiveness of the proposed controller in increasing the damping of local and inter area modes of oscillation is demonstrated in a two area interconnected power system.

Proposed System

Proposed Linear model of the system

In this method, firstly the amount of power is distributed to grids and from there further distribution takes place to all substations which needs to be maximized and is represented as an objective function. Without laws of generosity and to have linear distribution to all substations, the amount of values for the co-efficient of the objective function is taken as one (unit). The power that is supplied to the particular substations is divided into a fixed ratio. This ratio is estimated according to the capacity and location of substations. Further, the power reaches to different substations; again the power is divided into the same or different ratios but in a cyclic way as depicted in the figure 2. And according to those ratios, the power is supplied to the substations and it finally reaches to the consumers. The message transmission for the power excess and power deficient is controlled by the message control system under the transfer function and positive and negative feedback factor. The detailed flow of this proposed system is given in figure.1.

System Function

At first electricity is distributed to the various grids and it is further distributed to different sub stations according to the requirement of consumers at that period of time. The power is divided into different sub stations in a fixed ratio. Say k1, k2, k3 and so on.

Sum of ratios=k1+k2+k3+…..+kn

(k1+k2+k3+……..) k= supplied power

Or k=supplied power/(k1+k2+k3+……..)

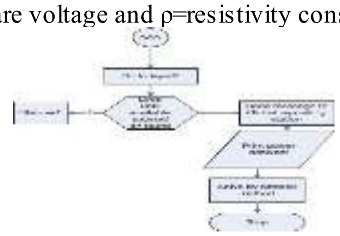
Simplex method is used to solve the linear equations and it will give the new required ratio that is "x" which decides the required amount of power with the help of bit pattern analysis and message control system. When this x is multiplied by different ratios it will exactly give the appropriate amount of energy what the substations required. This process is continuously repeated according to the signal generated by the feedback factor. The load frequency control system maintained the voltage as well as randomly varied load demand.

During the distribution of electricity, there is a loss of power due to resistance of the wire and other factors.

$$P_{\text{time averaged}} = \frac{V^2_{\text{rms}}}{R}.$$

R=ρ*len/A

Where len = length of wire ,A= cross section of wire, V_{rms}= root mean square voltage and ρ=resistivity constant of wire.



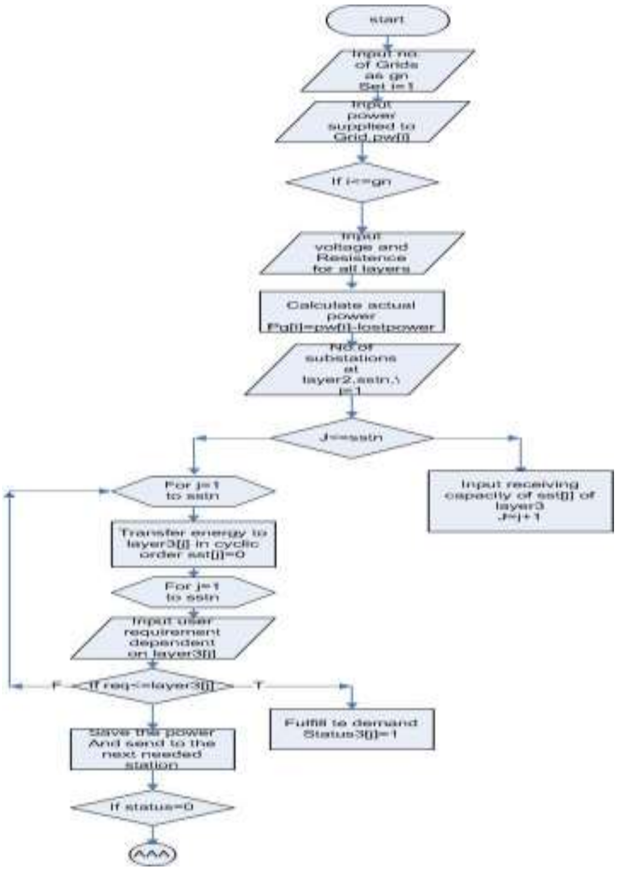


Fig1: Flow Chart of the Proposed System

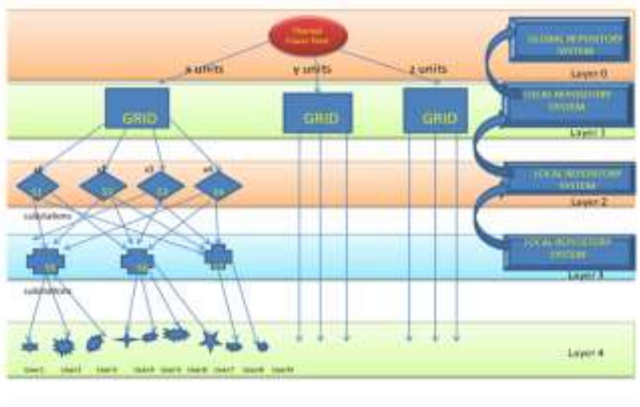


Fig 2: Electrical Network Based on Simplex Method

Total supply of power = required power + power loss

At any moment total energy requirement would be

For Area 1

MaxR1=k11X1+K12X2+K13X3++…+k1nXn

[level 1 for substation 1]

subject to constraint,

L1X1+L2X2+L3X3+… +LnXn <=PRS1 [level 3]

L2X1+L3X2+L4X3+… +L1X1<=PRS2 [level 3]

……………………………………………………………

LnX1+L1X2+L2X3+....+Ln-1Xn<=PRSn [level 3]

Similarly,

For Area 2

MaxR2= K11Y1+K12Y2+K13X3+……..+K14YN

[level 1 for substation 2]

subject to constraint

L1Y1+L2Y2+L3Y3+…...+Ln Yn<=PRS1 [level 3]

L2Y1+L3Y2+L4Y3+…...+L1Y1<=PRS2 [level 3]

……………………………………………………………

LnY1+L1Y2+L2Y3+…..+Ln-1Yn<=PRSn [level 3]

For Area n

MaxRn=K11Z1+K12Z2+K13Z3+…. +K1NZN
[level 1 for substation 3]
subject to constraint

L1Z1+L2Z2+L3Z3+……….. +LnZn<=PRS1 [level 3]

L2Z1+L3Z2+L4Z3+……….. +LnZ1<=PRS2 [level 3]

……………………………………………………………

LnZ1+L1Z2+L2Z3+……….+Ln-1Zn<=PRSn[level 3]

Where Lm = Fixed Load by which power is divided.
PRS= Power required for substation + Power loss.

After solving

(X1+X2+X3+…+Xn)*sum of ratios=C1
(Y1+Y2+Y3+…...Yn)*sum of ratios =C2
(Z1+Z2+Z3+...….+Zn)*sum of ratios =C3
Cn: Current requirement of Area n
Then many situation may arises,
if (R1=C1 , R2=C2 and R3=C3),
No power is required.
if (R1>C1) and R2= C2 and R3=C3)
Calculate C1- R1=x(say)
Supply C1 = R1+x amount of power to the needed Area.
If (R1>C1, R2>C2, R3>C3),
Calculate Z= (R1-C1) + (R2-C2) + (R3-C3),
Where Z is the amount of power needed to be produced in the grid.

Further, if the entire area required more than the capacity of the production of grid, then it will share the excess resource from other substations.

Message transmission

The message transmission part is subdivided into 3 steps, viz., Local repository maintenance, Global repository maintenance and Bit pattern calculation.

Parameters viz., time, block bits, substation number, and current efficiency are used in local repository maintenance.

At every fixed interval of time, the end systems update their log information to their local repository. If power deficiency is found in any of the system, then the local repository tries to maximize the efficiency. If the services are not available in local repository, it will request the load from the global repository.

The bit is interpreted from the clock signals given by the end system. The knowledge database have bit patterns to check whether there is power deficiency , power excess or power normal. The knowledge system in each level analyzes the bit pattern and calculates the threshold value (€).

Bit pattern analysis determines the efficient calculation of required energy; there are three fixed bit patterns which would be stored in the repository system.

11011011 for power deficiency (P_d)
01111100 for power normal (P_n)
10000110 for power excess **(**P_{ex})

The threshold value will be determined on the basis of above bit patterns by making comparison in the bit values. The Way of solving shortage of electricity is given in figure. 3.

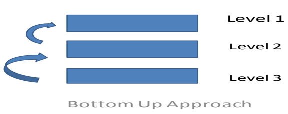
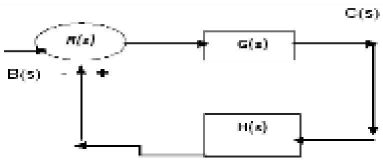


Fig 3: Way of solving shortage of electricity

The periodic information of the end systems are clocked down to the local repository. The LR calculates the threshold value of that horizontal level. Bit pattern is introduced to interpret those clock signals. The bit pattern is already stored in the knowledge system and according to clock signals submitted to the LR, it matches the functions. After the matching is done, it summarizes the stations with Normal or Excess or Deficient resource supply.

Message Control System

Message control Systems performs dynamically the functions of regulation, protection, control, monitoring, alarm and information management in the power plant. It is a central information system enabling the plant operators to supervise the plant effectively and to make the right decisions in time, and it also ensures fault free operation in the plant. Therefore control system is used to send required optimized power at the Power station. The proposed model works under closed loop control system with the positive feedback and the negative feedback [8][9]. The message sent by the message control system is reached at the grid and finally the internal function of the machine take place i.e. the local repository system contains overall information about the substations in case of power deficient then the actual action by the grid come into action for the power shortages. The figure.4 shows the actual transmission of power signal is being sent from the local repository system to the global repository system at the power plant.



Where H(s) =Feedback factor G(s) =Transfer Function[10] is defined as Laplace's transformation of output to the Laplace's transformation of input. R(s) =Input signal, C(s) =Output signal, B(s) =C(s)*H(s), C(s) =G(s)*R(s) Since cascaded series generally multiplied. Above control system works on following feedback to the electrical grid and the power station. The solid lines with arrows indicate the flow of signals between the components. The circle in the figure represents a summing junction, which combines its inputs by addition or subtraction depending on the + or - sign next to each input. The blocks in the diagram represent linear system components. Each block can represent dynamic behavior with any degree of complexity as long as the requirement of linearity is satisfied.

Positive Feedback

Positive feedback helps to maintain stability in a system by making some external changes. Since excess Power need to reduce it.

$$B(s)=C(s)*H(s)$$
$$E(s) =R(s)-B(s)$$
$$C(s) =G(s)*E(s)$$
$$\text{Or } C(s) =G(s) [R(s)-B(s)]$$
$$\text{Or } C(s) =G(s) [R(S)-C(s)*H(s)]$$
$$\text{Or } C(s) =G(s)*R(s)-G(s)*C(s)*H(s)$$
$$\text{Or } C(s) [1+G(s)*H(s)] =G(s)*R(s)$$
$$\boxed{C(s)/R(s) =G(s)/(1+G(s)*H(s))}$$

Above equation shows Power is excess and need to decrease the power in order to meet the demand.

Negative Feedback

Negative feedback determines how much gain must be produced in order to obtain certain stability and helps to maintain the stability in a system in spite of external changes.

$$B(s)=C(s)*H(s)$$
$$E(s)=R(s)+B(s)$$
$$C(s)=G(s)*E(s)$$
$$\text{Or } C(s)=G(s)\,[R(s)+B(s)]$$
$$\text{Or } C(s)=G(s)\,[R(S)+C(s)*H(s)]$$
$$\text{Or } C(s)=G(s)*R(s)+G(s)*C(s)*H(s)$$
$$\text{Or } C(s)\,[1-G(s)*H(s)]=G(s)*R(s)$$
$$\boxed{C(s)/R(s)=G(s)/(1-G(s)*H(s))}$$

Above equation shows, Power is excess and need to decrease the power in order to meet the demand.

Load Frequency Control System

In the interconnected power system, there is unexpected change in the demand of power load, which cause for the change in the load frequency in the interconnected power system with the same single generating unit. However, the load is randomly and momentarily changed by the users of the electric power. It will be impossible to maintain the balances of both the active and reactive powers [11] without control. Because of the imbalance, the frequency and voltage levels will be varying with the change of the loads. A power system thus satisfies all types of needs by transporting electricity to factories and houses. In order to optimize the performance of electrical equipment, it is necessary to ensure the quality of the power. Hence, it becomes necessary to maintain the load frequency as well as voltage in the generating power plant with steady state error to be zero. Thus a control system becomes essential to cancel the effects of the random load changes and to keep the frequency and voltage at the standard values.

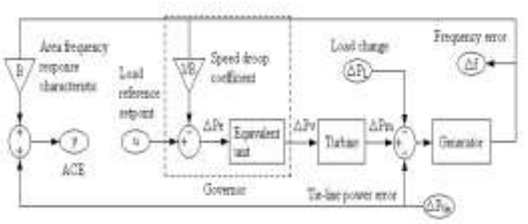


Fig 5: Dynamic model of one-area power generating units

In fig.5 there are three inputs, which are the controller input U(s), load disturbance $\Delta P_L(s)$, and tie-line power error $\Delta P_{tie}(s)$, one ACE output Y(s) and one generator output Δf. The input of the equivalent unit in the governor as ΔP_e for simplicity when developing the Laplace transform of the one-area power generating plant.

The Laplace Transform Model of One-Area Power Generating Plant. The relationships between the inputs and output in the above figure can be described as

$$U(s)-1/R\Delta F(s)=\Delta P_e(s)$$
$$G_{EU}(s)\,\Delta P_e(s)=\Delta P_v(s)$$
$$G_{EU}(s)\Delta Pv(s)=\Delta P_m(s)$$
$$(\Delta P_m(s)-\Delta P_L(s)-\Delta P_{tie}(s))G_{Gen}(s)=\Delta F(s)$$
$$Y(s)=B\Delta F(s)+\Delta Ptie(s)$$

Where $G_{EU}(s)$, $G_{Tur}(s)$ and $G_{Gen}(s)$ are the transfer functions for the equivalent unit, the turbine and the generator respectively.

Experimental Results and Challenges

The system has been implemented in C platform and executed for various amount of energy and its ratio of distribution. Energy required, new ratio after solving simplex method has been found for optimum distribution as result of execution and the results are tabulated.

The proposed system works in four categories:

- Location Independent.
- Unpredictable Scenario.
- Work on real time
- Efficient energy and time saving.

Future Work

As a future work, the system could be extended to more substations to make even more efficient. The fuzzy logic can be included into the system to make it even more precise and efficient. The temporal reasoning of the system could be extended to other time intervals that exist.

Conclusion

The proposed system showed a dynamic way of improving Load balancing. The power requirement is handled at the horizontal partition of layers; the severe load on grid is minimized. The simplex method provides optimized result for the system. The message transmission is made simpler by bit pattern communication. The power supply is uninterrupted using Local and Global Repositories services.

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Location	Energy supplied	Splitted Ratio	Actual ratio	N0. of substations at level 1 and 2	Energy splitted for substations at level 3	Energy required	New ratio after solving simplex method	Results
Area1	1000 Units	1,2,3	144.33	3,3	1,2,3	200 Units	171.50	151 Units Power required
					2,3,1	120 Units		
					3,1,2	145 Units		
Area 2	1200 Units	1,2,3	146.47	3,3	1,2,3	200Units	160.66	114 Units Power saved
					2,3,1	100 Units		
					3,1,2	100 Units		
Area 3	1500 Units	2,3,4	153.11	3,3	2,3,4	300 Units	180.50	246.50 Units Power Required
					3,4,2	290 Units		
					4,2,3	475 Units		