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Design of Rotation Monitor and Simulation Design to Record the Variation of Frequency Effect on ALFC Loop

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Abstract: Power Engineer has the responsibility to deliver economically, adequate and quality power to consumers. In order to achieve this, the power system must be maintained at the desired operating level by suitable modern control strategies. Load frequency control (LFC) mechanism to maintain or restore the frequency and tie line power flow among the interconnected power systems within the specified limit.

Keyword: Smart motor, load frequency control, matlab analysis.

I. INTRODUCTION

The active and reactive power balance must be maintained between the generation end and load end. With the slightest change of voltage or frequency the equilibrium point changes. Good quality of electrical power system means maintaining a flat voltage profile [1]. To mitigate the effect of load variation and to keep a constant frequency and voltage profile we need a control system. Even if the active and reactive powers have a combined effect on the frequency and voltage, the control problem of the frequency and voltage can be dealt with separately. Frequency is dependent on the active power and voltage is dependent on the reactive power [1]. Thus, the issue of controlling power systems can be dealt as two independent problems. The active power and frequency control is precisely known as load frequency control (LFC). The Responsibility of LFC is to maintain the frequency against the varying active power loads [2]. The motor will be in good compensation; this ideal motor is known as SMART MOTOR.

A. Reasons For The Need Of Maintaining Constant Frequency

Speed of a.c. motor and frequency are directly related, the speed of the alternating current motors depends on the frequency power supply. There are situations where speed consistency is expected to be of high order. We know the normal frequency is 50 hertz and if it happens that the turbine speed is less than 48 Hz or greater than 52 Hz then the turbine blades may get damaged [2].When frequency goes below rated frequency at constant system voltage then the flux in the transformer core increases hence the transformer core goes into the saturation region. Therefore, the operation of transformer below the rated frequency is not recommended. With reduced frequency, the blast by ID fans and FD fans decrease in power plant, and so the generation decreases and thus it becomes a multiplying effect and may result in shut down of the plant.

II. TECHNICAL DESIGN

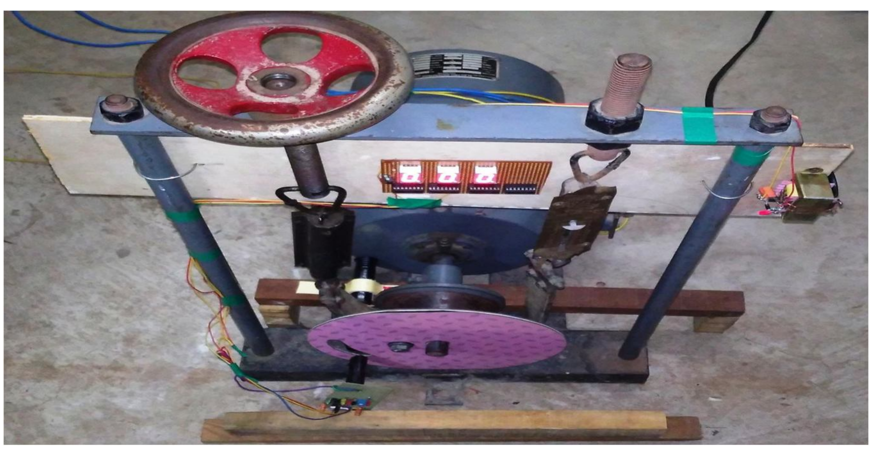


Figure I(Hardware set -up)

A. Objective Of Our Smart Motor Project

LFC is a very important item in power system operation and control for sufficient and reliable electric power with good quality. Many control strategies have been proposed to achieve improved performance. The Integral and Proportional plus Integral control approach is one such strategy. For this achievement, we are going to develop a **SMART MOTOR** for maintaining constant frequency as well as active & reactive power.

B. Equipments

For this project, there are so many equipment required. This are-

1) Autotransformer
2) Motor
3) Led (LIGHT SOURCES)
4) DISC(dia 11cm, shaft dia 19.7 mm)
5) Voltage Regulator(IC 7805)
6) LDR Circuit
7) Frequency Counter Circuit

C. Motor Specification

Developed By: Electro Enterprise Calcutta
Machine: Universal Motor
Speed 1400 rpm
Dc output :H.P 4
Dc volts:220
Amps:3.8
Wound: Shunt
No: K 228.02

III. FREQUENCY COUNTER

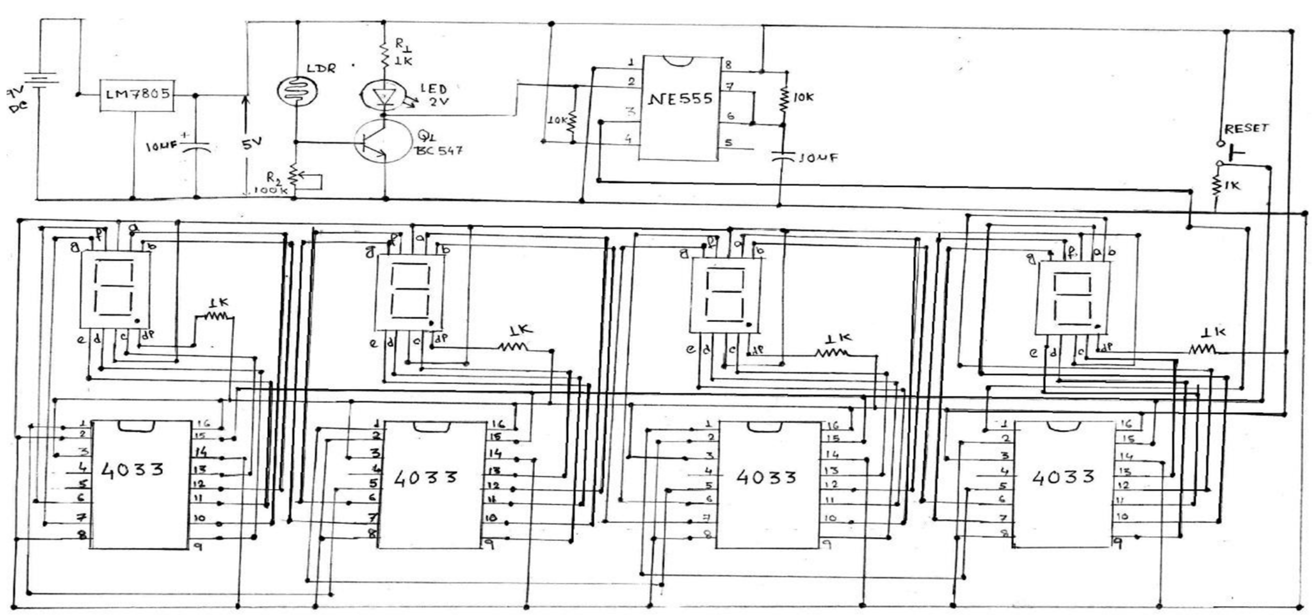


Figure II (Project Circuit diagram)[3]

A. Experimental Data Table

Power System Demand	Average Speed (rpm)	Output Voltage (V)	System Frequency (Hz)
No Load	354(ref. Speed)	49 ($V_{ref.}$)	5.9 ($F_{ref.}$)
On Load 1st	343	47	5.7
On Load 2nd	335	45	5.5

1) *Calculation:* System Frequency: - We know frequency is the number of wave cycle or revolutions per second.

f$=\frac{revolution}{second}$ Hz

a) No Load Frequency ($F_{ref.}$): - $\frac{354}{60}$ = 5.9 Hz

b) On Load 1st Frequency : - $\frac{343}{60}$ = 5.7 Hz

c) On Load 2ndFrequency : - $\frac{335}{60}$ = 5.5 Hz

2) *Conclusion about the Experiment:* We have done an experiment using the set-up described above. We have seen that if we vary the load then the frequency and the supply voltage varies in accordance to it. Now if we use the frequency as a feedback to the input system, which is again connected to the speed governor then as the frequency changes feedback is given to the comparator. The output of the comparator is fed to the speed governor, which again governs the turbine output, which in turn governs the governor output. Here in our laboratory there was no adequate provision for the arrangement of the feedback drive so we have calculated only the variation of frequency and voltage. The table of which is shown above.

IV. SIMULATION

The variation of frequency causes the voltage profile to change, even though a deviation of (+) 2% or (-) 2% is allowed but a deviation of more than that can lead to a bad voltage profile. Here we have analysed using Simulink the variations of frequency and its effect on the loop. The idea of the mat lab programming is taken from Stephan J. Chapman's, Mat lab programming for Engineers.

An isolated control consists of a 200-MW generator with an inertia constant of H=5 Kws/KVA having the following parameters-Kps=100, (power system gain Hz/p.u. MW) Tps=20 s, (power system time constant), R=3, (regulation is expressed in Hz/p.u. MW), f=50 Hz, (constant frequency),Tsg=0.4 s, (time constant of hydraulic amplifier)Tt=0.5 s. (time constant of turbine)

We have decided to obtain the frequency error and plot the graph of deviation of frequency when a step load disturbance of 1% is applied.

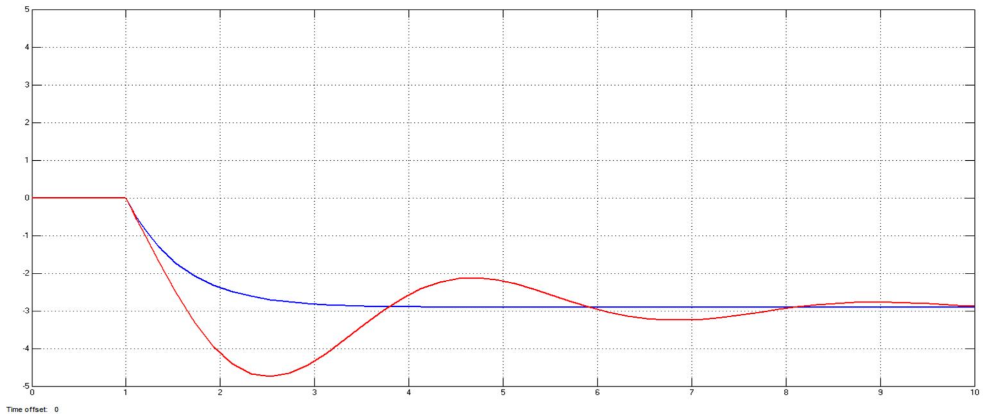
Now in the next case we consider the effect of governor and turbine dynamics is not allowed, Tsg=0 s, Tt=0 s for a step load changes of 1% is applied.

For the above problem if the effect of governor and turbine dynamics is allowed and turbine dynamics Tsg=0.4 s, Tt=0.5 s for a step load changes of 1%. [1]

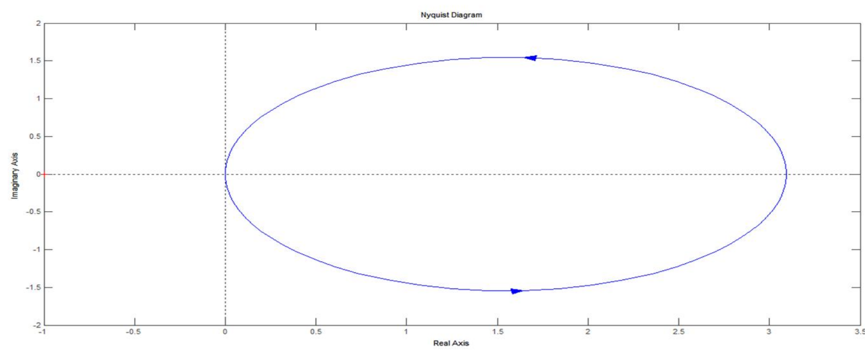
Now we simulate if we combine the above frequency plot for a load distribution the figure to be obtained.

A. Stability about ALFC Loop

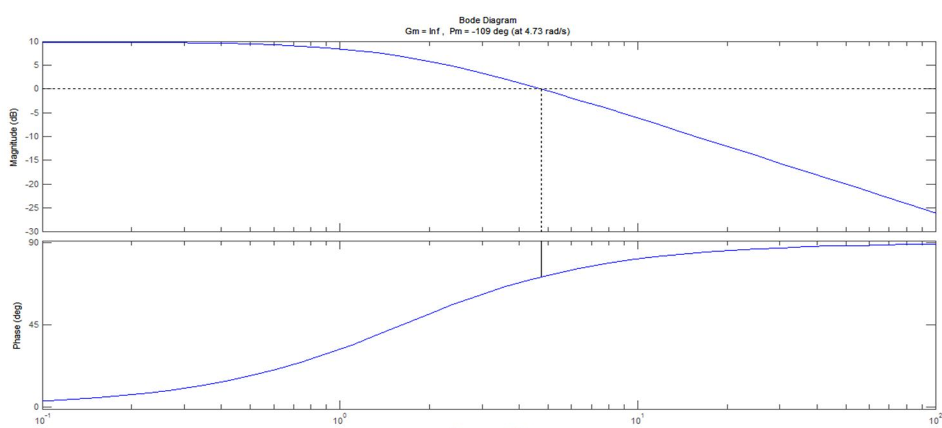
We can say from the above graph here red line curve i.e. with governor and turbine dynamics system is approximately stable than the blue line curve. We can get this decision through which point of view that is oscillations in terms of undershoot of red line curve produced on step unit change in load are much than blue line curve and settling time has also increase, as shown in curve. For the second curve (i.e. blue curve), the settling time of frequency deviation is low. So that this is less stable than the same type of alternator with governor and turbine dynamics system. It is observed that without governor and turbine dynamics system takes much longer time for stabilization than others do. Second Oscillation in terms of undershoot are observed in a mixed system consisting of thermal base Generation for a step unit disturbance in load [4]



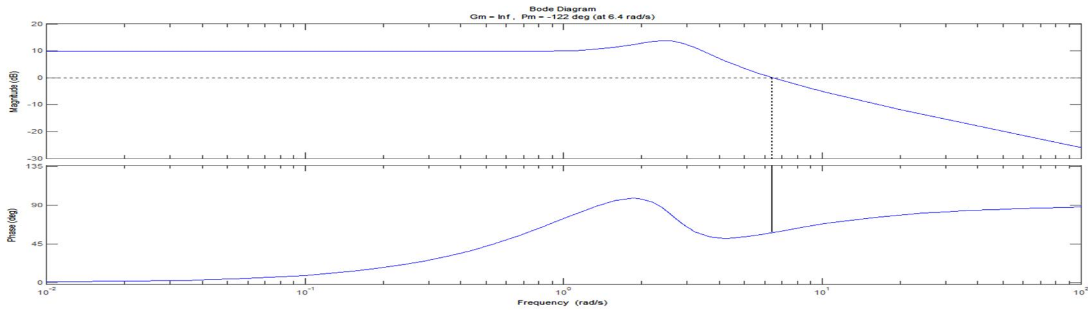
1) *Here in the First Case:* Gain Margin (GM) = Infinity, Phase Margin (PM) = 109^0, Gain cross over frequency (GCF) = 4.73 rad/s, Phase cross over frequency (PCF) = Infinity .We can see the Gain Margin (GM) & Phase Margin (PM) both are positive as well as Gain Cross over Frequency (GCF) less than Phase cross over Frequency (PCF) so the system is absolutely stable.



2) *Here in the Second Case:* Gain Margin (GM) = Infinity, Phase Margin (PM) = 122^0, Gain cross over frequency (GCF) = 6.4 rad/s, Phase cross over frequency (PCF) = Infinity. Here we can also see the Gain Margin (GM) & Phase Margin (PM) both are positive as well as Gain Cross over Frequency (GCF) less than Phase cross over Frequency (PCF) so the system is absolutely stable. But in this case phase margin is more from the first case, so we can say about that point only it is more stable from the first one but is it is not satisfactory result about the contribution. For that point of view we cannot say properly who is absolutely stable, so we are going to next plot for proper result is called Nyquist Plot. In this Plot, we can check who is stable with governor turbine dynamics or without governor turbine dynamics system.



3) *Here in the First Case:* we can see the point (-1+j0) is not encircled by the plot, therefore we can say N=0 .But from the transfer function we can see one open loop pole in the right hand side of the S plane. Now we can say P=1.Now the no. of zeros (roots) of the characteristics equation with real part is determined by using relation N= (P-Z).Because,P=1, N=1.Hence, the closed-loop system given in the example has one root with positive real part and closed-loop system is unstable.

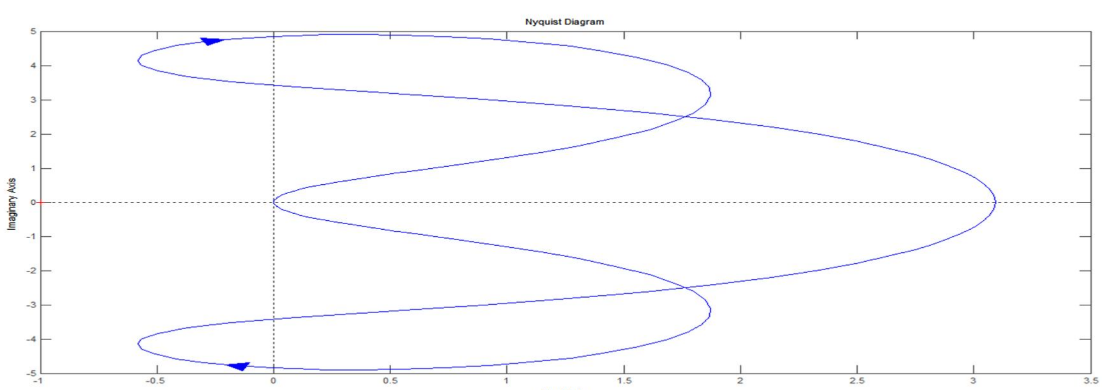


4) *Here in the Second Case:* We can see the point (-1+j0) is not encircled by the plot, therefore we can say N=0. Again from the transfer function we can see there is no open loop pole in the right hand side of the S plane.Now we can say P=0.Now the no. of zeros (roots) of the characteristics equation with real part is determined by using relation N= (P-Z)Because, P=0, N=0. Hence, the closed-loop system given in the example has no root with positive real part and closed-loop system is stable. At least we have done for the last frequency plot; second one is more stable from the first one ie. with governor turbine dynamics system is more stable from without governor turbine dynamic system.

Another isolated control is considered which consists of a 200-MW generator with an inertia constant of H=5Kws/KVA having the following parameters-Kps=100, (power system gain Hz/p.u. MW)Tps=20 s, (power system time constant)R=3, (regulation is expressed in Hz/p.u. MW)f=50 Hz, (constant frequency)Tsg=0.4 s, (time constant of hydraulic amplifier)Tt=0.5 s. (time constant of turbine)Obtain the frequency error and plot the graph of deviation of frequency when steps load change of 0.48pu with an integral controller action of Ki=0.1 is applied.Now if in the above case step change in load is allowed plot the graph.

B. *Stability about the Controller*

When there is sudden any inter connected system, the frequency are affected. It is essential to minimize these errors for economical, reliable operation of power system. So the integral controller is studied here to meet the starting demand. Integral square error and integral time absolute error has been considered as performance indices study.We can say from the above graph here red line curve i.e. with governor, turbine dynamics system and integral controller is more stable than the blue line curve. We can get this decision through which point of view that is oscillations in terms of undershoot of red line curve produced on step unit change in load are much than blue line curve and settling time has also increase, we know high settling time means low bandwidth i.e. in response to the error the controller is first, as shown in curve. As we all know for a good power system economic consideration is an economic factor so the controller design meet the requirement of system frequency, which is important aspect of AGC(AutomaticGenerationcontrol).[1]



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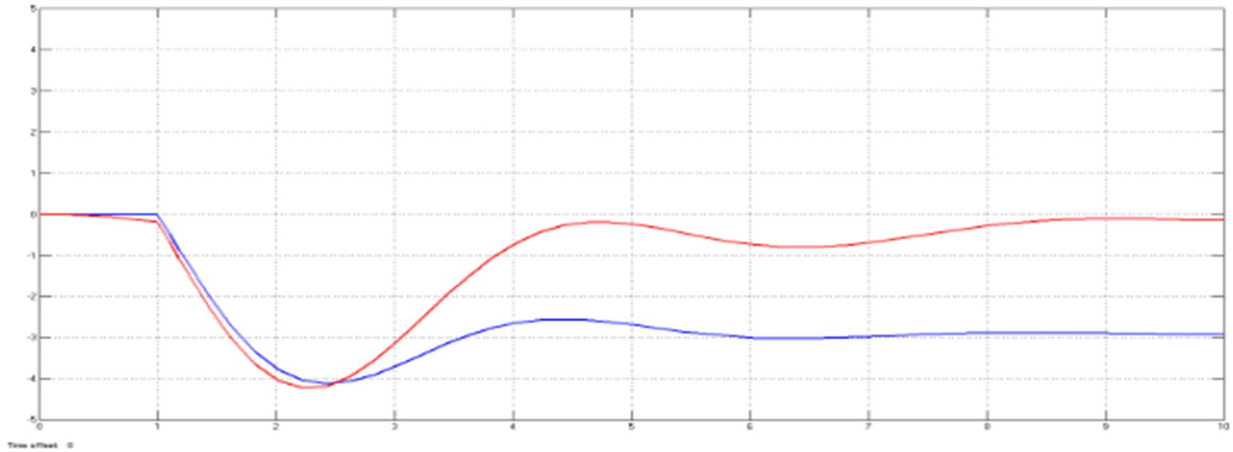

V. CONCLUSION

Load frequency control investigated in this project has recently come into question in operation of interconnected power networks.as frequency is a sensitive parameter so it needs to be controlled. Therefore, power utilities consider the frequency and active power balance throughout their networks to sustain the inter connection. In inter connection between national / continental networks, providing the constant frequency between areas is a serious operational problem. Hence first and no delay decision-making mechanism have to be installed in network controlled units namely the ALFC[1].The load frequency is achieved with in tree levels, considering many issues from maintaining constant frequency and the minimisation of losses through tie lines to the optimal dispatch of generation between units or even areas. The simulation techniques are very useful in study and predicting the response of control systems, given the opportunity to optimise the response and so behaviour of the system under study. The economic dispatch of generation plays a vital role in the AGC, and this issue could be studied as an extension of this project, adding an additional dimension to the task of our project.

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