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Embedded Based Control for Steam Turbine to Maintain Frequency using RGMO

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ABSTRACT

As per the CERC guidelines, Thermal generating sets with a capacity of more than 200 MW should be under RGMO. In RGMO, all generating units operating shall normally be capable of instantaneously picking up 5% extra load for at least 2 minutes and compensate the sudden drop in the grid frequency. It is necessary for the Power load operators and regulators to manage distribution services efficiently to maintain reliability of the power system. Frequency regulation is one of the distribution services to be supplied by the electricity market participants. Frequency mismatch between the load and generation is caused due to the sudden tripping in the generators. To compensate the drop in the frequency RGMO is implemented.
Keywords : Central Electricity Regularity Commission (CERC), Restricted governing Mode of Operation (RGMO).

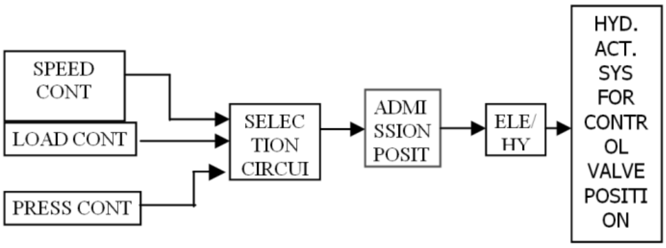
I. INTRODUCTION

Over the years in Thermal Power Station, they are generating 210 MW of power in each of 5 units. Power plant requires frequent monitoring and inspection at regular intervals. Each unit have number of boiling section, turbine, generator and transformer. A Turbine is a prime mover that derives its energy of rotation due to conversion of heat energy of steam into kinetic energy. Turbine governing system is meant for regulation of turbine speed under no load and varying load condition. It helps in precise control of grid frequency under normal operation and protects the machine as well as grid during emergency situation. There are two types of governing namely, Mechanical Hydraulic Governing and Electro Hydraulic Governing .In both the governing to increase the load, the steam admission is increased. Since the machine is in Grid, instead of increasing the speed of Turbine the Load is increased by means of electrical theory. Steam admission is through 4 control valves (2 HPCVs and 2 IPCVs).

Hence to increase the Load, the control valves are to be opened and to decrease the Load, the control valves are to be closed. Since the 4 control valves are opened / closed by means of secondary oil pressure (Blue Pipe line), the final output of both the Governing should be a signal to increase / decrease the secondary oil pressure i.e. by means of single signal, 4 control valves are opened / closed. The operation of IPCVs is advanced by means of their respective Follow – Up pistons and HP /IP Trim Device.

II. METHODS AND MATERIAL

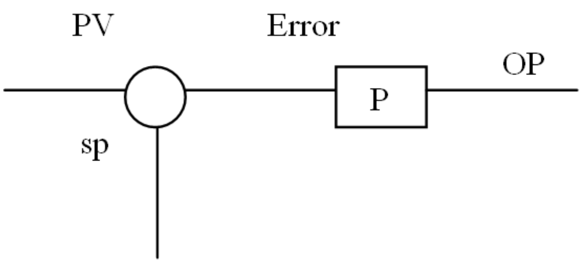
A. Turbine Governing System Electro Hydraulic Governing



In Mechanical Hydraulic Governing, we are just opening / closing the secondary oil drain thereby varying the HP /IP control valves position. Hence Load will be varying according to the Frequency and Drum Pressure. But in EHG Load is maintained constant to the set value by providing various closed loop control systems. In EHG we have 3 control loops namely

1. Speed Control Loop
2. Load Control Loop
3. Pressure Control Loop

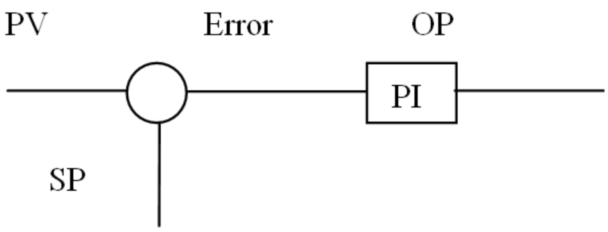
Generally for a controller we have to give Set point (SP) and Process Variable (PV).Depending upon the Algorithm the controller will give an Output. For an example:



Usually Error = SP – PV

For a (+) ve error i.e. If the controller output is (+) ve then it is Direct Acting controller**.** ii. If the controller output is (-) ve then it is reverse Acting controller.

B. Speed Controller



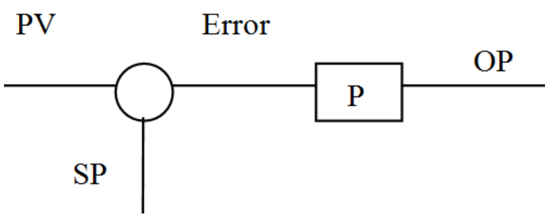
SP = Speed Reference
PV = Actual Speed

Error = Speed Reference - Actual Speed

For an error of +/-150 RPM the controller output will be +/- 100 %. Since this controller uses only P action, there should be some error i.e. some difference between Speed Reference and Actual Speed. Or otherwise the controller output will become **zero.**

C. Load Controller

SP = Final Load Reference
PV = Actual Load.



But this controller uses both P and I action the controller always tries to make the error zero i.e. there will not be any difference between Load reference and Actual Load.

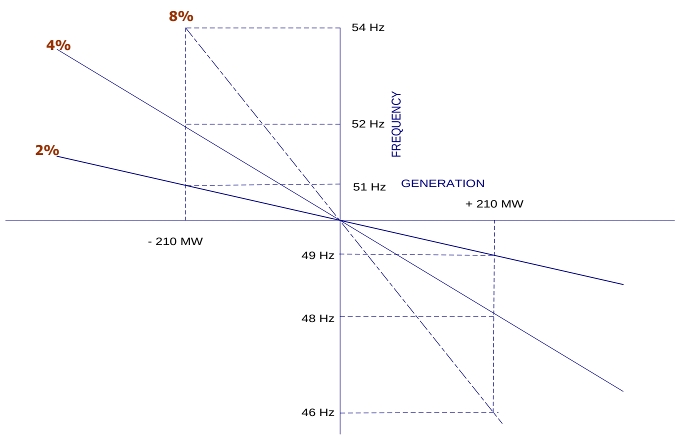
D. Pressure Controller

SP = Pressure Reference from Boiler Master Control (BMC)
PV = Actual Throttle Pressure.

E. DROOP or REGULATION

Droop can be defined as the percentage change in speed for a change in load. The sensitivity of the governor for a given change in load varies inversely with the percentage droop. The drop of the hydro turbines will be around 2 to 3% where as that of the steam turbines will be 4 to 8%

DROOP CHARACTERISTICS



F. Primary Response Vs Secondary Response:

Whenever the frequency varies due to a sudden loss of generation or demand, the governor immediately responds to negate the change. This response is known as Immediate Response or Primary Response. The subsequent control action by the unit controls viz., automatic controllers like pressure controller, Coordinated Master Controllers etc., or the operator –

initiated actions to restore the generation is called Secondary Response.

G. Free Governor Mode of Operation

Frequency instability occurs due to the mismatch between load and generation caused by tripping of generators and rejection of loads giving rise to a sudden change in frequency. When the turbo-generator is on bars, the governor of the turbine, if its wings are not clipped, responds to a change in frequency by varying the control valve lift and so varying the generation. The change in generation depends on the droop characteristics of the governor. All the turbo-generators in the grid participating in the governing action tend to annul the change in frequency by increasing or decreasing the generation. This mode of governor operation compensates the change in frequency by change in generation and is called Free Governor Mode of Operation (FGMO).

If the provisions available in the governor and control circuits viz., load limiter, dead band, switching off the governor etc., are employed to curtail the FGMO, it will lead to higher swings in frequency, instability of the grid and subsequent pull out even.

H. FGMO - GRID CODES:

All generating units should have their speed governors in normal operation at all times to enable Grid frequency control by loading / unloading

Droop characteristic for primary response should be within 3% to 6%

Each unit shall be capable of instantaneously picking up at least 5% extra load for a minimum of 5 minutes (up to 105%MCR), during fall in frequency

III. RESULTS AND DISCUSSION

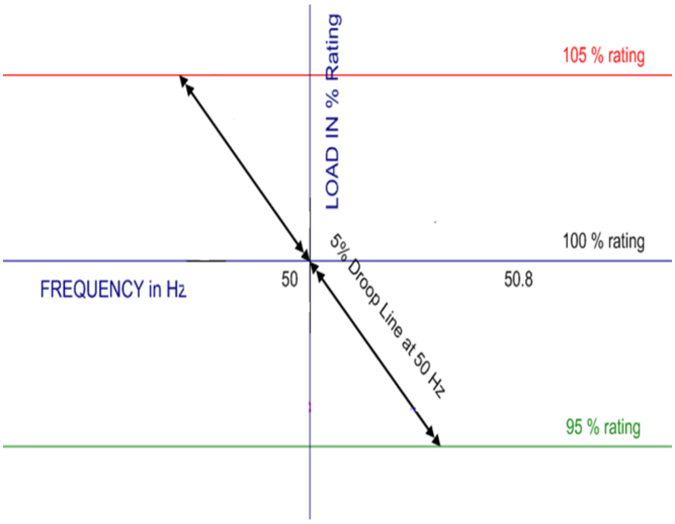
A. Implementation of FGMO:

In line with clause Clause 1.6 of IEGC and CERC order dated 30-10-99, date of FGMO implementation, as decided by REBs are :-

1) Western Region - 19-05-03 (ABT - 01-07-02)
2) Southern Region - 01-08-03 (ABT - 01-01-03)
3) Northern Region - 01-10-03 (ABT - 01-12-02)
4) Nor-East Region - 22-12-03 (ABT - 01-11-03)
5) Eastern Region - 02-01-04 (ABT - 01-04-03)

B. Existing FGMO Operation

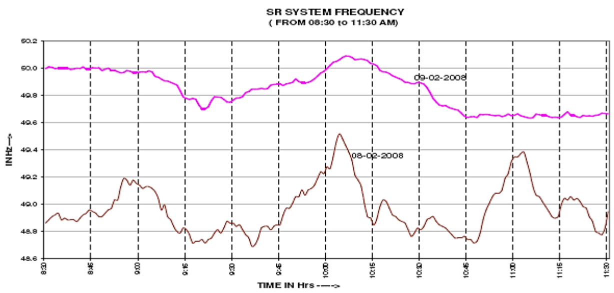
The magnitude of frequency deviation between the rated frequency and that existing in the grid system represents the measure of the ratio of the power generated (by all generating units) to the load demanded by all consumers. Accordingly if the power generated matches with the load demanded, the frequency in the grid will be equal to the rated frequency. In case of deficit in total power generation in the grid.



C. TRAIL in SR POWER SYSTEM:

An important exercise was successfully conducted in the power system of Southern Region on Saturday morning. Speed governors are an in-built feature of every turbine generator for equipment safety as well as system frequency control. They have however been kept out of service on most generating units for various reasons, for many years. An attempt is being made now to restore them, by adopting what is popularly called Free-Governor Mode of Operation or FGMO.

The Southern Region comprises of the States of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu, and the UT of Puduchery. A trial operation of FGMO was conducted with active participation of all State Utilities, NTPC and NLC. All thermal sets of 200 MW and above, and all hydro units were required to be on FGMO during this period, and most generating units did participate in the exercise, which was coordinated from the Regional Load Dispatch Centre at Bangalore. The results are being analyzed to assess the relative performance of each generating unit.



RGMO:

- The CEA Committee Consulate With BHEL For Implementation Of FGMO On KWU
- CEA has observed that the frequency profiles of power system in India has improved significantly after implementation of ABT and the same now generally remains within 49.0 to 50.5 Hz against pre-ABT levels of 47.5 to 52.5Hz. Thus, Requirement of implementing FGMO in a scenario of frequency variation of 49.0 to 50.5 Hz is unique.
- For 210 MW coal fired generating units with KWU turbines of BHEL make, the committee has recommended and adaptation of a control logic in which "Reference frequency" would be allowed to float and track the actual frequency.
- CEA has further the following moderated form of FGMO in the current scenario: "Load change is proposed to be limited to +/-5% of MCR in the frequency range of 49 Hz & 50.5 Hz and sustained for about 2 minutes before ramping back to original load automatically. Small changes up to +/-0.03% Hz are ignored for load corrections.

RGMO:

To include the above features in the existing ISKAMATIC controller of units 4 & 5, max DNA based RGMO module has been incorporated in the CJJ 02 panel of the Electro-Hydraulic Turbine Controller.

In the new RGMO controller, the frequency Set Point will be floating, not fixed as in the existing EHC. The Floating Frequency set point will be generated by the actual value of the turbine speed. Load changes are made whenever the frequency changes from the operating frequency by more than ± 0.03 Hz. During this change of frequency, for duration of 2 minutes proportional to the frequency change, a HOLD signal is generated. This signal forces the floating frequency set point to the last set value held. The frequency influence signal with the proportional gain corresponding to the droop setting starts coming down as the frequency deviation reduces under the action of the controller.

The frequency influence signal is added to the Load Set Point "Pr" to form the Final Load Set Point "Sigma Pr" of the load controller. This is in addition to the Pressure Deviation correction already available at the controller. The load change so made is sustained for about 2 minutes (dynamic time delay) after which period the load value comes back to the original value in a ramped fashion. If the frequency varies during this period by more than ± 0.03 Hz, dynamic time delay becomes zero and count starts again.

After the frequency stabilises at a value within ± 0.03 Hz, the HOLD signal is removed and the floating frequency set point assumes the new frequency value and the system is available for the next frequency change.

The RGMO will be available when the load controller is active. The pressure controller should be selected in Limit Pressure Mode.

The pressure controller of EHTC in Limit Pressure mode ensures that the load is reduced to maintain the boiler header pressure ·in the event of a sudden pressure drop more than set limit value.

The outputs of FGMO are blocked under following conditions:-

- CMC OFF
- Boiler master not on 'AUTO'
- Load Controller not active

For blocking the output following condition is provided as per CERC

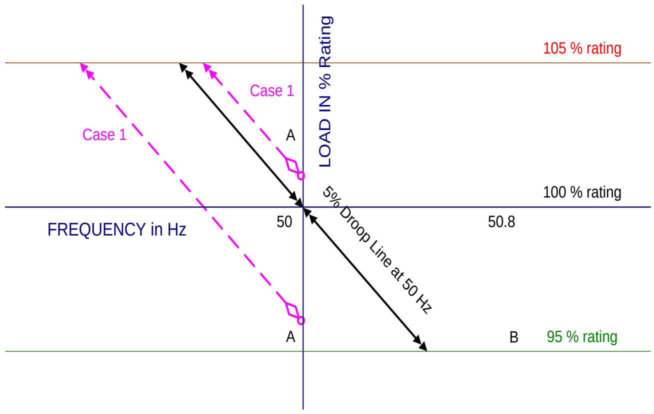
- If frequency is between 49.0Hz to 50.0Hz and it is increasing towards 50Hz then 5% unloading is blocked.
- If frequency is between 50Hz to 50.5 Hz and it is decreasing towards 50Hz then loading upto 5% is blocked.

D. Restricted Free Governing Mode Of Operation:

As per the CERC guidelines, thermal generating sets with a capacity of more than 200 MW should be under Restricted Free Governing Mode of Operation which is characterised as below:

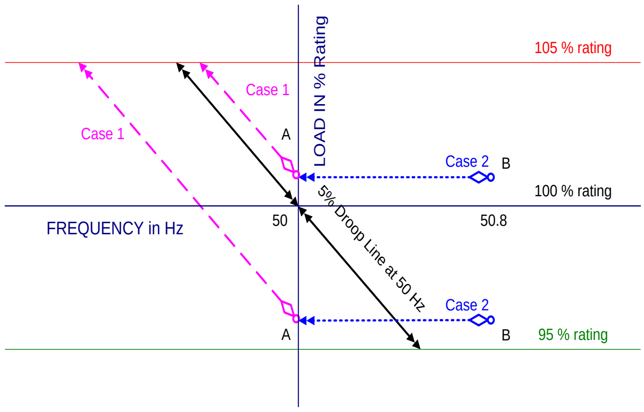
- The RGMO should be in operation by the sets between a frequency range of 49 and 50.5 Hz.
- When the frequency is lowering from 50 Hz, Load rise has to be effected up to 5 % rating as per the droop characteristics of the set.

Case 1: Frequency lowers from 50 Hz from "A"



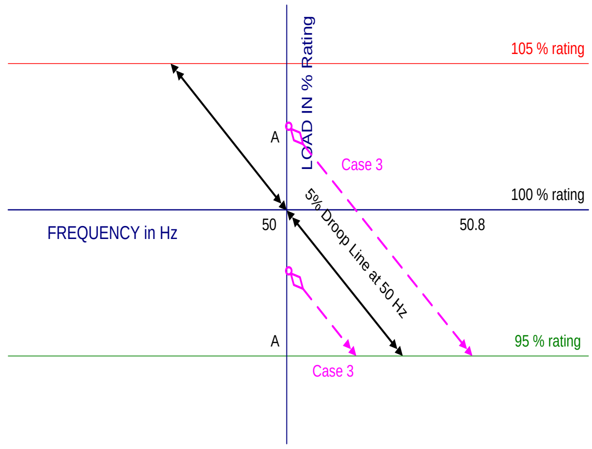
When the generator frequency is lowering towards 50Hz from a higher frequency, the load correction signal is blocked.

Case 2: Frequency lowers from a higher frequency < 50.8 from "B" (from "A" it is same as Case 1)



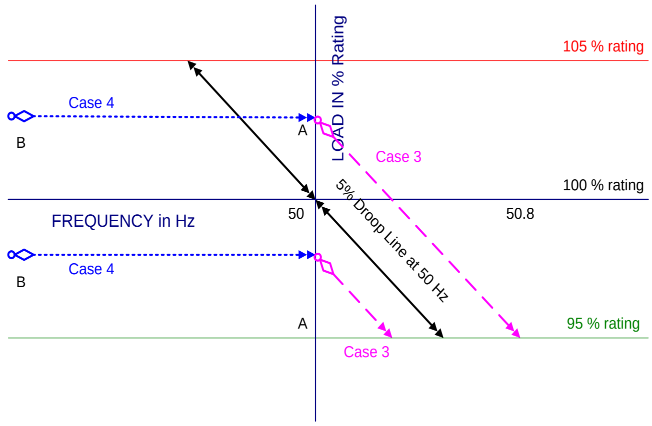
During the frequency rise from 50 Hz to a higher value, Load reduction signal is released up to 5 % as per the droop characteristics.

Case 3: Frequency rises from 50 Hz from "A"

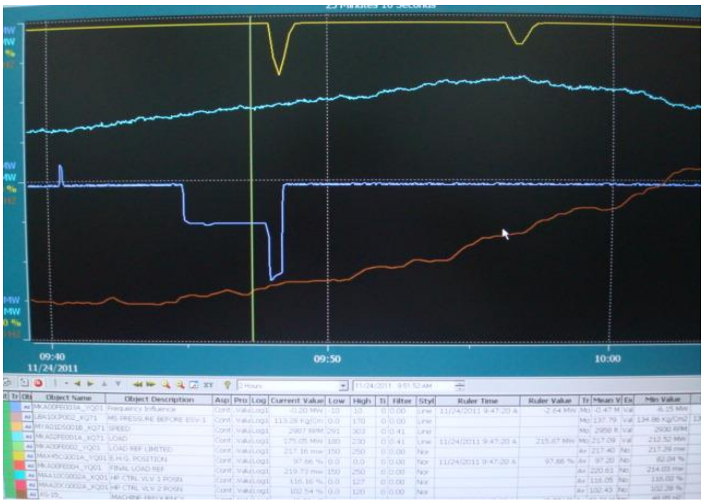


When the frequency rises from 49 to 50 Hz, Load reduction signal should be blocked.

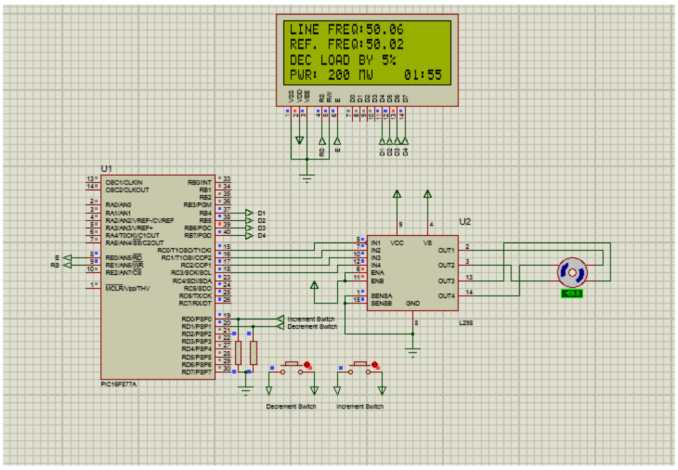
Case 4: Frequency rises from a lower frequency towards 50 Hz from "B" (from "A" it is same as Case 3)



When the frequency is more than 50.8 Hz, the existing feature of Isolated Grid will take control of the turbine.



SIMULATION RESULTS:



IV. CONCLUSION

This RGMO is considering being the efficient method for maintaining the frequency range within the bandwidth. All the turbo generators in the grid participating in the governing action tend to annul the change in the frequency by increasing or decreasing the generations. This mode of governor compensates the change in frequency by change in generation and is called Restricted Governing Mode of Operation. In RGMO, Load change is proposed to be limited + /- 5%of MCR in the frequency range of 49 hz to 50.5 Hz and sustained for about 2 minutes before ramping back to load automatically. Small changes up to +/- 0.03 hz are ignored for load corrections. This may be implemented in all thermal power stations to meet out a balance between demand and supply and also as rectification of existing free governing system.

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