Speed Stabilization of Hydroelectric Turbine with Digital Governors for Smart Power Station

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***Abstract*- In this paper digital speed governors for Hydroelectric Turbines is presented. Its configuration and its sophisticated features that improve protection of over/under speed of alternators, power control quality and robustness are described. Windfall functions of the Hydroelectric Turbines governor, whereby secondary systems are controlled, are also illustrated. this system can over take the concept of mechanical governors ,despite the fact that both mechanical and digital governors serve the same purpose, they are very different from several point of views, the latter are more reliable, more efficient and significantly more cost-effective in the long run. This type of structure can be used with all kind of alternator drives.**

Keyword- Governors; Robustness; Hydroelectric; Turbines; Alternators; Drives.

I. INTRODUCTION

Research effort presented in this paper initiated with the goal to develop an efficient control and supervision system for turbine governors for hydroelectric power plants. The method described herein offers automatic under frequency detection, competent load sharing, the speedy load rejection management and integrated automatic synchronization [1, 2].

Advanced modes in the control algorithm can include provisions for speed sensing, regulation, and stabilization of the governor system via the algorithm [3] and electronics that provide signals to control the turbines. An automatic synchronizing algorithm can even put the turbines online automatically. Repair time for problems is also shorter with a digital governor system because it utilizes built-in diagnostic tools and alarms allowing maintenance personnel to quickly and easily determine where a fault has occurred. Admittedly, replacing a single electronic plug-and-play component is far easier than coping with a mechanical oil blowout or coupling [4]. This type of speed stabilization is suitable for the smart control of power station mechanical drives.

II. DIFFICULTIES WITH MECHANICAL GOVERNORS

These governors are relatively simple devices that monitor, limit and determine speed under various load conditions [7].

The traditional electro mechanical governors have the following difficulties [5].

- They are less likely to respond stably to load variations.
- Minor load variations can put a governor into undesirable oscillations.
- Troubleshooting is difficult and time consuming.
- Needle sequencing is difficult because needle control is indirect, there is no ability to individually position the deflector or needle, and operators must manually link and unlink the nozzles as in figure (1).
- Mechanical governors cannot respond to rapid load acceptance.
- Mechanical governors cannot be rebuilt efficiently after an outage.
- Due to slow response the overall system stability factor remains poor, resulting in frequent system collapse.
- A high operating cost, in fact, diesel generation represents the single most costly resource while using mechanical governors.
- Incapacity to hold an isolated load.
- Transitions are severe, resulting in substantial output disruption.
- Operations cannot obtain turbine’s optimum operating efficiency.
- Installation is more time-consuming and difficult, and installation cost is higher than digital governors.
- Deflector control and needle control are not independent

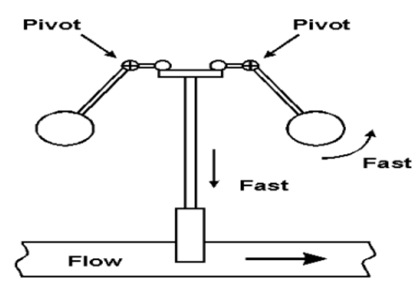

Figure 1 Traditional Mechanical Governors

III. DIGITAL GOVERNOR ARCHITECTURE

Architecture of digital governor consists of the following major parts.

- HMI “Human Machine Interface”
- Central Controller
- Actuator for water valves
- Analog to Digital Converter
- Feed back
- Speed sensors

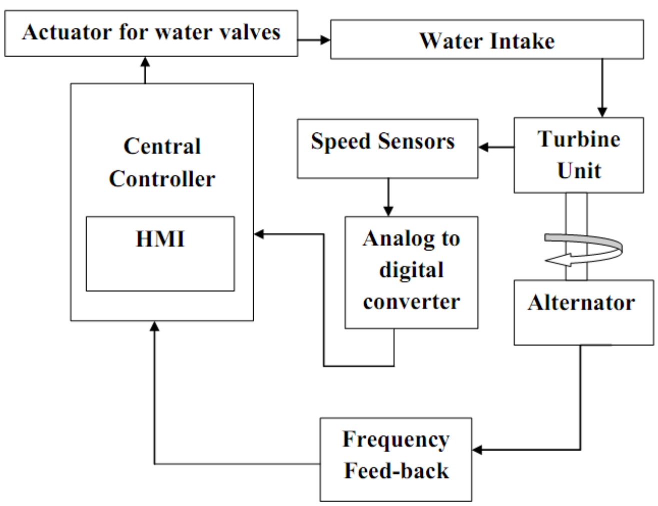

Figure 2 Digital Governor Architecture

IV. OPERATION OF DIGITAL GOVERNOR

Speed sensors are mounted at a convenient point turbine-alternator (machine) assemble. These sensors sense the speed of machine and give output in the form of analogue signal (4-20 m Amp), the analogue speed signal is converted into digital signal and is fed to central controller for processing. The central controller give command to actuators according to the fed logic / programming and feedback signals received from alternator is also provided to controller that basically judge the running frequency as in figure (2). The actuator components execute the commands given by the controller and regulate the water intake to control the speed of alternator according to load conditions. All the commands given to actuator components, feedback signals received from field devices, alarms, events and sequence of events are also recorded in HMI(human machine interface) and can be monitored as shown in figure (3) and retrieved any time for analysis of the faults or any abnormality.

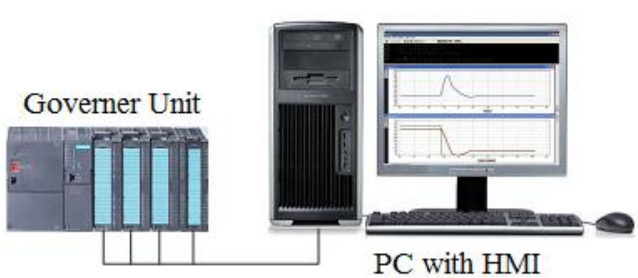

Figure 3 Governor Unit & Control unit

V. RESULTANT RESPONSE OF FREQUENCY

The response of mechanical governor is very slow due to which fluctuation occur and the system is not remain stable on 50 Hz as in figure (4.1) .On the other hand digital governor is one which responds very quickly due to which no fluctuations occur and the system not face any failure and remains stable on 50 Hz as can be seen in figure (4.2).

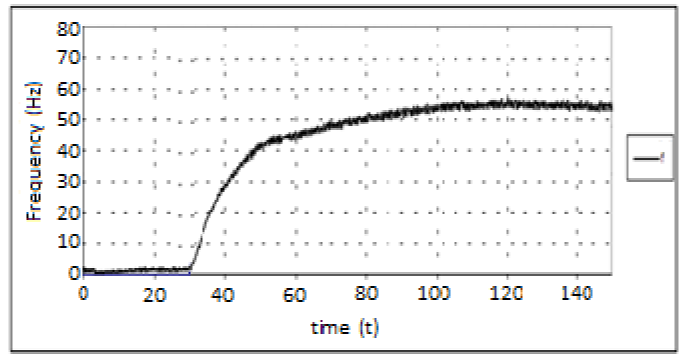

Figure 4.1 Frequency Responses from Mechanical Governor

In figure (4.1) reference frequency of system is 50 Hz. in case of mechanical governor output frequency is fluctuating and not stable on 50 Hz.

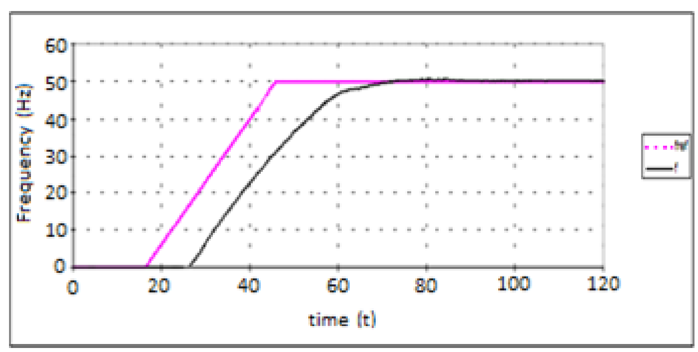

Figure 4.2 Frequency Responses from Digital Governor

In figure (4.2) reference frequency of system is 50Hz. in case of digital governs output frequency is stable on 50 Hz.

VI. THE BENEFITS OF UPGRADING TO A DIGITAL GOVERNOR

When it comes to replacing the classic mechanical governor with a new, digital one it must be mentioned that there are several benefits that should not be ignored [6],[8]. First of all, the mechanical governor has movable parts which are susceptible to break down, thus resulting in very high maintenance costs in the long run, while the electronic digital governor is maintenance free, because there are no moving parts that break or wear [9]. Nonetheless, even if the electronic device breaks down at a certain point, you do not have to worry about replacement part availability, which are extremely hard to find in the case of mechanical governors. All the components are off the shelf, and this is what ensures availability [10]. Digital governors are also more cost-effective in the long haul, given the fact that they are basically maintenance free and you do not have to worry about replacing any parts [11]. They are very easy to use and maintain over the years, and they can also help you save some money. The accuracy of the device also plays a pivotal role: it is true that mechanical devices can be reliable and accurate, but the digital ones are definitely superior in terms of accuracy. In addition to accuracy, the improved system response is another benefit that should be taken into account if you want to upgrade to a digital governor [12]. The fast delivery and quick response are mainly given by the powerful control algorithms, which cannot be found in the traditional, mechanical governors. Besides, the electronic governor is also very versatile both in terms of design and usage, and it requires no mechanical work whatsoever – this is what reduces the installation time, and it also delivers faster commissioning[13][14]. Older governors did not benefit from this tool; this is why they were considerably slower in response.

VII. APPLICATIONS

This type of governor can be installed with Hydroelectric Turbines, Steam turbines and all kind of drives to achieve smart control.

VIII. CONCLUSIONS

This paper describes a new concept of hydro generating unit control system realized by means of digital governor. Experimental results show superior behavior of digital governor during variable load and speed with a remarkable load acceptance. Frequency stabilization and responses of digital governor are too quick as compare with mechanical governor.

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