Frequency Control Capability of Micro Hydro Power Plants

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Abstract— An Electronic Load Controller (ELC) control the output power flow and henceforth the frequency of a MHPP system, by keeping up a close steady load on the generator. The ELC redirects the power that isn't devoured by the customer load to a damper load which are regularly resistors or warming components. The proposed ELC is tried in MATLAB 2017a SIMULINK. The generation limit with regards to this specific model is 17 KVA. The controller utilized for the ELC is PI Controller of 2500 and 6000 for P and I gain. In this model the incentive for dump resistor is 60 ohms, parasitic load is 120 ohms and nonlinear load of each phase is 15 ohms, 25 ohms and 40 ohms. The outcomes got and the graphical portrayals unmistakably demonstrate the adequacy of the ELC to dump overabundance capacity to the damper load when the consumer load changes, and keep up the supply frequency between 49.5 to 50.5 Hz. The switching time between the consumers load and dumb load is 1.5seconds.

1 Introduction

Hydropower is generated from source water by creating a proper head. Hydropower contributes around 22% of the World about 7,50,000 MW of installed capacity in many countries. The world hydropotential resources are shown in Fig. 1 [1]. In Pakistan it contributes about 31% to the total power generation. The hydro potential exploited till yet contributes to the total generation is shown in the graph of Fig. 2 [2]. Micro hydropower plants are the hydroelectric system having a capacity up to 100KW usually based on run-of-river type.

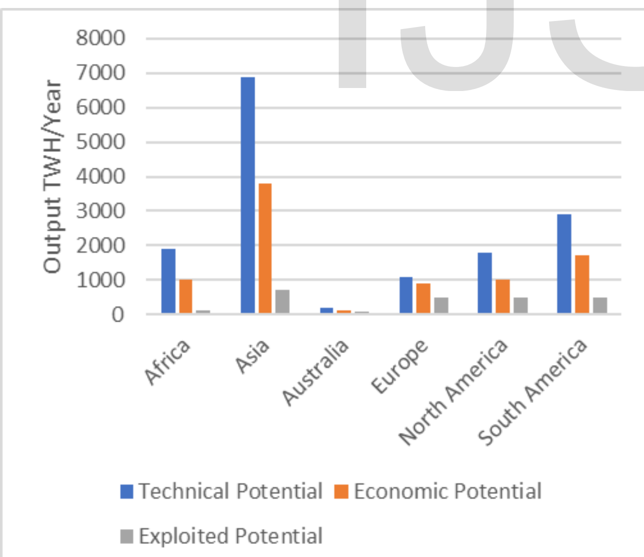

Fig.1: World hydro power potentials

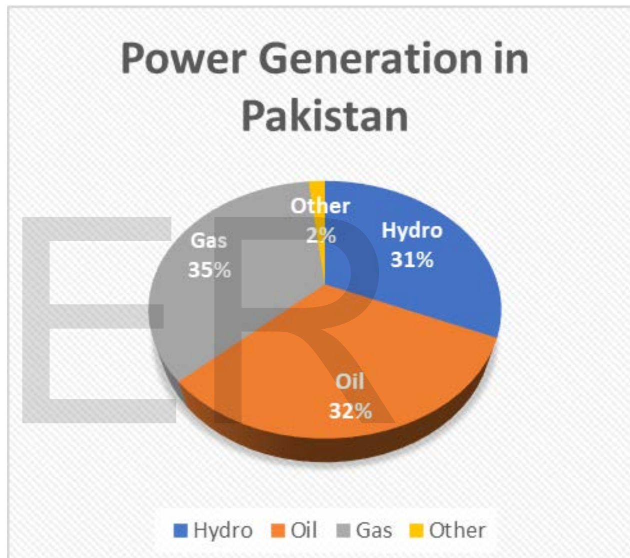

Fig. 2: Pakistan Hydropower potentials

The generator for MHPP's usually delivers fixed power and operate on rated speed, rated voltage and rated current. The speed of generator varies when the consumer load changes which cause the unsteadiness in the frequency. The variation in the consumer load connected is balanced by the electronic load controller, which diverts the extra power to a dump load. ELC regulates the frequency of the generator through monitoring of consumer load variation and automatically transfers any surplus load to the dump load, so that, the total output power of generator remains equal to its rated power [3-7]. Synchronous generator is more preferred over induction generator for MHPP systems [8-10]. Synchronous generators have inbuilt automatic voltage regulation AVR for voltage regulation and by using synchronous generator with ELC one can achieve good frequency regulation. Literature has revealed that lots of work has been done on ELC with asynchronous generator [11-13]. Therefore, this paper deals with the design of the ELC for a micro hydropower plant using synchronous

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generator. The developed model consists of hydraulic turbine and the governor, excitation system, universal bridge as rectifier, and IGBT/MOSFET. With the help of MATLAB, Simulink developed model has been simulated and analyzed.

2 Proposed Metrhodology

In proposed methodology, a schematic diagram has been developed for ELC system with synchronous generator and has been shown in Fig. 3 [14]. The figure consists of 3-phase synchronous generator model of 17 KVA, 400 V, 50 Hz, 3000 RPM, loads, and frequency control block. The model is simulated using MATLAB Simulink 2017a. When the model is simulated it demonstrate that the switching time between the damper load and the consumers load is 1.5second due to which the generator speed doesn't go beyond the permitted tolerance level. The MHPP model consist of a PI controller for the ELC. The model consists of synchronous generator which delivers electric power at fixed frequency and voltage. When consumers load changes, the load on the generator change and the generator speed fluctuates, which result an inconsistency in the frequency. This inconsistency in the frequency is overcome by using Electronic Load Controller. The ELC controls the output power by switching the load on and off of the damper load to balance the total load on the generator when the consumer load changes.

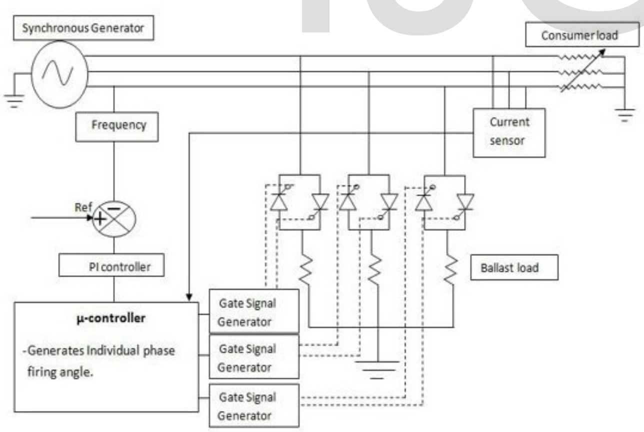

Fig. 3: Schematic Diagram of ELC

ELECTRONIC LOAD CONTROLLER

The ELC controls the output power by switching the load on and off of the damper load to balance the total load on the generator when the consumer load changes. When the load changes ELC detect it and switch the damper load on or off accordingly so as to balance the total power generation of the generator. The power consumed by the consumer load, dump load and the total power generation of the plant is shown in Fig. 4 [14]. The ELC protect the generator by making the generator speed stable. The speed characteristic graph is showed in Fig. 5. The switching time between the consumers load and the dump load is 1.5seconds.

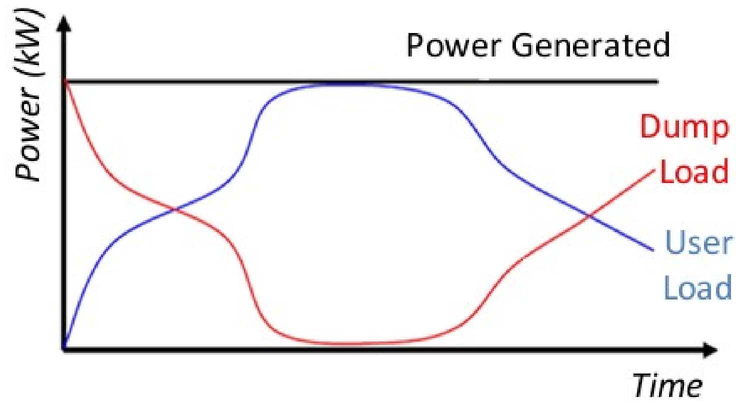

Fig. 4: Power generated and power consumed

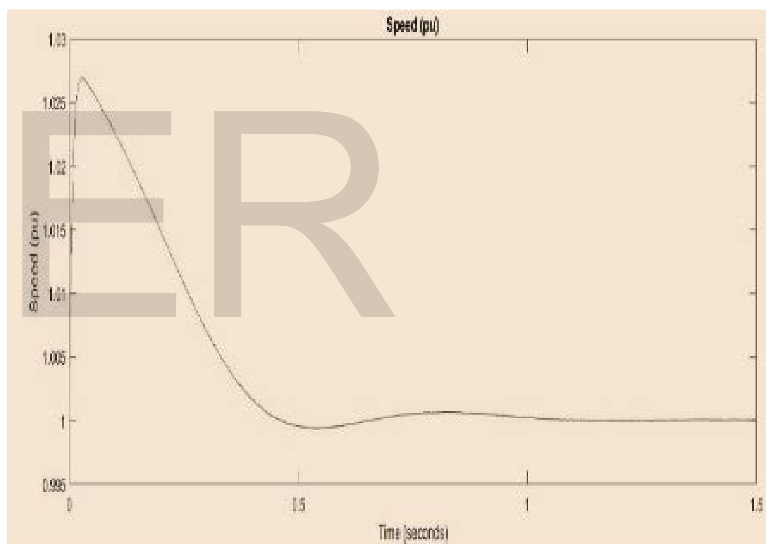

Fig. 5: Generator speed characteristic

The model is simulated and the results are noted in the Table 1. The behavior is observed that the ELC function properly the frequency fluctuation is under the tolerance level. The load is scaled 1/100 from the original value. The same values are when plotted the graph of Fig. 6 is obtained. The variables in the graph are not linear because the generator speed changes abruptly but the change is within the tolerance level.

Table 1: Frequency variation with generator load with ELC

Voltage (V)	Main load (W)	Consumer load (W)	Damper load (W)	Frequency (HZ)	Speed (RPM)
220	160.30	160.30	0.00	50.00	3000
220	160.45	129.42	31.03	50.10	3007
220	160.38	103.62	56.76	50.00	3000

220	160.45	80.55	79.89	50.10	3006
220	160.01	52.89	107.12	50.20	3013
220	159.27	43.62	115.66	50.35	3021
220	158.47	39.67	118.84	50.46	3028
220	160.23	34.95	125.28	50.10	3006
220	160.45	31.69	128.76	49.95	2997
220	160.38	28.38	132.00	50.00	3000
220	159.13	23.77	135.36	50.30	3019
220	158.91	0.00	158.91	50.40	3024

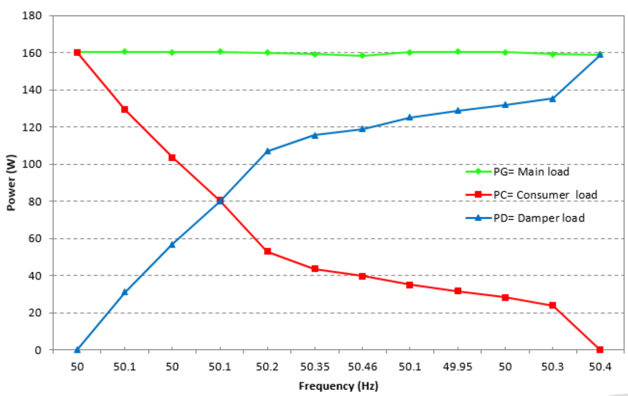

Fig. 6: Main load, consumer load, damper load and frequency variation with ELC

The power generated, the power consumed by the dumb loads and the power consumed at the consumers end are shown in Fig. 7, Fig. 8 and Fig. 9. From these figures it can be seen that Eq. 1 is confirmed. The total power generation is 14KW. The power consumed by the dumb load is 6.5KW and the power consumed at the user end is 7.5KW.

$P_G = P_L + P_C$ Eq. 1

In Eq. 1,
P_G = Power Generated
P_L = Power Consumed at the user end
P_C = Power Consumed by the dumb load

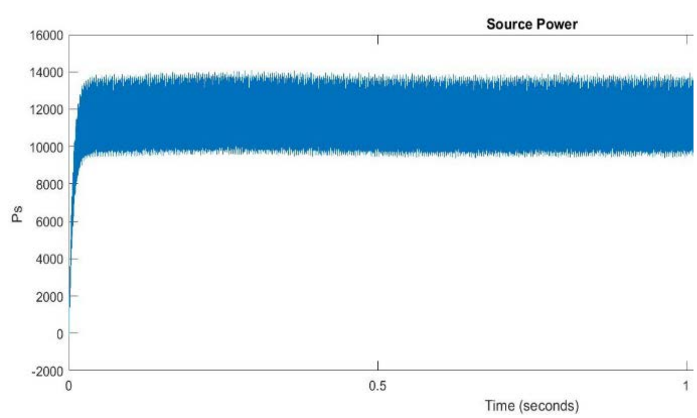

Fig. 7: Generated Power

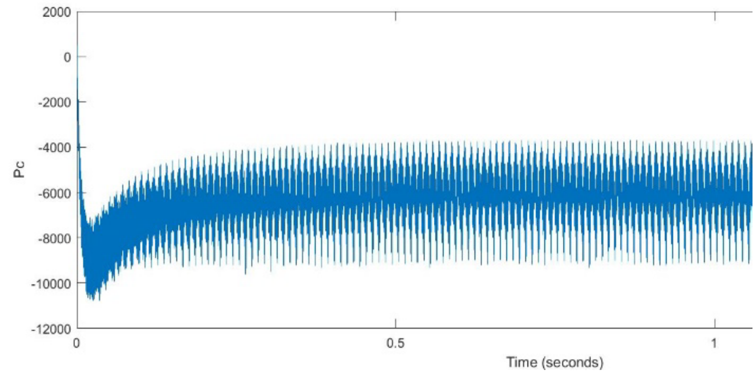

Fig. 8: Power Consumed by Dumb load

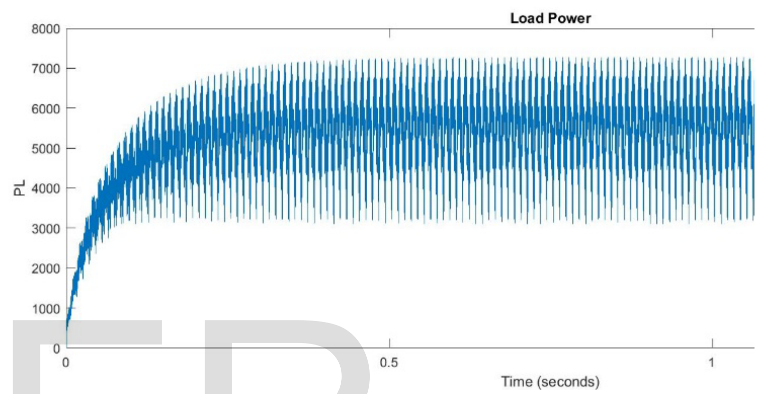

Fig. 9: Power Consumed by the Users

CONCLUSION

When the model run on Simulink the function of ELC is observed and found to be very good, the switching time between the consumers load and dumb load is much improved to 1.5seconds. Also, it controls the frequency successfully by maintaining it between 40.95- 50.46hz.

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