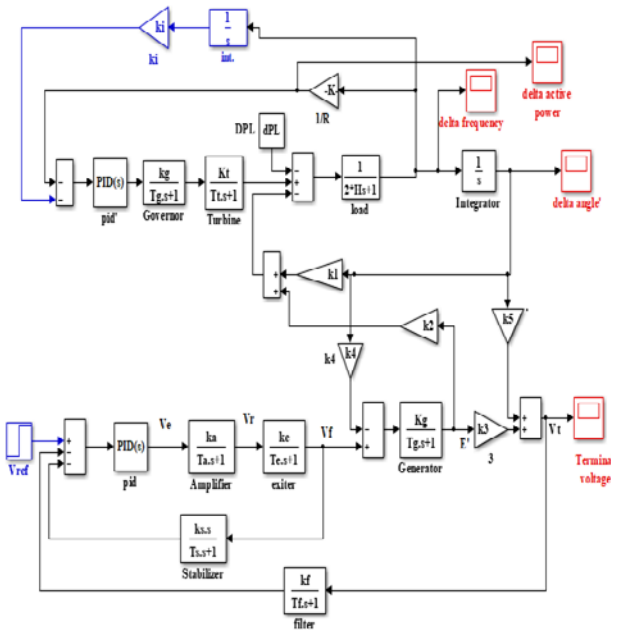

Fig. 5: Block diagram of AGC and AVR loop

III. SIMULATION RESULT AND DISCUSSION

The following operating conditions for a synchronous machine connected to an infinite bus through a transmission line of sample hydroelectric power system to compare the performance of the angle, speed, frequency, active power and voltage of the generator chose with a reference.

Table 1: Assumptions used in the Simulation for AGC

Quantity	Area 1	Area 2	Area 3
Governor time constant	T_{g1} = 0.5 s	T_{g2} = 0.5 s	T_{g3} = 0.5 s
Turbine time constant	T_{t1} =0.05s	T_{t1} =0.04s	T_{t1}=0.05s
Inertia constant	H_1 = 2.6	H_1 = 3.14	H_1 =2.5
Speed regulation	R_1 =0.04	R_1 =0.05	R_1 =0.04
Load disturbance (pu)	ΔP_{L1}= 0.1	ΔP_{L1}=0.15	ΔP_{L1}= 0.2
Tie line coefficient (pu)	$\Delta T12$=0.011	$\Delta T23$=0.006	$\Delta T31$= 0.018
Normal frequency	f_1 =50Hz	f_1 =50Hz	f_1 =50Hz

Table 2: Assumptions used in the simulation for AVR

Quantity	Gain	Time constant
Amplifier	K_a = 60	T_a = 0.02 s
Exciter	K_e = 1	T_e = 0.4
Generator	K_g = 0.7	T_g = 1
Filter/sensor	K_f = 1	T_f = 0.05

Table 3: Assumptions used in the simulation for PID

Quantity	Gain
PID controller	K_P = 0.1
	K_D = 0.07
	K_I = 0.06

❖ ***The simulation result of combination of AGC and AVR***

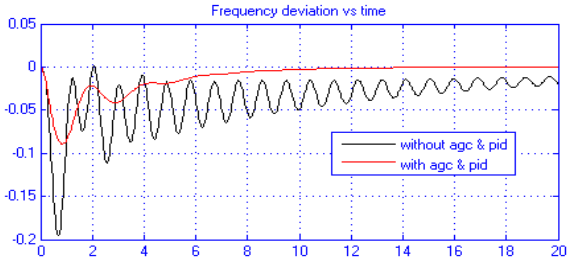

Fig. 6: Frequency deviation response of AGC with AVR

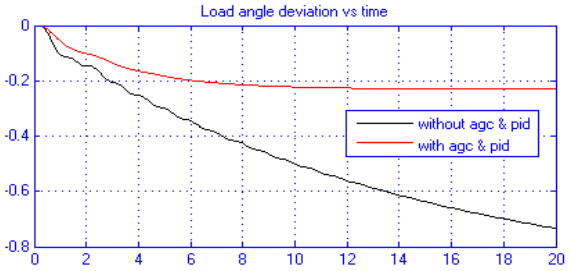

Fig.7: Load angle deviation response of AGC with AVR

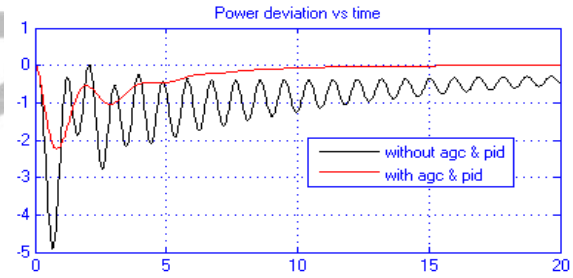

Fig. 8: Active power deviation response of AGC with AVR

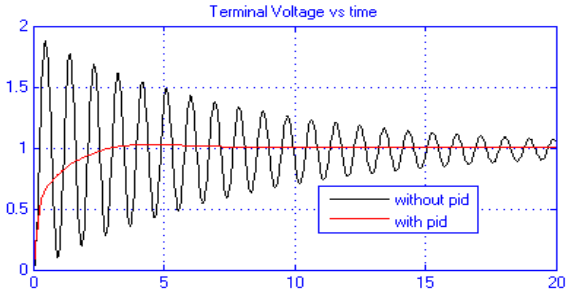

Fig.9: Terminal voltage response of AGC with AVR

Table 4: Comparisons of the simulation result for the output response of AGC with AVR.

Mode	Controller	Settle time	Rise time	Over shoot	SS error
Δf	without agc & pid	30s	1s	-0.2	-0.003

	with agc & pid	4s	1s	-0.09	0
$\Delta\delta$	without agc & pid	40s	40s	0	-0.9
	with agc & pid	4s	-0.23	0	-0.23
ΔPe	without agc & pid	30s	0.9s	-0.5	-0.2
	with agc & pid	4s	0.9s	-0.21	0
Vt	without agc & pid	35s	0.5	1.8	-0.01
	with agc & pid	2.5s	0	0	0

- ***The simulation result of three area interconnected system***

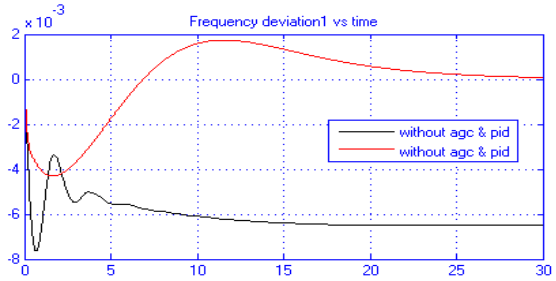

Fig. 10: Frequency deviation response for Area 1

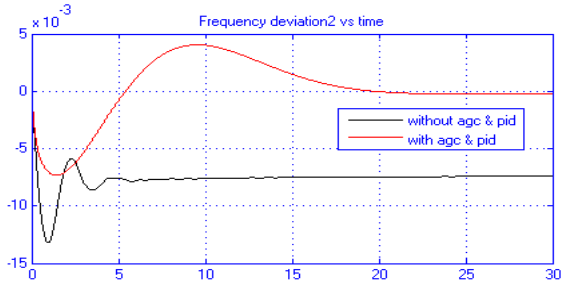

Fig.11: Frequency deviation response for Area 1

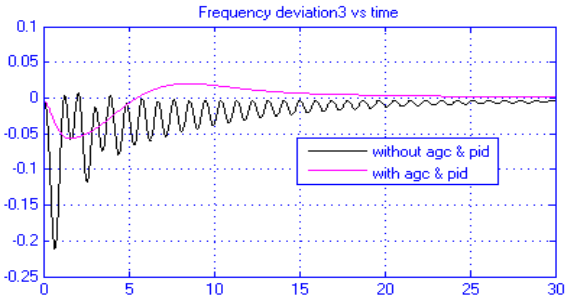

Fig.12: Frequency deviation response for Area 2

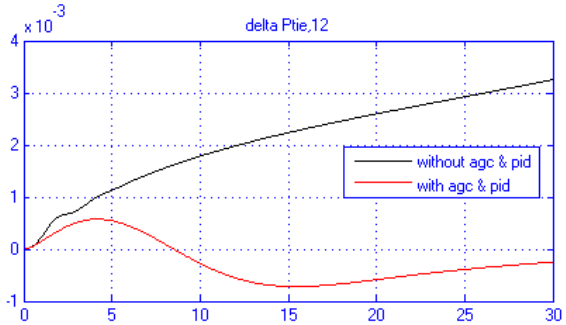

Fig.13: Tie line Power deviation response for Area 12

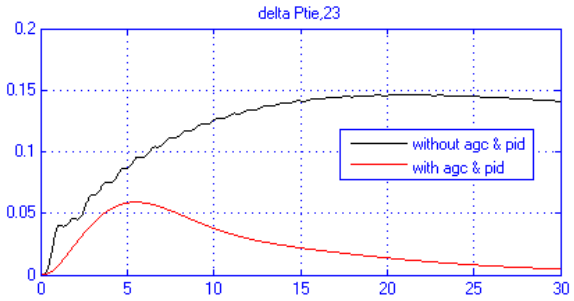

Fig. 14: Tie line Power deviation response for Area 23

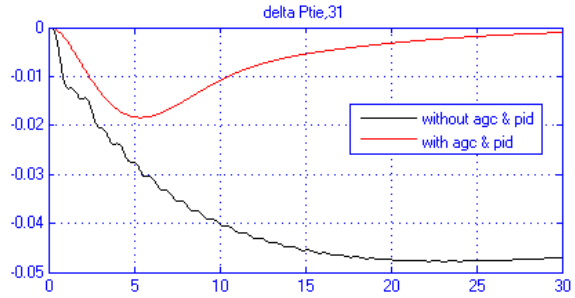

Fig.15: Tie line Power deviation response for Area 31

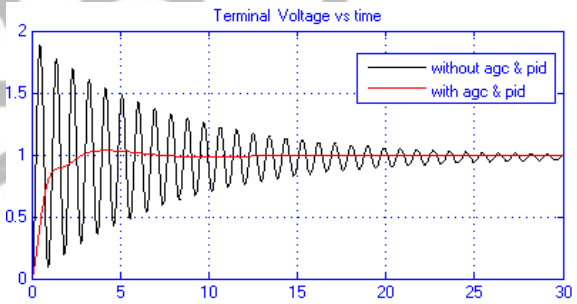

Fig.16: Terminal voltage response of interconnected system

Table 5: Comparisons of simulation result for the output response of three area interconnected system

Mode	Controller	Settle time	Rise time	Over shoot	SS error
$\Delta f1$	without agc & pid	7s	1s	-0.008	-0.006
	with agc & pid	25s	2s	-0.004	0
$\Delta f2$	without agc & pid	5s	1s	-0.012	-0.01
	with agc & pid	20s	2s	-0.007	0
$\Delta f3$	without agc & pid	30ss	1s	-0.2	-0.01
	with agc & pid	12s	2s	-0.05	0
$\Delta Pt,12$	without agc & pid	30s	30s	0.003	0.003
	with agc & pid	25s	15	0	0
$\Delta Pt,23$	without agc & pid	20s	20s	0.15	0.15
	with agc & pid	25s	5s	0.05	0

$\Delta Pt, 31$	without agc & pid	15s	15s	-0.045	-0.045
	with agc & pid	20s	5s	-0.02	0
Vt	without agc & pid	30s	1s	1.8	-0.01
	with agc & pid	2s	1s	0	0

IV. CONCLUSION

The aim of this paper was to study, design and evaluate the performance of AGC, and AVR control for multi area interconnected hydroelectric power system using PID controller. The conventional controller (LFC with PID) method exhibits relatively poor dynamic performance as evidenced by large overshoot and steady state error. So, the proposed modern controller used in this work provides stabile the terminal voltage, tie line power, active and reactive power overshoot, zero steady state error, rise time and settling time.

REFERENCE

[1] Abdulkerim, "Design and Control of Synchronous Generator Using Power System Stabilizer and Automatic Generation Control - Case Study on Tis Abay II Hydroelectric Power", 2016.

[2] K.Karna, G.Veeranna, "Improved Particle Swarm Optimization Algorithm Assisted AGC in interconnected Power System", 2019.

[3] C. Reddy & Dr. Krishnarayalu, "Automatic Generation Control of Multi-area Power System using Active Disturbance Rejection Control", 2017.

[4] D. Sambariya & V. Nath, "Load Frequency Control Using Fuzzy Logic Based Controller for Multi-area Power System", 2016.

[5] D. K. Sambariya & V. Nath, "Optimal Control of Automatic Generation with Automatic Voltage Regulator Using Particle Swarm Optimization", 2015.

[6] V.Nath & D. Sambariya, "Analysis of AGC and AVR for Single Area and Double Area Power System Using Fuzzy Logic Control", 2015.

[7] N.Tanwani, P. Memon et al., "Simulation Techniques of Electrical Power System Stability Studies Utilizing Matlab/Simulink", 2014.

[8] R.Narayan, S.Jaiswal et al. "Fuzzy Logic Based Automatic Load Frequency Control of Multi-Area Power Systems", 2013.

[9] P.Dabur, N.Yadav, et al., "Matlab Design and Simulation of AGC and AVR for Single Area Power System with Fuzzy Logic Control", 2012.

[10] P. Dabur, N. Yadav & V.Kumar, "Matlab Design and Simulation of AGC and AVR for Multi Area Power System and Demand Side Management", 2011.

[11] G. Singh & R.Bala, "Automatic Generation & Voltage Control of Interconnected Thermal Power System Including Load Scheduling Strategy", 2011.

[12] CIGRE Task Force, "Analysis and Modeling Needs of Power Systems Under Major Frequency Disturbances", Jan. 1999.

[13] P. Kundur, D. C., "Impact of turbine generator controls on unit performance under system disturbance conditions", IEEE Trans. Power Apparatus and Systems, 1985.

[14] N. Mohamad, ''Power System Transient Stability Analysis Using Matlab Software'', December 2013.

[15] R. Narne, P. C. Panda, et al, "Transient Stability Enhancement of SMIB System using PSS and TCSC-Based Controllers," IEEE PEDS, 2011.

[16] K. Suhail, "Feed forward Neural Network-based Power System Stabilizer for excitation Control System," M.E. Thesis, Department of Electrical Engineering, 2011.

BIOGRAPHIES

Abdulkerim Ali was born in Bahirdar, Ethiopia on Sep. 12/1991 G.C.

He was learned from primary to preparatory school in Bahirdar. He graduated from Adama Science and Technology University in B.Sc. by Electrical Engineering specialized Control System Engineering in 2013G.C and finished a Master degree in June, 2016G.C with Electrical Engineering specialized Power system Engineering. And now studied PhD. from Bahirdar Institute of Technology, Ethiopia by Power System Engineering. My employment experience included the lecturer on the Bahirdar Institute of Technology. My special fields of interest include teaching modern control systems, machine, and other related courses.