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An analysis of tuned PID controller using different optimization algorithms

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Abstract

the present work has been motivated to improve the tuning of PID controllers with different evolutionary algorithms. The tuned PID controllers are used along with the Automatic voltage regulator to improve the terminal voltage response of the synchronous generator. The terminal voltage has been analyzed using environment of MATLAB and the responses are compared. The various algorithms used for the analysis of the controllers are the genetic algorithm, the whale optimization algorithm the water cycle algorithm and the particle swarm optimization algorithm.

Keywords—evolutionary algorithms, the swarm optimization, the genetic algorithm, the WOA, the WCA, the AVR

I.INTRODUCTION

The main role of synchronous generator is to provide energy to the electrical networks. They are responsible for the maintenance of the stability hence are prone to unwanted signals, hence needed to be tuned. The Automatic Voltage regulator is an important device that controls the terminal voltage and also controls the reactive power. The AVR main function is to control the exciter voltage in order to control the terminal voltage characteristics.

There are many logics that have been develop in the past decades in order control the tuning efficiency of the PID controller that is used together with the AVR in the industrial automations. The main accent of the paper is the improvement of the time response of the terminal voltage and also to improve the computation efficiency.

The present era is devoted to the world of automation that includes tremendous amount of the potential for the development of the controller that rule the enigmatic regime of automata. The controlling of the PID controllers in order to provide the most ideal results that are essential for the better understanding of the machine to human interface so that they can be very near to human psychology. The motivations behind the work are just the attempts that are provoked in order to closely understand the biological phenomenon of the animals working for an objective and to link them with machine to make them smarter and to think like humans.

II. Related work

The present work is the extension of the work done by the previous researches in the field of tuning of the PID controller by algorithms that are inspired from animals like whale, ant. The previous work done for this tuning is by simple genetic algorithm that provides the optimum values of the three Ks of the PID controller there by optimizing the controlling equation.

The given work is done under the constrained environment where the gains of the amplifier, exciter, the generator and the feedback path are ka, ke, kg and kf are 1, 1, 2, the corresponding time constants are T_a, T_e, T_g, and T_f having respective values 0.01s, 0.05s, 0.001s and 0.1s.

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Fitness function to be optimized is given by F= Trap (t_o, $(de)^2$) where $dE = \Delta V_{ref} - \Delta V_g$, t_{out} is MATLAB simulation time.

The trapezoidal integral converges more swiftly when used with particle swarm optimization technique. The values of the optima recorded in table 1 are given below.

Proposed Algorithm	**Fitness function of the proposed algorithm**	**K_p**	**K_i**	**K_d**
GA	0.000741	1.91	1.88	1.9
WOA	0.000733	1.97	2	2
WCA	0.000721	1.95	1.99	1.98
PSO	0.000744	1.99	1.97	1.97

TABLE 1

III. Simulation Results

The given PID controller is tuned using many evolutionary algorithms the genetic algorithm,the PSO, the whale optimization algorithm, the water cycle algorithm and the particle swarm optimization algorithm. And the terminal voltage response is viewed. The operation is carried for the optimal values of the three Ks and also the convergence.

The analysis of the system is done with the following values of the gains concerened;

$$K_A = 10.1, \quad (1)$$
$$K_E = 13, \quad (2)$$
$$K_G = 1.2, \quad (3)$$
$$K_F = 0.05, \quad (4)$$
$$K_R = 1.4 \quad (5)$$

The values of the time constants are

T_A=0.2, T_E=0.3, T_G=0.99, T_F=0.99, and T_R=0.04.

($K_f s$ / $T_f s$ + 1) is the transfer function of the stabilizer concerned.
where the gain and time constant as 0.05 and 1

The simulation results are summarized

1. The terminal voltage response of the generator without the PID controller is shown in Fig 1. It shows about 17.5 % steady state error.

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2. The terminal voltage response of the synchronous generator using evolutionary algorithms is also seen in Fig2. It shows that the response is improved and the steady state error is minimized. We have obtained the values of the corresponding steady state error with the optimization algos 0.034 % for the WCA, 0.043 % for the WOA, 0.046 % with the WCA and 0.031% with the PSO.

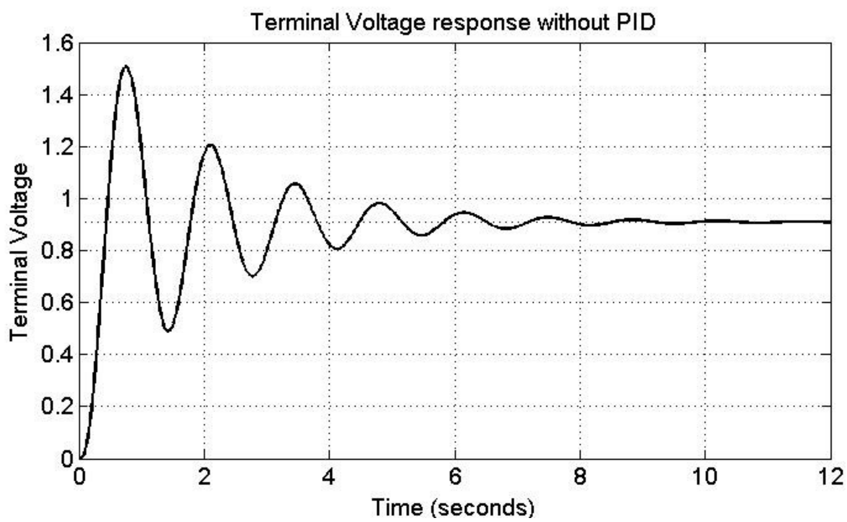

Fig 1. Terminal Voltage Response without a PID control

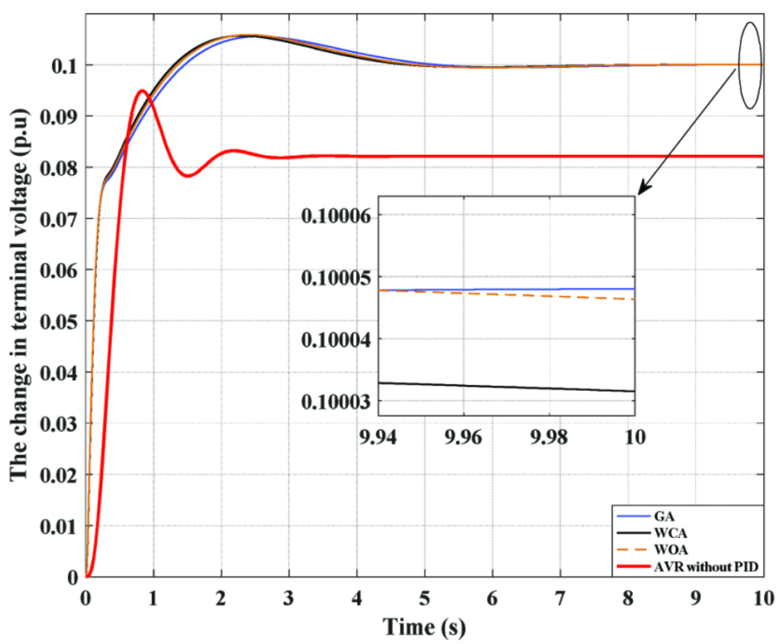

Fig 2.time response of terminal voltage tuned with the algorithms

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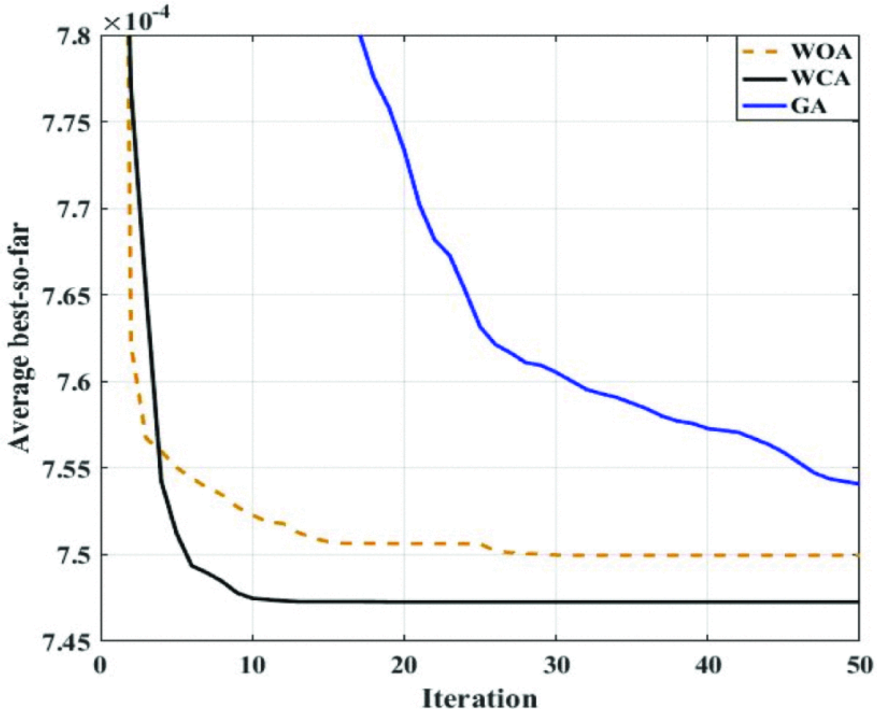

Fig 3. Convergence of the algorithm discussed

The Fig 2. And Fig 3. Shows the convergence shown by the algorithms concerned in the given number of iterations.

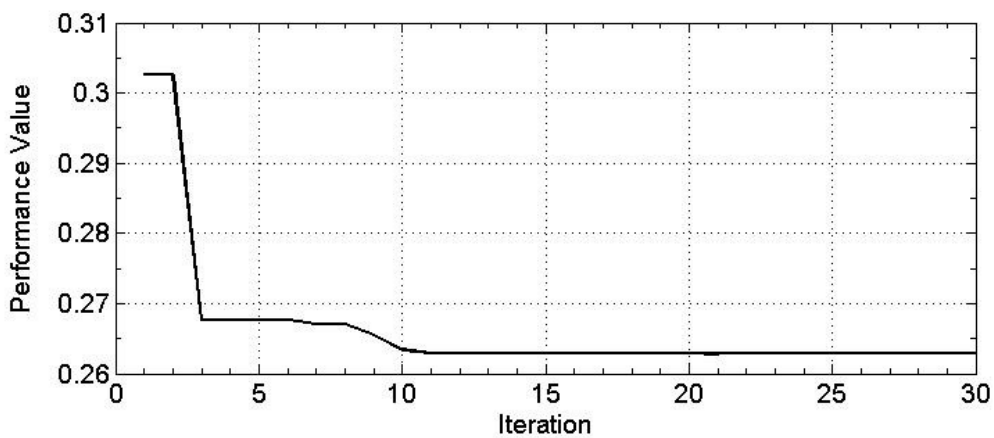

Fig 4. Convergence shown by A PID controller tuned by PSO

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IV. Conclusions

The given work concludes that the AVR is the vital component of the synchronous generator that improves its terminal voltage characteristics if tuned with different optimization algorithms. The present work proves that the PID controller tuned with the PSO is the more beneficial as compared with other algorithms.

The output of the synchronous generator is showing instability in the terminal voltage that is the main objective to be minimized in this work. The parameters of the PID controllers are designed to increase the output voltage of the synchronous generator. The virtue of the two algorithmic procedures are not enough to produce optimal results but the use the particle swarm optimization has proved an boon to the analysis of the AVR response. The convergence of the PSO is seen much more efficient as compared to the view of the WOA and WCA algorithms.

The steady state error has been minimized to a value that is much efficient and use full for the input of the PID controller and it is seen that the use of negative feedback from the output of the exciter has controlled the gain of the closed loop efficiently. The given fact can be illustrated by using the block diagram of the tuned PID controller.

V .References

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