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Differential Evolution and Genetic Algorithm Based MPPT Controller for Photovoltaic System

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ABSTRACT

This paper presents a comparison between two proposed approaches for optimization of power of a solar PV panel. The algorithms are used for the tuning of PID controller parameters. The PID controller will set the duty cycle of the boost converter to give maximum power at load. The algorithms are written in the manuscript file of MATLAB to work in sync with the closed loop model of PV panel in SIMULINK.

Keywords: Differential Evolution algorithm, Genetic Algorithm, MPPT, PID Controller

I. INTRODUCTION

In the modern day world, we are in the need of finding new sources of energy. These sources should be capable of replacing the conventional sources of energy. This can happen if the newer sources have lower cost of hardware implementation, higher efficiency, ease of use, and flexibility to adapt in varying environmental conditions. A major source of energy can be the solar PV panel. The PV panel converts the sun's irradiation to a power signal. Due to the non linear characteristics of the PV panel, the need for maximum power point tracking arises.

Maximum Power point tracking has been carried out by conventional methods like Perturb and Observe and Incremental Conductance. These are gradient based methods and work only for continuous evaluation of photovoltaic power[1]. They produce oscillations at steady state which are undesirable. On the other hand, algorithms like Genetic algorithm and Differential Evolution are based on biological evolution. They can be used for optimization of non linear, stochastic and discontinuous functions[2].

The genetic algorithm initializes a population of individuals randomly. It uses methods of crossover and mutation to generate off springs for next generations. But differential evolution uses methods of mutation and selection to generate off springs. The fitness value of all the individuals is calculated at each step. Individuals with lower fitness are promoted to next generations preferably. When one of the stopping criteria is met the algorithms stop and the final fitness and the parameter values are returned[3].

II. DIFFERENTIAL EVOLUTION ALGORITHM

The differential evolution algorithm works on minimising an objective function also called a fitness function. It finds the values of optimum parameters to get the objective function minimised. The population size, number of generations and lower and upper limits of parameters are selected. The children produced in subsequent generations depends on mutation factor and crossover probability. The fitness value is evaluated after every iteration. When a stopping criteria is met, the algorithm stops as shown in Fig. 1.

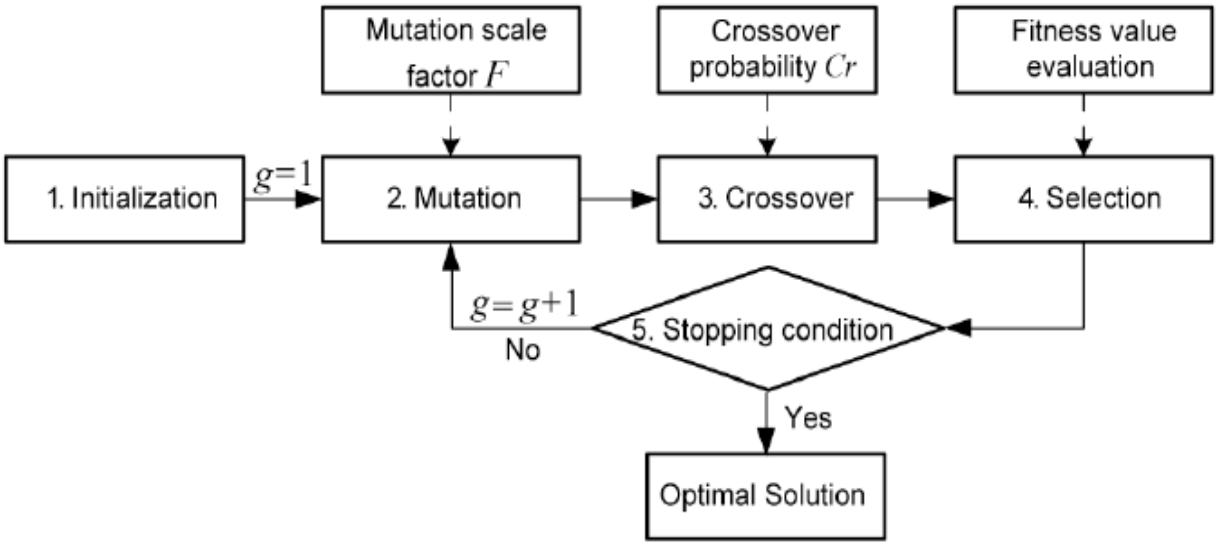

Fig. 1: flowchart of DE algorithm[3]

2.1. Maximum Power Point Tracking using DE based PID controller

The configuration of maximum power point tracking system using differential evolution algorithm is shown in Fig. 2. The error signal is generated from the difference of PV panel voltage maximum voltage and the output voltage. The DE algorithm generates optimum values of controller parameters to get steady optimised power at the DC load.

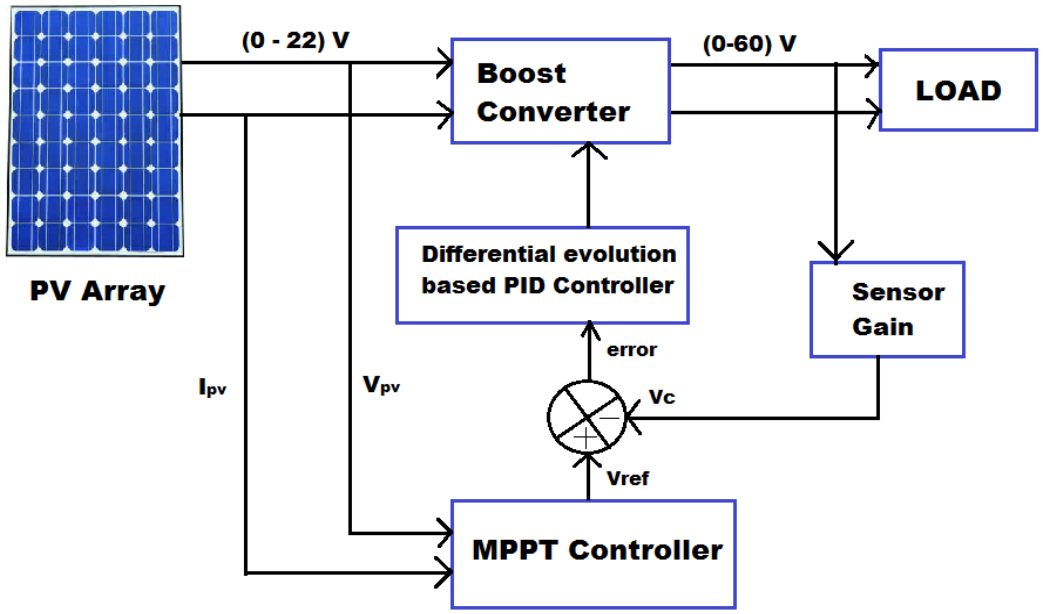

Fig 2: block diagram of closed loop MPPT system

2.2. Simulation

The simulation of a subsystem consisting of DE based MPPT system is shown in Fig. 3. A closed loop negative feedback configuration is formed. The PV panel voltage is the reference input and the measured output voltage is the output. The input and feedback measured output power is sent to workspace. The DE generates optimum

values of PID controller parameters. The output of the PID controller is connected the duty cycle generation block. Hence, the required duty cycle of boost converter is set to get the maximum power at dc load[4] .

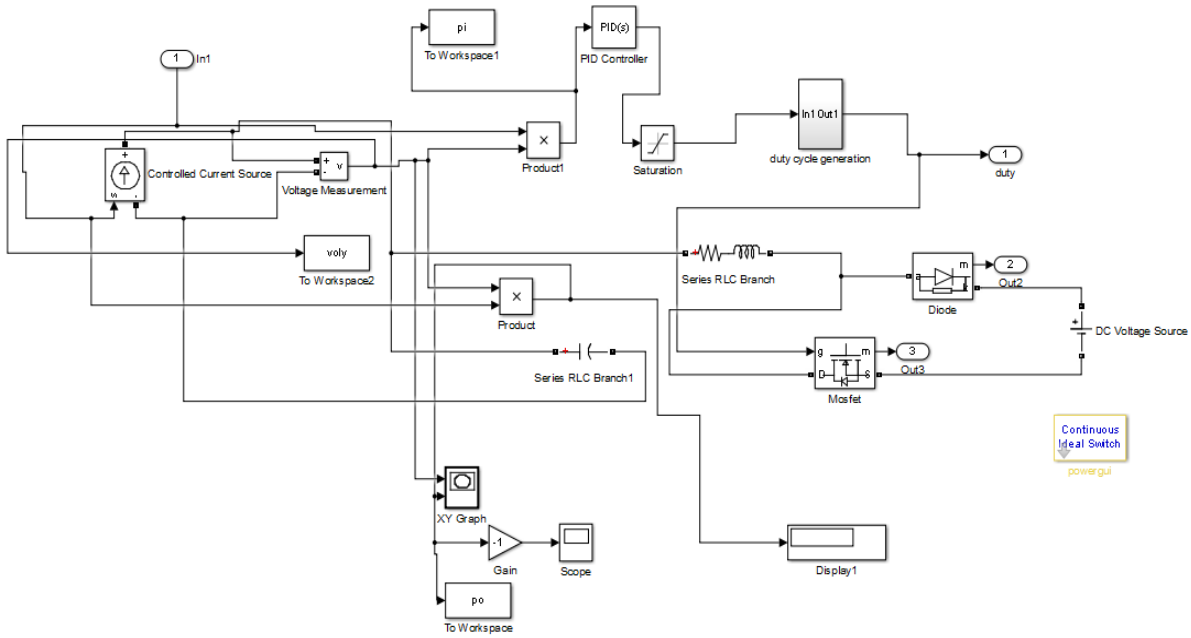

Fig 3: Subsystem of Closed loop DE based MPPT

2.3 Results

In the proposed model of differential evolution based PID controller for maximum power point tracking, the proportional gain converges to 0.0102 as seen in Fig. 4. The Integral gain converges to 25.8527 as seen in Fig. 5. The Derivative gain converges to 0.0029 as seen in Fig. 6. The output power converges to 4.68 W at an irradiation level of $1W/mm^2$ as shown in Fig. 7.

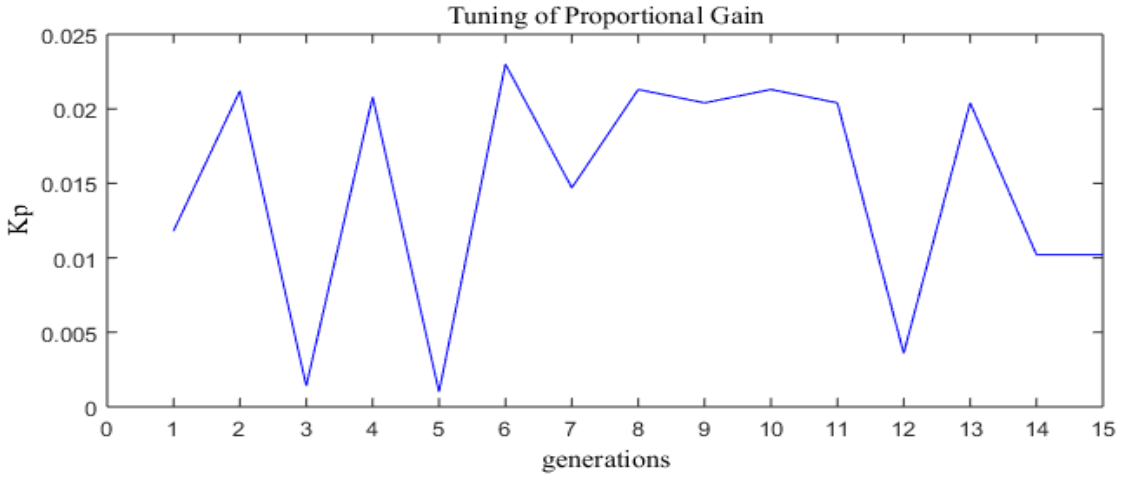

Fig 4 :Variation of Kp with number of generations

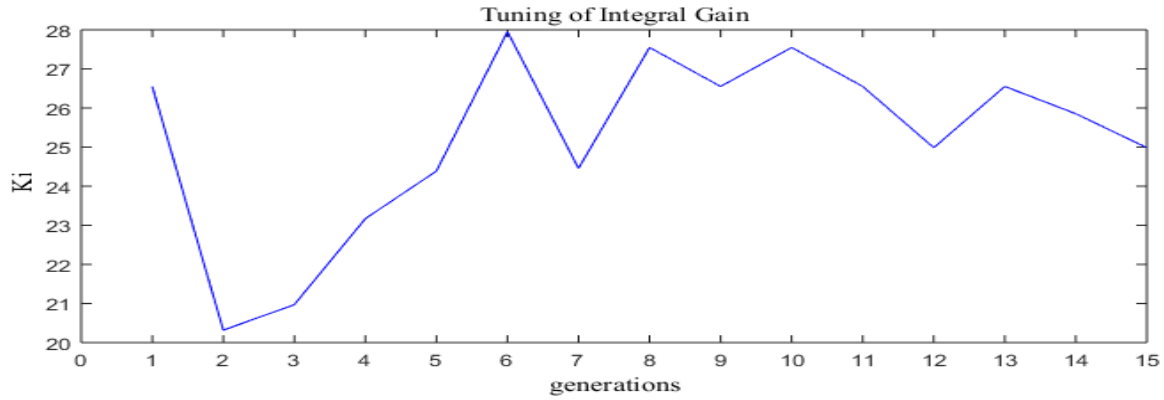

Fig 5 :Variation of Ki with number of generations

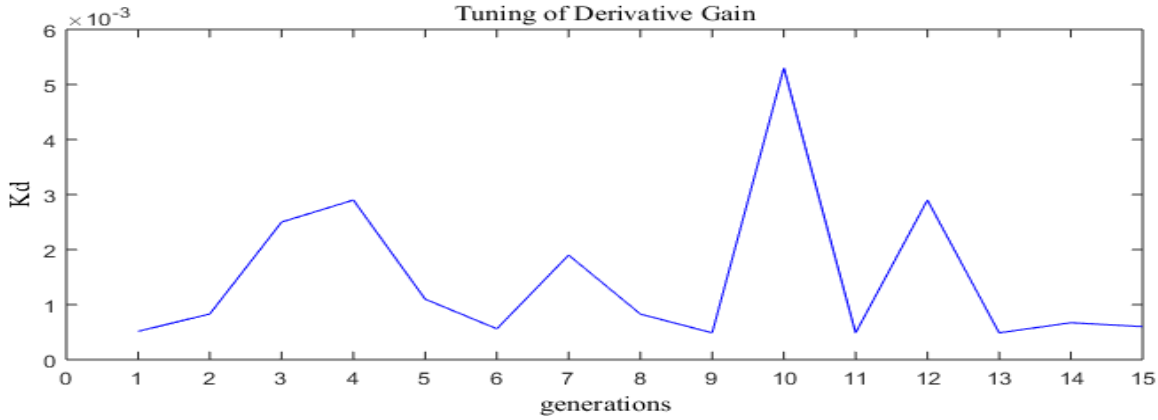

Fig 6 :Variation of Kd with number of generations

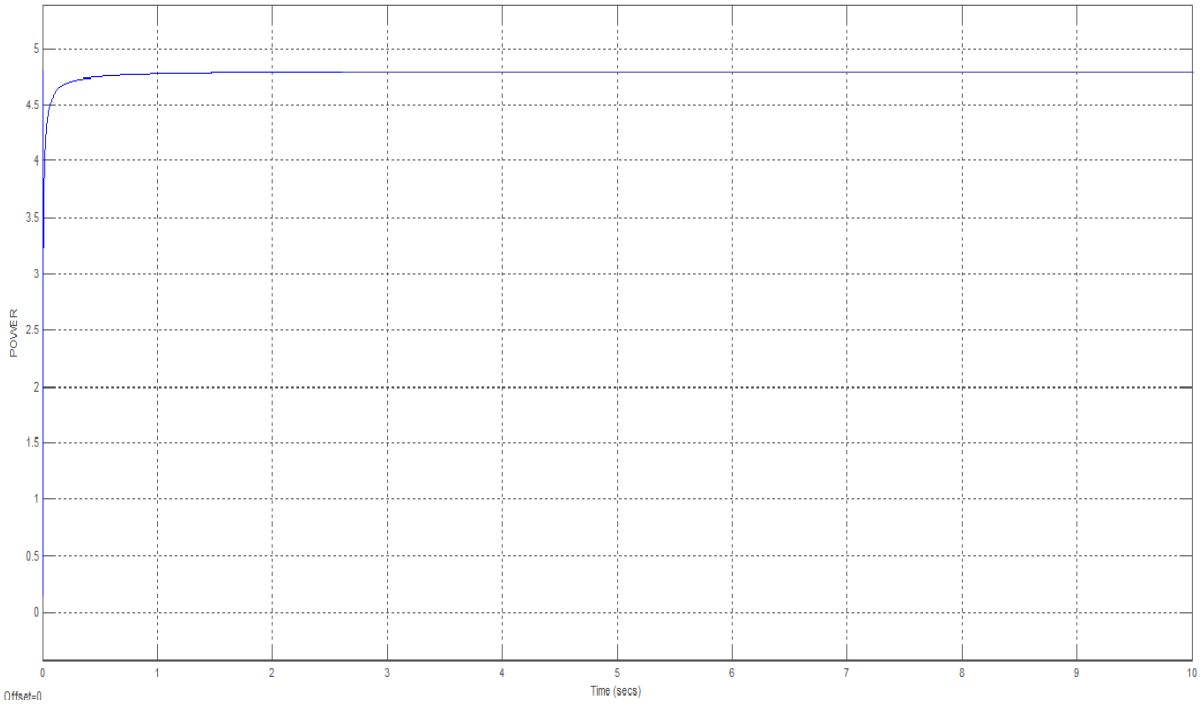

Fig 7: Output power versus time curve

III. GENETIC ALGORITHM

The genetic algorithm is also an evolutionary algorithm. Its aim is also to minimize the fitness function. It produces children for subsequent generations depending on the values of crossover and mutation factors[1] . The genetic algorithm toolbox can be used to set these values. The MATLAB manuscript file can also be used to set these values according to the syntax.

3.1 Simulation

The simulation of a subsystem consisting of GA based MPPT system is shown in Fig. 8. A closed loop negative feedback configuration is formed. The PV panel voltage is the reference input and the measured output voltage is the output. The error signal is passed through the PID controller. The output of PID controller is connected to the duty cycle generation block. Hence, the required duty cycle of boost converter is set to get the maximum power at dc load. The genetic algorithm is written in manuscript file of MATLAB as a function.

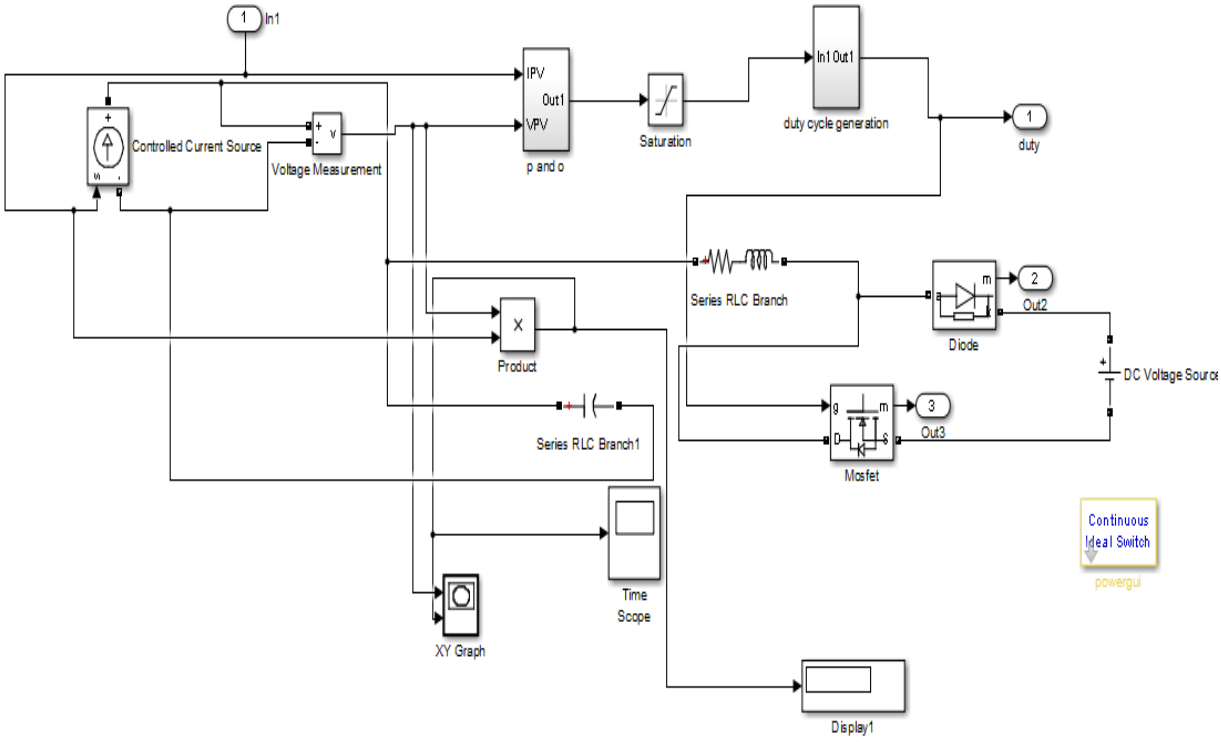

Fig 8: Subsystem of GA based MPPT

3.2 Results

In the proposed model of genetic algorithm based PID controller for maximum power point tracking, the proportional gain converges to 0.3010, integral gain converges to 24.2210, and derivative gain converges to 0.1400. The output power converges to 0.5 W.

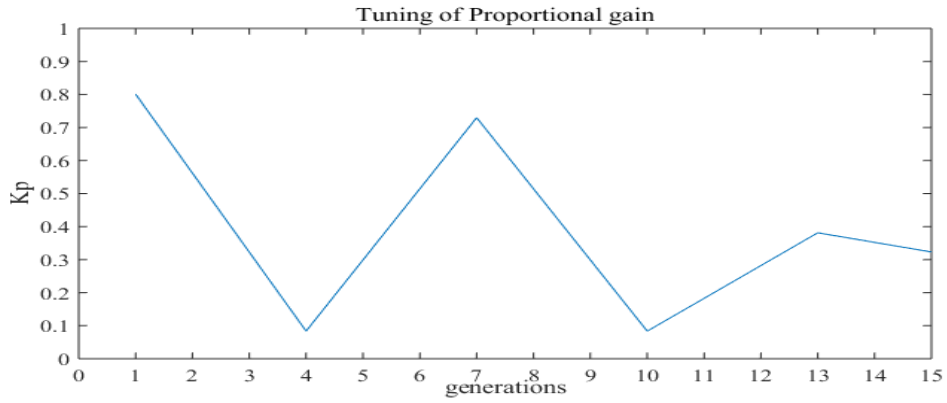

Fig 9 :Variation of Kp with number of generations

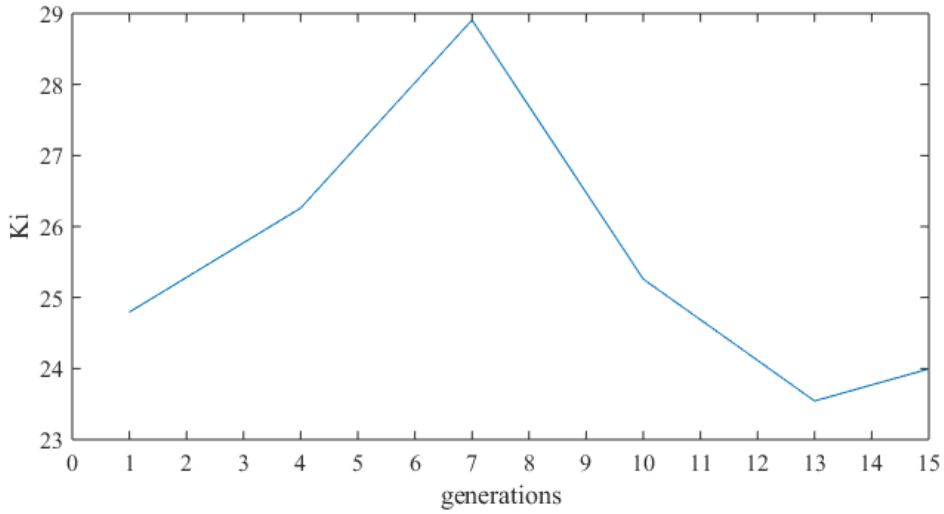

Fig 10 :Variation of Ki with number of generations

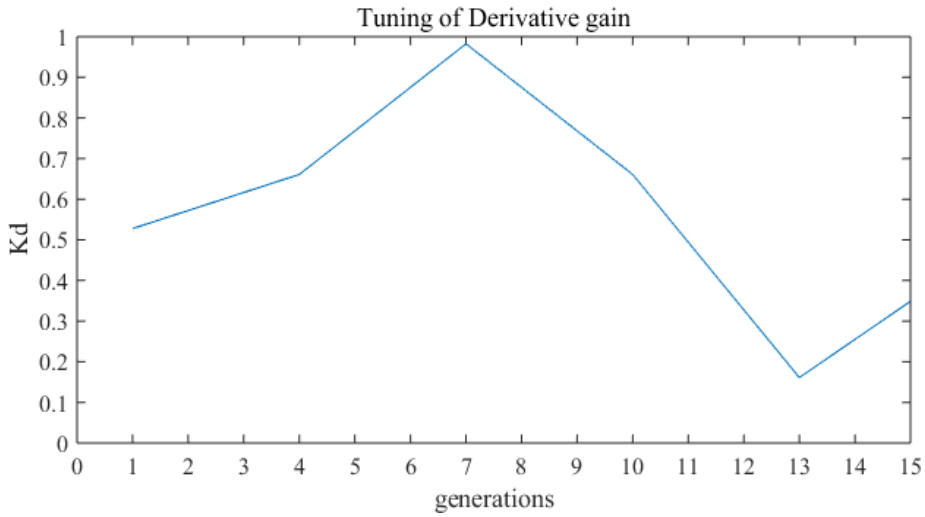

Fig 11 :Variation of Kd with number of generations

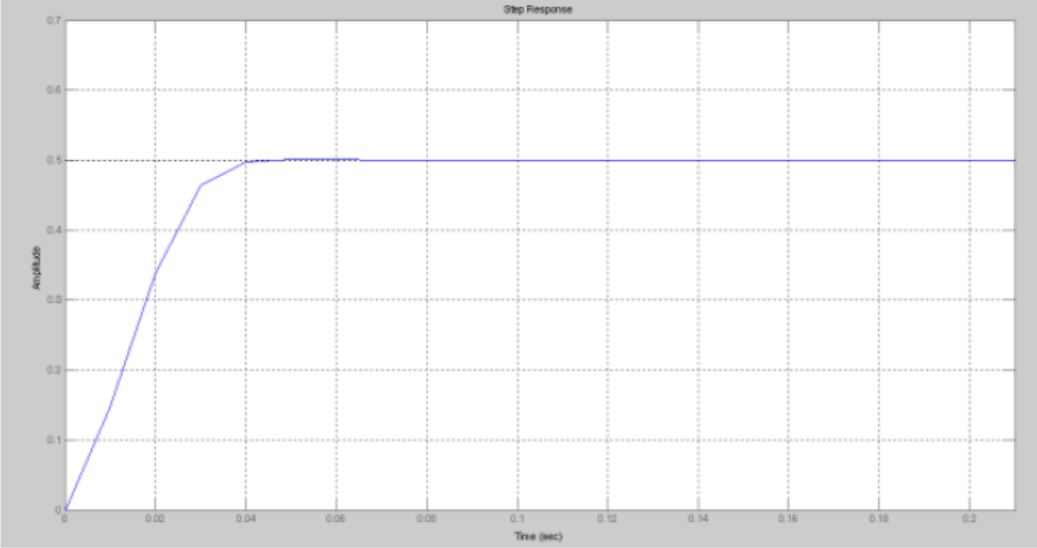

Fig 12: Output power versus time curve

Table 1: Comparison of Performance Parameters

Differential Evolution	Genetic Algorithm
Kp = 0.0102	Kp = 0.3010
Ki = 25.8527	Ki = 24.2210
Kd = 0.0029	Kd = 0.3400
Rise time = 0.02 sec	Rise Time = 0.07
Settling Time = 0.03 s	Settling Time = 0.09s

IV. DISCUSSION

The values of performance parameters with DE approach and GA approach are noted. The rise time is very less 0.02 seconds with the use of DE algorithm and 0.7 with the use of GA algorithm. The time taken to reach steady state is 0.03seconds and 0.09 seconds respectively.

V. CONCLUSION

The proposed models of the DE based and GA based MPPT systems are used to control the parameters of the PID controller. The input is the error signal generated by the difference of PV panel power and the feedback power from boost converter.

The disadvantage of using gradient-based methods like Perturb and observe or Incremental Conductance is that they can get stuck in a local minimum and their performance is dependent on initial values of design variables. It can be seen that differential evolution algorithm is more efficient than genetic algorithm with PV panel maximum power point tracking. As we have achieved optimum values of performance parameters, these method are more efficient than other methods like PandO or InCon. Also, there are almost no oscillations at steady state.

IV. ACKNOWLEDGEMENT

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