Simulation of DSTATCOM for Distribution Generation based System with Various Algorithms

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ABSTRACT

The growth in protection devices in the field of power systems has been rising from the preceding years which enlarge life span of the power system. This paper aims at designing of various types of Custom Power Device (CPDs) for stabilizing the system under abnormal conditions like sudden switching of loads. One of the Custom Power Device Namely Distribution Static Compensator (DSTATCOM) has been proposed for dealing with various power quality issues. This work involves design of feedback control strategy with different algorithms like BAT algorithm and ANT colony optimization algorithm for controlling the parameters at the grid side and also at the load side. The three-phase grid connected system has been tested with various conditions with sudden occurrence of fault and also with sudden switching of various loads. The assessment of performance of algorithms has been verified for various parameters like PCC voltage, current, active power, reactive power and power factor. The proposed system is simulated using MATLAB and results are also analyzed.

Keywords: *Distribution Static Compensator (DSTATCOM), Custom Power Device (CPD), ANT Colony Algorithm, BAT Algorithm*

1. INTRODUCTION

The power demand is higher when compared to expansion of transmission system which is limited to certain capacity and so the electrical stresses will be larger which leads to different power quality issues like voltage sag, swell, interruptions, harmonics and oscillation in the system [1]. It also results in imbalance in the reactive power which has to be mitigated to avoid instability at the system side. So, it is required to control the reactive power along with the controlling of power flow through the transmission lines. This can be achieved with the usage of controller's through modern power electronic devices.

One of the modern technologies is flexible AC transmission system (FACTS) devices which are implemented for mitigating the various power quality issues. The FACTS are basically classified into three configurations- shunt devices, series devices and shunt-series devices. A type of shunt compensator has been designed in the proposed work to observe the performance of FACTS devices. The FACTS device requires the controlling of the gate signals of the inverter there by controlling the voltage, power flow through the line and so for controlling purpose, feedback controller is required.

The PID controller can be used for controlling the source and load parameters, but the disadvantage with the conventional PID controller is low dynamic performance and also involves oscillations at the output. The intelligent fuzzy [6] controller can be used which involves the design of membership functions and also framing of rules for the membership functions, but sometimes requires higher number of membership functions which leads to [7] complexity of the system. Neural network with back propagation algorithm can be designed

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with certain layers of input, output and hidden neurons, adjusting weights [8] to attain minimum error, but the disadvantage with the neural network is slow convergence rate. Genetic algorithm which works on the principle of natural evaluation can be applied for optimization problems but suffers with the problems of parameter tuning, [14-16] because of complicated cross over and mutation operators and also speed of convergence. So to overcome the above discussed disadvantages, ANT and BAT algorithm has been proposed which controls the source and also load side parameters.

The paper is organized as follows: Section I presents Introduction to the proposed system, Section II deals with the explanation of block diagram of proposed system with CPDs. Section III deals with the discussion of ANT algorithm Section IV deals with the software implementation and discussion of results. Section V deals with the conclusions drawn from the proposed work.

2. BLOCK DIAGRAM OF CUSTOM POWER DEVICES BASED DISTRIBUTION SYSTEM

The block diagram for the grid connected distribution system with CPDs has been revealed in below figure. It consists of three phase system with source [1-2] and load which are always connected and also consists of various loads like synchronous generator-based wind mill and induction generator-based wind mill which are connected and disconnected at various times. The Custom Power Devices namely DSTATCOM consisting of voltage source inverter connected in shunt with the system through shunt transformer. When an abnormal condition like occurrence of fault or sudden connection of load happens, there will be imbalance of voltage, current and also power. So, at that time, the algorithm-based controller operates generating error which will be fed for gate pulse generation for the CPD controller. Then Custom power Device will inject or absorb the power based up on the requirement there by controlling the parameters at Point of Common Coupling (PCC).

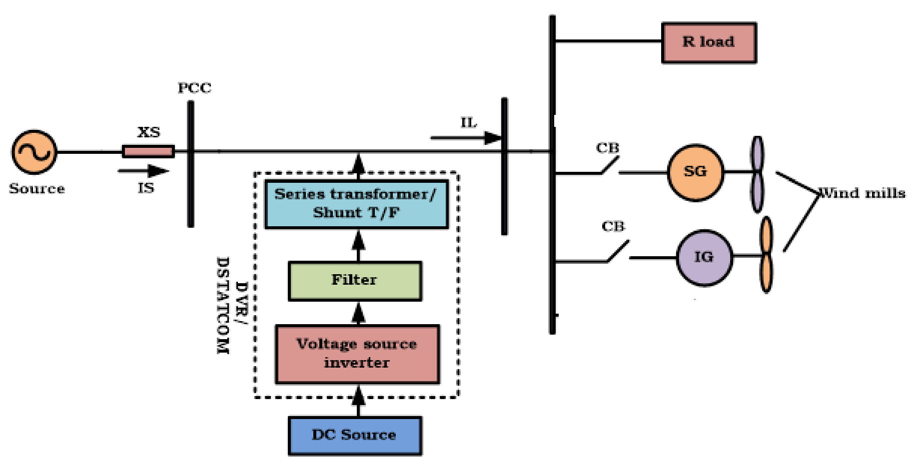

Figure 1: Block diagram of grid connected distribution system with CPDs

2.1. DISTRIBUTION STATIC COMPENSATOR (DSTATCOM)

The DSTATCOM is a custom power device which generates [2] three phase synchronous voltage with the supply voltages by means of DC source in combination with inverter by compensating reactive power also. In general, the voltage generated by the compensator will be always in phase with the line voltages, with no exchange of active power but there will be

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exchange of reactive power in this case with the variation of amplitude of voltages. The compensator will always be connected in parallel with the line through the shunt transformer. Depending up on the amplitude of voltages, three conditions can be realized with the DSTATCOM.

Case 1: If the line voltage is less than the shunt voltage, the current of DSTATCOM leads the line voltage by 900, and then leading reactive power flows from the DSTATCOM.

Case 2: If the line voltage is more than the shunt voltage, the current of DSTATCOM lags the line voltage by 90^0, and then lagging reactive power flows from the DSTATCOM.

Case 3: If the line voltage is equal to the shunt voltage, then no reactive power flows from the DSTATCOM.

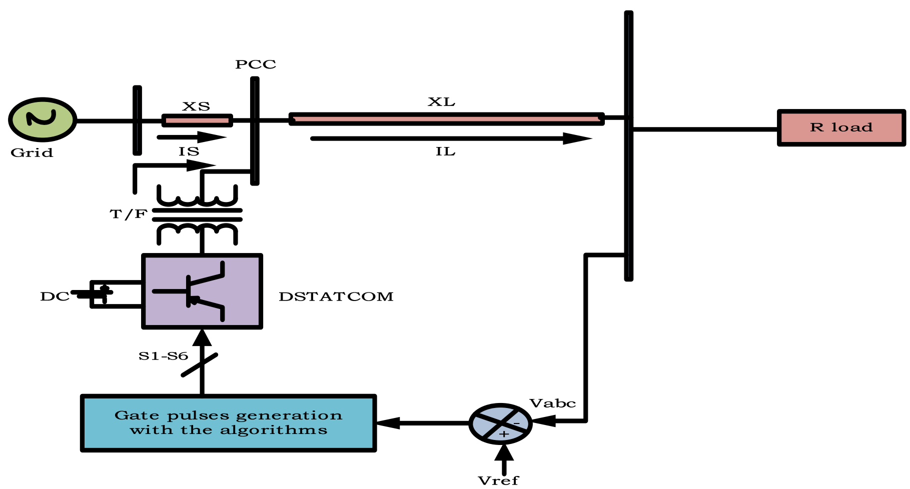

Figure 2: one-line diagram of power system with DSTATCOM

3. Software Realization of DSTATCOM

The software implementation of the DG system with DSTATCOM has been implemented with various test cases like switching on of loads. Also, two algorithms namely ANT Colony optimization algorithm, BAT algorithm.

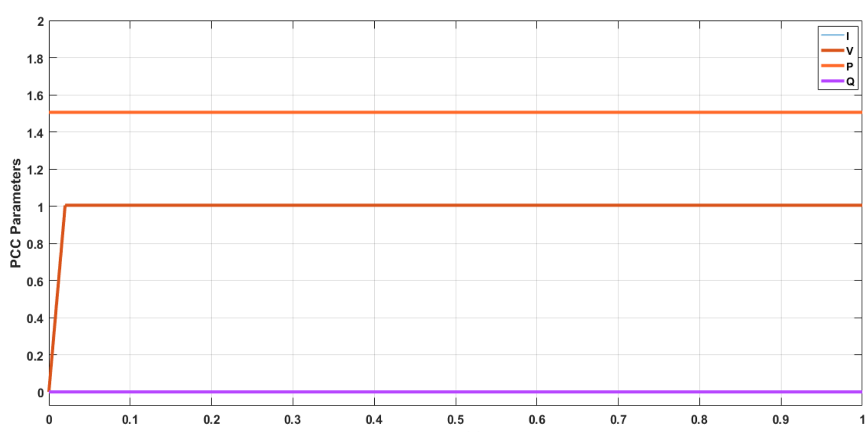

Figure 3: PCC Parameters of power system

The below table shows the rated parameters of the power system

Table 1: PCC Parameters of power system

Parameter	Rated values
Voltage	1pu
Current	1pu
Active power	1.5pu
Reactive power	0pu
Power factor	1pu

- **With fault condition in the power system**

The LLL fault has been created in the system at t=0.1s to t=0.65s and various algorithms have been tested for dynamic voltage restorer.

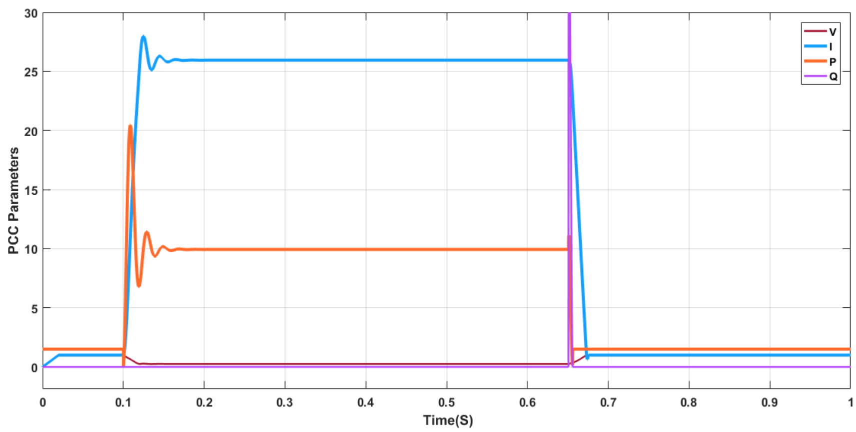

Figure 4 : PCC Parameters of power system under faulted condition

➢ ***DSTATCOM***

The power system has been simulated with grid at source side and load at the end side and the below waveform shows the PCC parameters at rated values.

The voltage has been almost remained constant, current has been maintained at 7.7times the rated value, active power has been maintained at 4times the rated value and reactive power is almost zero.

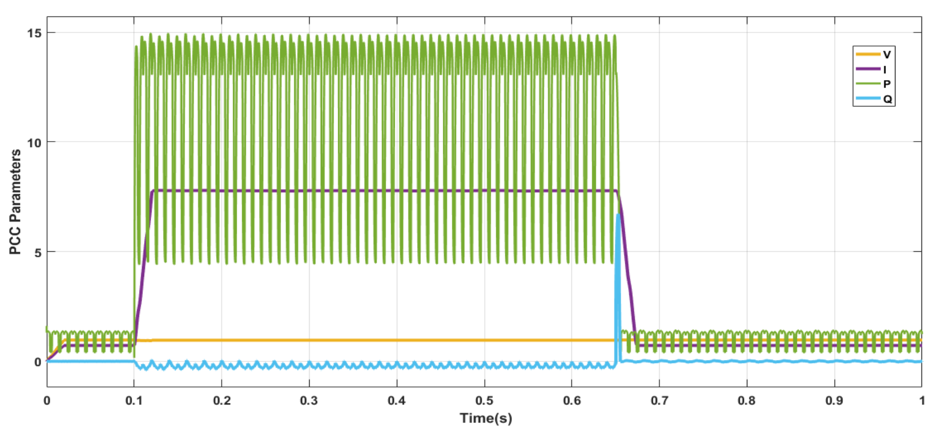

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Figure 5 : PCC Parameters of power system under fault condition with DSTATCOM

Table 2: PCC Parameters with DSTATCOM using BAT, ANT algorithms

Parameter	Without CPDs	With CPD	
		BAT Algorithm	ANT Colony Algorithm
Voltage	0.998pu	0.96pu	0.6pu
Current	1.018pu	7.78pu	4.9pu
Active power	1.526pu	15pu	5.1pu
Reactive power	0.0001pu	0.0037pu	0.0037pu
Power factor	0.999pu	0.946pu	0.99pu

- ***With wind-based induction generator***

The wind turbine-based induction generator has been connected to the system at t=0.1s to t=0.65s and various algorithms have been tested for distribution static compensator.

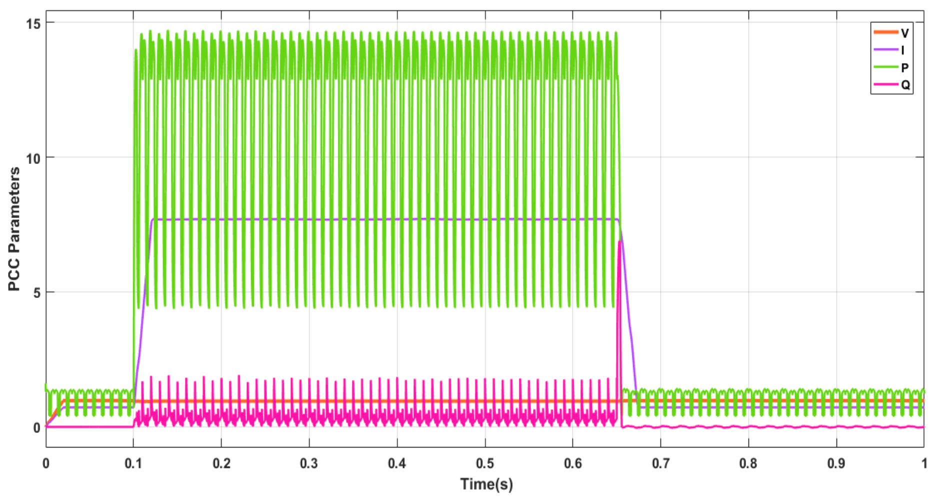

Figure 6: PCC Parameters of power system with induction generator with DSTATCOM

Table 3: PCC Parameters with induction generator, DSTATCOM, BAT, ANT algorithms

Parameter	Without CPDs	With CPDs	
		BAT Algorithm	ANT Colony Algorithm
Voltage	0.998pu	0.953pu	0.6pu
Current	1.018pu	7.7pu	3.5pu
Active power	1.526pu	14.6pu	5.9pu
Reactive power	0.0001pu	2pu	1.1pu
Power factor	0.999pu	0.95pu	0.95pu

- ***With wind based Synchronous generator***

The wind turbine based synchronous generator has been connected to the system at t=0.1s to t=0.65s and various algorithms have been tested for distribution static compensator.

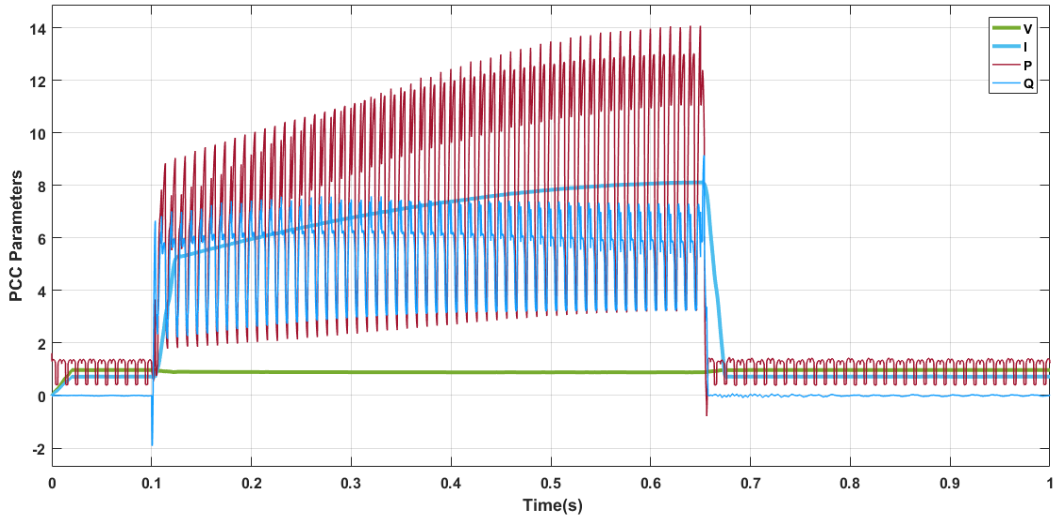

Figure 7: PCC Parameters of power system with synchronous generator with DSTATCOM

Table 4: PCC Parameters with synchronous generator, DSTATCOM BAT, ANT algorithms

Parameter	Without CPDs	With CPDs	
		BAT Algorithm	ANT Colony Algorithm
Voltage	0.998pu	0.89pu	0.59pu
Current	1.018pu	5.2pu	2.7pu
Active power	1.526pu	8.5pu	1.8pu
Reactive power	0.0001pu	7.1pu	3pu
Power factor	0.999pu	0.6pu	0.38pu

The DSTATCOM, DVR have been tested with three algorithms namely Weighted feedback, BAT, ANT algorithms for various conditions like fault occurrence, switching of synchronous generator, switching of induction generator, switching of RLC load where at every case DVR shows the better performance with weighted feedback algorithm than DSTATCOM with comparison of remaining two algorithms.

4. CONCLUSION

The Custom Power Devices Distribution Static Compensator has been proposed for dealing with various power quality issues in this paper. The design BAT algorithm and ANT colony optimization algorithm for controlling the parameters at the grid side and also at the load side have been proposed in this paper. The three-phase grid connected system has been tested with various conditions with sudden switching of various loads and the assessment of performance of algorithms has been verified in terms of various parameters like PCC voltage, current, active power, reactive power and power factor where the control strategy with ANT Colony Algorithm shows the better performance than the BAT algorithm. The entire system has been simulated using MATLAB/Simulink and also analysis of the results has been performed.

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