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Proportional and Integral constants Optimization Using Bacterial Foraging Algorithm for Boost Inverter

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Abstract

A boost dc-ac inverter is one which is capable of generating in a single stage ac voltage whose peak value can be higher or lower than the given input dc voltage. The major problem with this system is that the closed loop gain parameters kp and ki have to be optimized because these parameters help us to get desired result with better system response by lowering the rise time, settling time, peak overshoot and steady state error. Moreover when they are not optimized load line disturbances arise because of which the stability of output voltage decreases and THD value increases. So to overcome these difficulties bacterial foraging algorithm is being used.

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Keywords: Boost Inverter; Bacterial Foraging Algorithm; PI Controller.

1. 1. Introduction

A boost inverter can generate a peak ac voltage higher or lower than the input dc voltage [1-6]. Battery sources, photovoltaic solar systems [2] and fuel cells [5] are some of the major areas which involves the use of boost inverters. The major disadvantage with the present day inverters is that the stability of the output voltage decreases, THD value increases and the dynamic response of the system is not satisfactory [2]. The value of THD is reduced by using closed loop system and optimizing the controller gain of proportional and integral controller constants

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respectively. A particular set of optimizing values for these parameters is obtained for a particular load. Bacterial Foraging Optimization Algorithm (BFOA) is being used in this paper for obtaining these optimizing values. The foraging behaviour of Escherichia coli bacteria is being replicated by this optimization algorithm. The survival of a bacterium in a population is perceived as "survival of fittest" and is used for performance enhancement of this model.

2. Proposed bacterial foraging algorithm based boost inverter (BFOABI)

Kevin M.passino was the one who proposed the BFOA which is actually derived by the social foraging behavior of Escherichia coli bacteria. The optimization algorithm is based on the group foraging strategy principle used by a group of E.Coli. A bacterium considers two factors for taking foraging decisions. The first one is the maximum energy that it is able to get per unit time while moving in search of nutrients and the second one being its communication with the other bacterium. Chemo taxis is the process by which a bacteria progresses in steps while searching for nutrients. Thus the strategy of chemo tactic movement of virtual bacteria in the problem search space is used in BFOA. When bacteria gets its sufficient food, it grows by increasing in length and a stage occurs wherein the presence of environment causes the bacteria to break and produce an exact replica of itself which is termed as reproduction. A sudden or an abrupt change in the environment can result in the movement of bacteria to some other place or may get destroyed. From here we get the process of elimination and dispersal. The three underlying biological mechanisms observed in a group of bacteria are chemotaxis, reproduction and elimination- dispersal and these things are being used in the BFOA. A virtual bacterium is actually one trial solution and it is able to locate the optimum solution by moving on the functional surface[7-8].

PWM converter switching, optimization of power converters and control of power converters involves the use of BFOA. Examination of BFOA model has been done and is being shown in Fig. 1. The proposed system follows small signal model based voltage mode control strategy. Kp and Ki values of the PI controller is being accurately obtained with the help of BFOA. Load disturbances and line disturbances causes the rise time, peak time settling time and steady state error to vary that will disturb the system response. Also for better dynamic response, we formulate the situation into the given optimization problem which is given by equation (1) and (2). Objective function:

$$F = (1+t_r)(1+t_s)(1+P_o)(1+E_{ss}) \tag{1}$$

$$\textit{Subject to} \quad \varphi_{(lower)} \le \varphi \le \varphi_{(upper)} \qquad \textit{Where,}\ \varphi = \{K_p, K_i\}$$

$$\text{Fitness function} = \frac{1}{\mathrm{F}(\varphi)} \tag{2}$$

The BFOA design parameters are shown in Table 1.

Table 1. The BFOA design parameters.

Parameter Name	No.	Parameter Name	No.
Population size	10	Elimination and dispersal loop size	2
No of iteration	10	Swim length	4
Chemotactic size	4	Dispersal probability	0.2
Reproduction loop size	4		

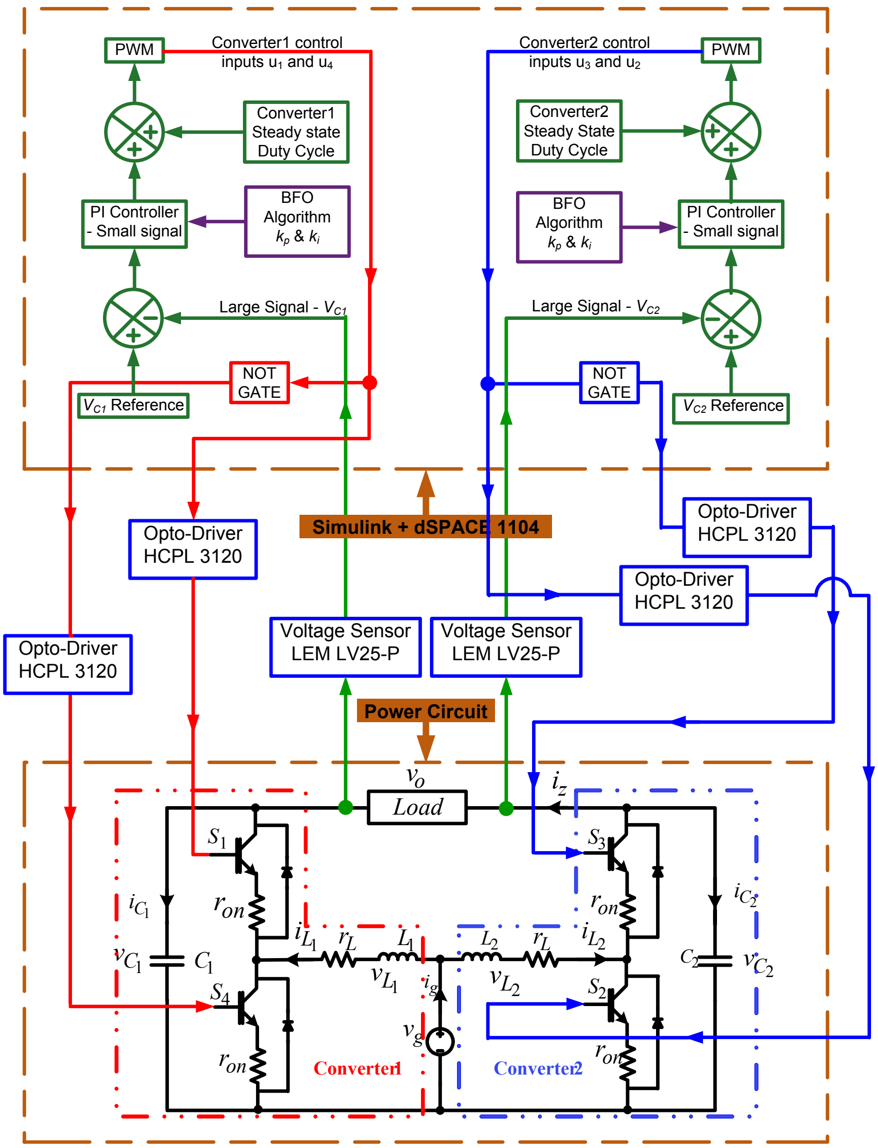

Fig. 1. Block diagram of the proposed BFOABI.

3. Result

The performance of the BFOABI model is tested. The design parameters are shown in Table 2. Steady state, linear, non-linear, line and load disturbances tests were done on the existing boost inverter model and satisfactory results were obtained. However by the use of BFOABI model a particular set of k_p and k_i values were obtained from simulation that gave a minimum value for the parameters rise time, peak time settling time and steady state error as shown in Table 3. In this model of BFOABI a new experiment was done by changing the load from lagging to unity power factor and vice versa. The hardware results obtained were extraordinary and in the coming sections detailed analysis about the line and load regulation is being done.

Table 2. Boost inverter design parameters.

Parameter Name	No.	Parameter Name	No.
Input dc voltage, Vg	36 V	Capacitors, C1 and C2	20 µF
Output ac voltage, VO	100 Vmax	Load resistor, R	220 Ω
Switching frequency, fs	20000 Hz	Real time interfacing kit,	dSPACE-1104
Dual IGBT modules, S1 to S4	CM75DU-12H	Voltage Sensor, LEM LV 25 – P	500V
Inductors, L1 and L2	200 µH with 0.3 Ω parasitic resistance		

Table 3. Obtained optimization parameters.

No. of iteration	K_p (x 10^{-5})	K_i (x 10^{-5})	Peak overshoot (M_p)	Steady state error (ess)	Rising time (t_r) in sec	Settling time (t_s)in sec
50	3.756	3.595	2.14x 10^{-8}	0.414	0.00562	0.017

3.1. Line Regulation

In order to test the systems under line regulation, stepping down of inverter voltage has been done from 36 to 33 volts and the result shows regulated output for the BFOABI model and the output reaches steady state within a fraction of 20ms and the quality of waveform we got from BFOABI system is much better. It is also being observed that the rise time, peak time, settling time and steady state error attains a minimum value and the above mentioned primary objective is being met. The hardware result obtained for the BFOABI is shown in Fig.2.(a)

3.2. Load Regulation

In order to test the systems under load regulation, a sudden change of load was done that is from a lagging power factor to a unity power factor load. It is being observed that the output voltage reaches steady state within a fraction of 20ms and the corresponding graph is being shown in Fig.2.(b) Similarly a sudden change of load was done from unity power factor to a lagging load and the output voltage reached steady state within a fraction of 20ms.It is also being observed that the rise time, peak time, settling time and steady state error attains a minimum value and the above mentioned primary objective is being met. We can infer that the BFOABI system reaches quickly to steady state and the above mentioned parameters attains a minimum value in spite of the above mentioned disturbances.

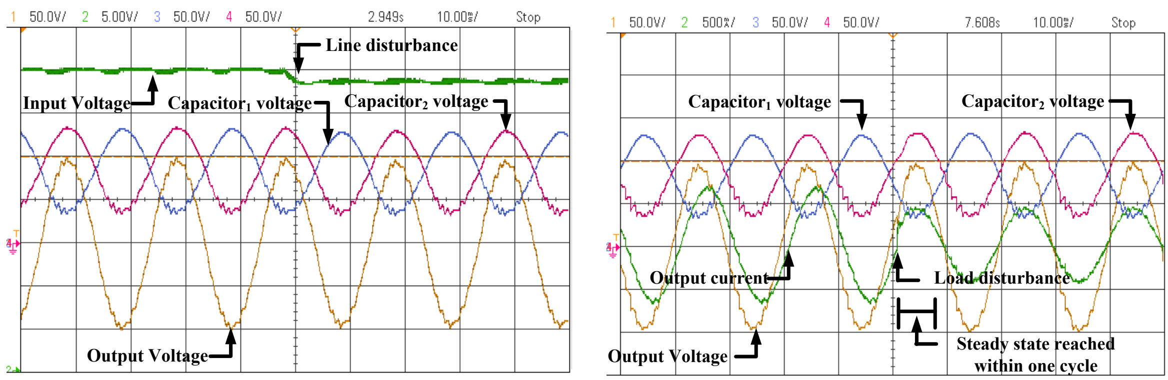

Fig. 2. (a) Line Regulation; (b) Load Regulation.

4. Conclusion

A boost inverter which would convert the given DC voltage supply to single phase AC voltage has been implemented in closed loop in voltage control mode. The PI controller constants have been obtained by using bacterial foraging algorithm and it is observed that when the model is implemented by bacterial foraging algorithm it gives a better system response by reducing rise time, settling time, peak overshoot and steady state error and the THD value was observed to be 3.12% which is a very minimum value than the traditional topology inverters. Moreover it can be seen from the results that even during the line and load disturbance conditions, output voltage reaches steady state within a time duration of 20 millisecond proving that the system will remain stable, adaptive and robust and can withstand the disturbances in any system in which it is employed. So, the above results prove that the proposed system is best suited for all sort of grid connected and renewable energy applications.

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