Particle Swarm Optimization based Control Algorithm for Cost Minimization of Hybrid Micro source- Residential Load System

Mr. Gireesha B[*1]
[*1]Ph. D Scholar – E.C.E Department, School of Engineering, C.U.K-585367, Karnataka, India

Abstract— ***This paper presents a particle swarm optimization (PSO) based optimized control algorithm for cost optimization of hybrid microsource- residential load system. In this work the PSO based Battery Energy Storage System (BESS) has introduced between the grid and hybrid microsource- residential building. During the peak hours the PSO based BESS supplies energy to the grid and during the normal base condition hours the PSO based BESS gets charged from the grid. The objective of this work is to perform peak cutting, total electricity cost minimization of hybrid microsource-residential building and making the use of dynamic energy pricing model. The proposed algorithm is not only for one microsource, it will applicable to 'n' number of input microsources.***

Index Terms— Micro energy sources (MES), renewable energy sources (RES), photo voltaic (PV) panel, wind energy (WE) , maximum power point tracking (MPPT), optimization techniques, particle swarm optimization (PSO).

I. INTRODUCTION

From few decades microsource based microgrids becoming popular due to the many advantages and various electrical and social aspects of advantages ware given in literature [1] - [5]. Battery Energy Storage Systems (BESS) plays a key in renewable energy source based systems and as well as in domestic along with many other applications. Energy management of BESS is a major issue in many BESS based systems. By optimizing the BESS, the total system can be optimized [6]-[10].

Few of the well-known population-based optimization techniques developed during last few decades are: Genetic Algorithms (GA), Artificial Immune Algorithms (AIA), Particle Swarm Optimization (PSO), Differential Evolution (DE), Harmony Search (HS) , Bacteria Foraging Optimization (BFO), Shuffled Frog Leaping (SFL), Artificial Bee Colony (ABC), Biogeography-Based Optimization (BBO), Gravitational Search Algorithm (GSA) and Grenade Explosion Method (GEM). These algorithms have been applied to many engineering optimization problems and proved effective to solve some specific kind of problems. Among these optimization techniques, PSO is more popular because of simplicity, high convergence rate, minimal storage requirement and ease of use to engineering and applications [10]-[17].

At the distribution power generation level by integrating a microsource based generation residential-load system with BESS to the smartgrid or microgrid will provide a better way of utilizing the renewable energy sources and can minimise the electricity bill of the residential system. Most of the studies related to the mircogrids keep focus on how to manage the flow of electric energy between distributed generation, BESS, connected loads and the grid in order to minimise the electricity bill of customers , improving generating stations efficiency, saving of electric energy and stabilizing output power and so on [18]-[22]. In this paper, to optimize the operation and cost of electricity bill of 'n' number of microsource based residential load system; the PSO method has been adapted.

Over view of this paper is organized as follows. A brief introduction to significance of renewable energy based power systems, integration of microgrid with BESS and optimization methods ware discussed in Section 1. Proposed system configuration, modelling and PSO based optimized operation of BESS is given in the Section 2. Section 3 is given the Conclusion.

II. PROPOSED SYSTEM CONFIGURATION AND PSO BASED OPTIMIZATION APPROACH

This converse the problem formulation, PSO based BESS solution of proposed system. To optimize the cost of the 'n' number of microsource based residential load system with BESS by PSO of proposed system is drawn in a single line diagram and is shown in Fig.1 and nomenclature of the proposed algorithm is given by Table. I

Problem formulation of Proposed System

In this subsection, PV array modeling is presented. The equivalent circuit of a PV cell is given by Fig.1., the related responses are given by equations (1)-(7) [18]-[23]. Nomenclature of the PV array is given by Table. I

$$Min. c(k). e_g(k) \quad (1)$$
$$s.t: -r_d \leq e_b(k+1) - e_b(k) \leq r_c \quad (2)$$
$$\alpha_m E_m \leq e_b(k) \leq \alpha_m E_m \quad (3)$$
$$e_b(N) = E_o \quad (4)$$

The above equations (1)-(4) can be converted into cost function as follows:

$$Cost\ Function = (C^{*}e_g) + (Constraints) \quad (5)$$

$$Constraints = \lambda_1 C_1 + \lambda_2 C_2 + \lambda_3 C_3 + \lambda_4 C_4 \quad (6)$$

$$C_1 = e_s - e_l + r_d - e_g \quad (7)$$

$$C_2 = e_s - e_l - r_c + e_g \quad (8)$$

$$C_3 = e_s - e_l + e_b - e_g - \alpha_m E_m \quad (9)$$

$$C_4 = e_s - e_l + e_b + e_g - \alpha_M E_m \quad (10)$$

$$e_s = e_p + e_w + \cdots e_n \quad (11)$$

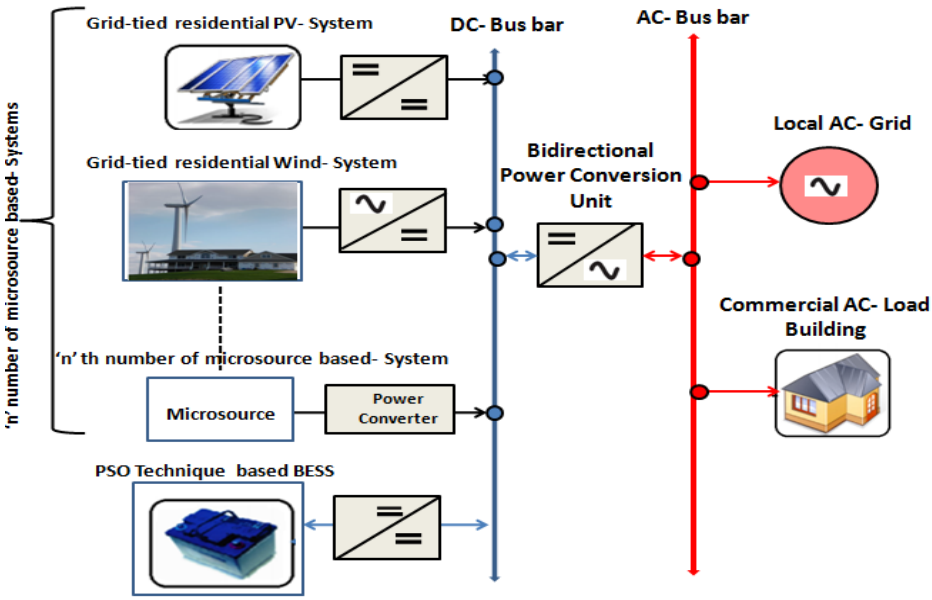

Fig.1. Single line diagram of proposed BESS-PSO based optimized 'n' number of microsource based residential load system

TABLE I
NOMENCLATURE OF THE PROPOSED MODEL

Sl. No	Symbol	Defined term
1	C	Cost
2	e_g	Grid energy
3	e_s	Microsource Energy
4	e_n	n^{th} number of microsource
5	e_l	Energy drawn by load
6	e_b	BESS Energy
7	λ	LaGrange's coefficient
8	r_c	Rate of charge of Battery
9	r_d	Rate of discharge of Battery
10	E_m	Energy rating of Battery
11	E_o	*Initial Energy of Battery*
12	α_m	Minimum percentage of Battery
13	α_M	Maximum percentage of Battery

Flowchart of Particle Swarm Optimization (PSO)

Fig.2. shows the flow chart diagram of PSO algorithm, which is used in this work to optimize propose the algorithm scheme to minimize the electricity bill of microsource based residential load system [22].

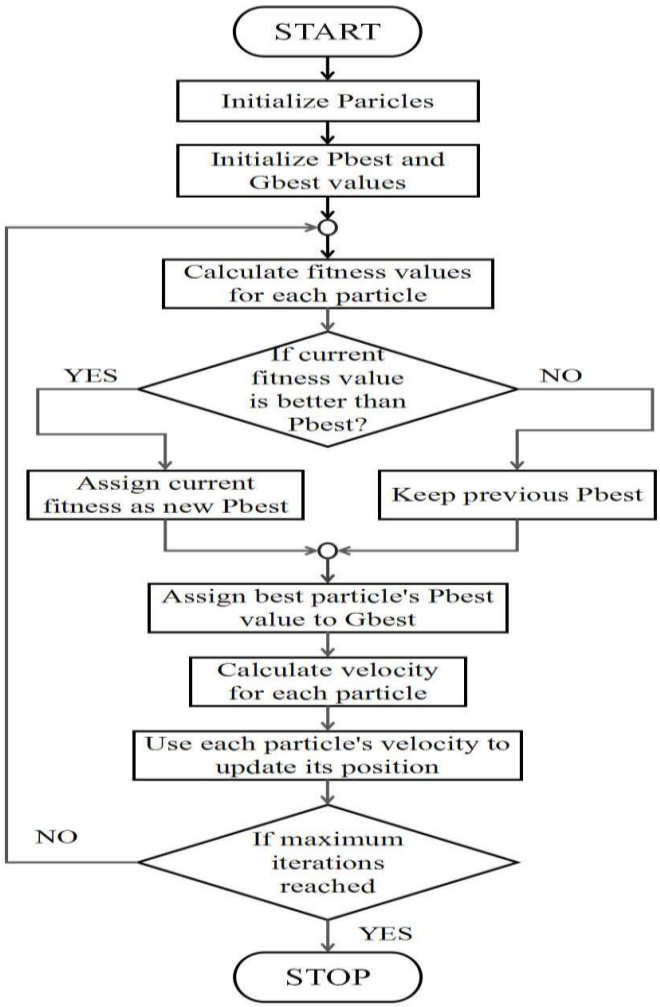

Fig.2. PSO flow chart diagram algorithm.

Steps for Particle Swarm Optimization (PSO) implantation:

The fallows steps give a clear idea to implement PSO algorithm for considered systems.

Step 1:	*Read Inputs (dynamic pricing, load, Microsource energy schedule)*
Step 2:	*Initialize parameters*
Step 3:	*Initialize loop variable to 1*
Step 4:	*Define the cost function as given in the equation (5)*
Step 5:	*Use PSO to optimize the cost function to get optimized grid power*
Step 6:	*Now update battery energy for next iteration*
Step 7:	*Increment the loop variable by 1*
Step 8:	*If the value of loop variable is less than the total no. of samples of input* go to "Step-4"
Step 9:	*Calculate the total electricity bill*
Step 10:	*Plot the graphs*

III. CONCLUSION AND SCOPE OF THE FUTURE WORK

Hence in this paper to optimize the electricity bill of a considered model an efficient algorithm has presented by integrate the microsource based residential load system, PSO implemented BESS with bi-directional power converter and local microgrid through a AC and DC bus bars. Through the proposed algorithm, the dynamic characteristics of battery energy storage system decides the microsource based system either give the electric energy to the grid or take the electric energy from the grid.
For further research on optimization of the considered model, other optimization techniques can be adapted and checked. To increase system rating PSO based maximum power point tracking (MPPT) algorithms can be considered and also for more accuracy in battery energy management system Artificial Intelligence (AI) based methods can be used

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