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# Quantum behaved artificial bee colony based conventional controller for optimum dispatch

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**ABSTRACT**

Since a multi area system (MAS) is characterized by momentary overshoot, undershoot and intolerable settling time so, neutral copper conductors are replaced by multilayer zigzag graphene nano ribbon (MLGNR) interconnects that are tremendously advantageous to copper interconnects for the future transmission line conductors necessitated for economic and emission dispatch (EED) of electric supply system giving rise to reduced overshoots and settling time and greenhouse effect as well. The recent work includes combinatorial algorithm involving proportional integral and derivative controller and heuristic swarm optimization; we say it as Hybrid-particle swarm optimization (PSO) controller. The modeling of two multi area systems meant for EED is carried out by controlling the conventional proportional integral and derivative (PID) controller regulated and monitored by quantum behaved artificial bee colony (ABC) optimization based PID (QABCOPID) controller in MATLAB/Simulink platform. After the modelling and simulation of QABCOPID controller it is realized that QABCOPID is better as compared to multi span double display (MM), neural network based PID (NNPID), multi objective constriction PSO (MOCPSO) and multi objective PSO (MOPSO). The real power generation fixed by QABCOPID controller is used to estimate the combined cost and emission objectives yielding optimal solution, minimum losses and maximum efficiency of transmission line.



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## 1. INTRODUCTION

Combined economic emission dispatch (EED) is a difficult problem to obtain most favorable result for optimum dispatch of electric power with optimum emission level due to insecurity and rigorous time consuming tests like Newton–Raphson method used by Chen and Chen [1], lambda-iteration method used by Ramadan *et al.* [2], linear programming techniques and non-linear combined-integer quadratic rule method practiced by Palanichamy and Babu [3], Kiani and Pourtakdoust [4], Papageorgiou and Fraga [5], and Abido [6]. Improved heuristic methods mimicking natural selection processes applied by Bakirtzis [7], followed by Daryani and Zare [8], in group search optimization (GSO) processes adopted by Bora *et al.* [9], chaotic self-adaptive search (CHS) processes, and do not perform satisfactorily for bulky coal fired plants due to presence of complex varying nonuniformities resulted out of multi-valving criteria of impulse reaction turbines. Ghoshal [10] in the recent work put forth a modified technique by amalgamating limiting factors of the quantum behaved artificial bee colony optimization technique and proportional, derivative and integral controller giving rise to quantum behaved artificial bee colony optimization based proportional, derivative and integral controller (QABCOPID) where a more balanced approach among regional and global search capabilities can be used to examine the EED situation and swiftly arrive at the minimum location. More specifically authors in this article present the utility of the quantum behaved artificial bee colony (ABC) optimization technique to govern the real time proportional integral and derivative controller to ascertain tie line response and incremental frequency deviations of two area systems and finally results real power generations of the alternators. These real power generations solve the EED problem of huge thermal power plants of western countries having bulky thermal generating units involving cubic cost, emission and combined objective approach using different training methods for the 30-bus test case system depicted in Figure 1 with six alternators and are utilized to estimate the limiting factors of transmission line and simulate the power lines as well. Since the incremental real power generation depends upon the incremental frequency deviation so by regulating the unbalanced power demand at the demand center and turbine intent and governor setting at the place of generation and by touching the automatic load-frequency control (ALFC) adopted by Prasanth and Kumar [11], Juang and Lu [12], automatic voltage regulation (AVR) parameters through the quantum behaved artificial bee colony optimization proportional–integral–derivative (QUABCOPID) controller model shown in Figure 2, the optimal values for cost of cost of coal and greenhouse gas level rate are obtained for multi-area complex bulky thermal power plants connected through a tie line by exploiting the waggle dance of artificial bees shown in Figure 3 to venture into across-the-board area. The authors of this work attempted to improve the convergence and across-the-board optimization capabilities of the QABCOPID controller in order to increase its relevance as a more effective approach for assessing various EED problems. The advantage of this strategy is that it allows for instantaneous tuning of proportional–integral–derivative (PID) controllers, as demonstrated by Sahu *et al.* [13], Sharifi *et al.* [14], Dhawane and Bichkar [15], Pradhan and Majhi [16]. The following are the characteristics discussed in this dissertation.

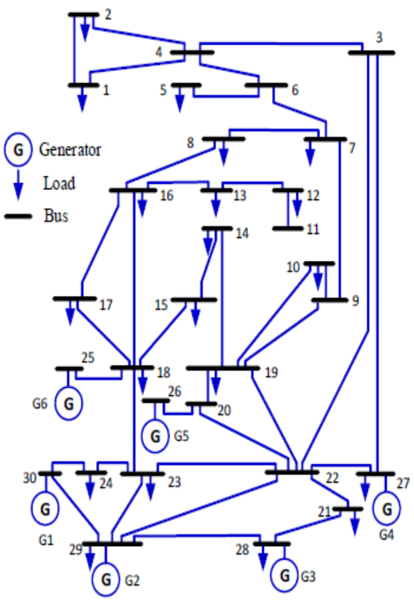

Figure 1. IEEE 30 bus 6-unit test case system

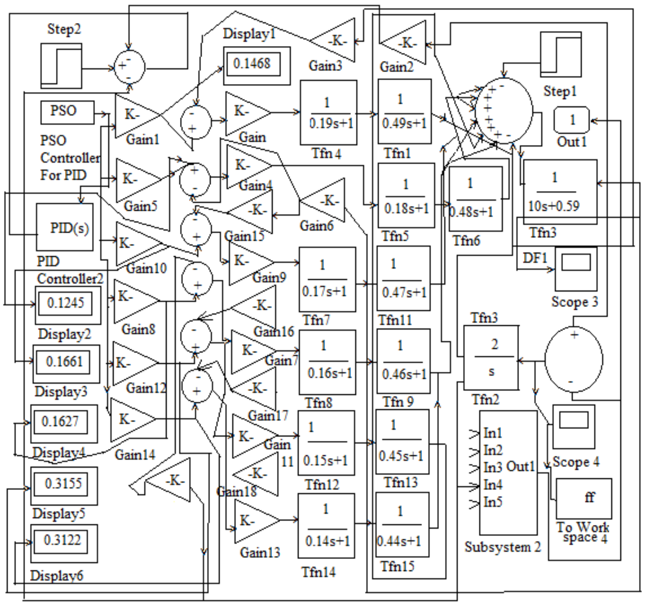

Figure 2. Model for the proposed method

Figure 3. Waggle dance of honey bee

The enhanced particle swarm optimization (PSO) algorithm, namely the QABCOPID technique established by Xu and Sun [17], is implemented to obtain the most favorable result for EED and to perform better analyses on the results obtained with the proposed QABCOPID algorithm, which includes a formulation of the EED problem with losses. The outcomes of EED solutions achieved using QUABCOPID were compared to those acquired using other heuristic optimization algorithms. The obtained real optimal powers are used to access the stability of transmission lines using the transmission characteristics determined using a bench power transmission simulator based on HONALEC.

The following is the structure of this article: The formulation of the combined dispatch problem was described in section 2. Section 3 demonstrated the conventional PSO technique and the new QUABCOPID technique, respectively. Section 4 details the aforementioned approach's flow chart and implementation. Section 5 showed the optimization findings obtained using the suggested technique, including a case study, and compared them to previously published researches, as well as plotted the results. Section 6 discusses the methods and results of a simulation of a 252-kilovolt transmission line. Finally, sections 7 and 8 give findings and future prospects.

## 2. FORMULATION OF EED PROBLEM

The QUABCOPID optimization approach is introduced in this study to optimize fuel cost and emission level as objective functions. The alternator units are all thermal and operate continuously on-line, posing many limitations such as equality, inequality, and including transmission losses to ensure the novel project's completion. A combinatorial approach based on quantum behaved artificial bee colony optimization and a conventional PID controller were used by Rahimian and Raahemifar [18], Shankar and Mukherjee [19], Soni and Bhat [20], Huang *et al.* [21], Lu *et al.* [22], to optimize a cubic cost, emission, and combined objective function for a six-unit thermal power plant.

### 2.1. Formalization of the fundamental objective function

Taking, $a_i, b_i, c_i, d_i, e_i and\ f_i$as the price Table 1 of fuel price function $fli$

$$f1i = \sum_{i=1}^{n}(a_i + b_iP_i + c_i{P_i}^2 + \left|d_i sin\{e_i(P_i^{min} - P_i)\}\right| + f_i{P_i}^3 \text{Rs/hr} \tag{1}$$

$f1i$ is fuel price function of thermal units, $Pgi$ is real unit outage of the $i^{th}$ unit, $n$ is total number of alternators, $P_{gi}^{min}$ is minimum power of $i^{th}$ unit.

$$f2i = \sum_{i=1}^{n}(\alpha_i + \beta_i P_i + \gamma_i P_i^2 + \eta_i \exp(\delta_i P_i)) + \Gamma_i P_i^3 \text{kg/hr} \tag{2}$$

Taking, $\alpha_i, \beta_i, \gamma_i, \eta_i, \delta_i and\ \Gamma_i$ as emission coefficients of emission function $f2i$. $f2i$ is emission level function in kg/hr. Constraints on equality: In equation, the overall output power outage of the units must equal the output at the demand center plus transmission line losses in the power lines (3):

$$\sum_{i=1}^{N} P_i - (P_D + P_L) = 0 \tag{3}$$

wherein, $P_D$ is actual energy demand.

PL denotes power dispatch losses, which are modelled using loss factors (4):

$$P_L = \sum_{i=1}^{N}\sum_{j=1}^{N} P_i B_{i_j} P_j\ MW \tag{4}$$

where B-coefficients for six-generating units are calculated and denoted (5).

$$B_{ij} = \begin{pmatrix} 0.00010.000010.000010.000010.000020.00002 \\ 0.000010.000050.000010.000010.000010.00001 \\ 0.000010.000010.000060.000010.000020.00001 \\ 0.000010.000010.000010.000060.000020.00002 \\ 0.000020.000010.000020.000020.000060.00003 \\ 0.000020.000010.000010.000020.000080.00003 \end{pmatrix} \tag{5}$$

The inequality constraints imposed on generator real power output are

$$P_i^{min} \leq P_i \leq P_i^{max} \tag{6}$$

where, $P_1^{min}$ is the lower limit and $P_1^{max}$ is the top limit of generator output [18], [19]

$$\Rightarrow P_L = \begin{pmatrix} B_{11}P_1^2 + (2\sum_{i=2}^{n} B_{1i}P_i + B_{01})\, P_1 \\ + \sum_{i=2}^{n}\sum_{j=2}^{n} P_i B_{ij} P_j + \sum_{i=2}^{n} B_{0i}\, P_i \\ +B_{00} \end{pmatrix} \tag{7}$$

where, $B_{00}, B_{01}, B_{li}, B_{0i}, and\ B_{ij}$ are B (transmission loss) coefficients.

Table 1. Cost and emission co-efficient with real power generation bounds for QUABCOPID controller

| Units | $P_i^m$ | $P_1$ | $P_i^{max}$ | $a_i$ | $b_i$ | $c_i$ | $d_i$ | $e_i$ | $f_i$ | $a_i$ | $\beta_i$ | $\gamma_i$ | $\eta_i$ | $\delta_i$ | $\Gamma_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10 | 32.6 | 40.6 | 1000 | 40.54 | 12 | 33 | 0.01 | 0.001 | 360 | 3.98 | 0.04 | 0.25 | 0.01 | 0.022 |
| 2 | 10 | 25.5 | 20.5 | 950.6 | 39.58 | 10 | 25 | 0.01 | 0.002 | 350 | 3.95 | 0.04 | 0.25 | 0.01 | 0.028 |
| 3 | 47 | 150 | 158 | 900.7 | 36.51 | 12 | 32 | 0.01 | 0.008 | 330 | 3.9 | 0.04 | 0.25 | 0.01 | 0.022 |
| 4 | 50 | 147 | 155 | 800.7 | 39.51 | 12 | 30 | 0.01 | 0.002 | 330 | 3.9 | 0.04 | 0.25 | 0.01 | 0.011 |
| 5 | 50 | 285 | 293 | 756.8 | 38.53 | 15 | 30 | 0.01 | 0.017 | 13.8 | 0.32 | 0 | 0.24 | 0.01 | 0.03 |
| 6 | 70 | 282 | 290 | 451.3 | 46.15 | 10 | 20 | 0.01 | 0.005 | 13.8 | 0.32 | 0 | 0.24 | 0.01 | 0.02 |

## 3. UTILITY OF QUABCOPID OPTIMIZATION TECHNIQUE

To overcome the slow convergence of Newton Raphson method a quantum behaved artificial bee colony based controller involving ABC technique is implemented vide a Simulink model to control the up Q-bit and down Q-bit of quantum behaved algorithm which in turn regulates the conventional PID parameters namely *Kp*, *Ki* and *Kd* to yield optimal values of real power that normally goes erroneous following mismatch in power demand, equality, inequality constraints, congestion constraints security constraints, ramp rate constraints involving prohibited operating zones. This optimized real power reduces frequency mismatches to great extent in timeline power control unit. In the proposed work bio-inspired algorithms (BIAs) applied to unravel various economic and emission objective issues have shown promising outcomes that are vital in this severely complex real-world system. QUABCOPID controller algorithm, a type of BIA that produces enormous results compared to certain other soft computing methods. The purpose of this study is to offer a replacement-modified algorithm based with the goal of increasing convergence speed and avoiding convergence rate. To demonstrate the suggested algorithm's robust application, it has been used to solve the active power optimization problem. The proposed individual's outputs outperform other ABC variations in terms of fast convergence. Additionally, the suggested method has demonstrated superior performance and solution of economic-emission objective functions.

## 4. PROPOSED QUABCOPID TECHNIQUE FOR EED

The proposed method, which utilizes a QUABCO and PID controller, is discussed in this section. It is used for multi-objective generation dispatching when dealing with severe non-linear load behavior of large thermal power stations subjected to multiple constraints. It utilizes a cubic cost and emission threshold objective function. The ABC approach along with incremental fuel costs regulates q-bits of quantum behaved algorithm and the combinatorial approach of ABC and quantum behaved algorithm regulates the PID parameters bringing thereby an optimal value of real power that becomes suitable to meet out the cost and emission objectives of economic load dispatch.

## 5. ABC TECHNIQUE

The fast convergence process of ABC technique is discussed vividly in the following steps involved in the algorithm. Typically, spectator bees wait inside the hive and collect food sources by exchanging information with the hired foragers, and there is a far greater likelihood of watchers identifying more profitable sources. As follows is a description of the ABC algorithm:

Step 1: The first step is to provide food sources for any and all engaged bees.

Step 2: An engaged bee explores a food source, striking her memory and establishing a familiar source, then judges the amount of honey produced by conducting a flutter kick within the hive shown in Figure 1.

Step 3: An observer sees engaged bees prance and then approaches one of their sources based on the waggle prances. She estimates the amount of honey produced by the source after choosing an acquaintance in the vicinity.

Step 4: Unwanted food habitats are identified and swapped for newly discovered food habitats by vanguards.

Step 5: Till all requirements are met, the smallest food habitat discovered during this procedure is noted.

## 6. PID TECHNIQUE

Conventional PID controller using Zeigler Nichole's tuning method involving S shaped curves finds suitable to some extent for controlling system stability except for multi-constraint and contradictory multi-objective electrical power system dispatch problem. The traditional controller must be updated with the assistance of the heuristic controller (QUABCOPID) for meeting out the contradictory fuel cost and emission objectives for economic dispatch. Simulation studies were performed for a system comprising a 2-area system associated by a tie line whose real power is updated to obtain the optimal power for meeting out the cost and emission objective for economic dispatch. Each area of electrical power grid comprises 6 generating units contributing to 30 busses, is modelled by a group of non-linear differential equations supported Park's equations. The prototype comprises typical flow restriction and gain impregnation in power plants. Using the PID parameters developed by Dash *et al.* [23] gain values are tabulated in Table 2, the traditional PID controller metamorphoses to a QUABCOPID controller which is regulated by the hybrid action of the quantum behaved algorithm and ABC technology to regulate the up Q-bit and down Q-bit states of tie line power and governor output and regulate the nectar level by appointing more scout bees to interact with employed bees within the neighborhood to perform the sort of waggle dance inside the hive. These vanguard bees plan for help in achieving the worldwide optimum solution in economic and emission dispatch problems. The results shown in Figures 4 to 6 clearly demonstrate that the QUABCOPID controller possesses much slighter undershoot and quicker settling time to understand the steadiness of a feedback system for all frequency range. The open-loop frequency response curve must get on the right-hand side and away from the juncture (-1, jo). This vital objective is fulfilled by using QUABCOPID controller that constantly monitors *Kp*, *Ki* and *Kd* values following the mismatch in power demand, equality, inequality constraints, congestion constraints security constraints, ramp rate constraints involving prohibited operating zones.

Table 2. Gain values and time constants of fast acting ALFC loop with QUABCOPID controller

| S.L No | Component | Gain | Time constant in Second |
|---|---|---|---|
| 1 | Governor | $G_g$=1 | $T_g$=0.4 |
| 2 | Turbine | $G_t$=1 | $T_t$=0.47-0.44 |
| 3 | Amplifier | $G_a$=0.9 | $T_a$=0.19-0.14 |
| 4 | Exciter | $K_e$=1 | $T_e$=1.5 |
| 5 | Generator | $G_p$=16.94 | $T_p$=1.6 |
| 6 | Sensor | $K_r$ =1 | $T_r$=0.06 |
| 7 | Inertia constant | | H=5 sec |
| 8 | Regulation | | R=0.04 Hz PU MW |
| 9 | Proportion controller (QUABCOPID) | | $K_p$=0.0041 |
| 10 | Integral controller (QUABCOPID) | | $K_i$ =0.25 |
| 11 | Derivative controller (QUABCOPID) | | $K_d$=0.26 |
| 12 | Step load change for area1 | | 0.03 PU |
| 13 | Step load change for area2 | | 0.06 PU |

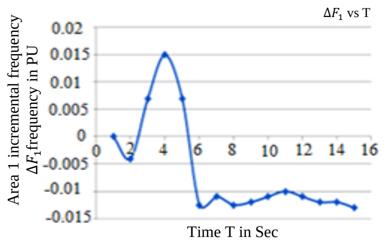


Figure 4. Simulink model for incremental frequency $\Delta F_1$

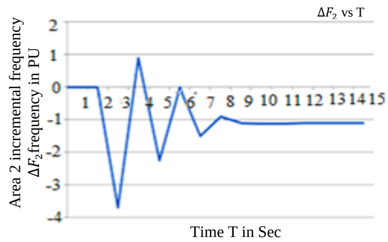


Figure 5. Simulink model for incremental frequency $\Delta F_2$

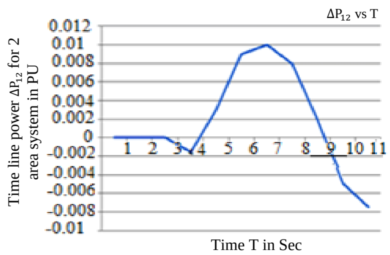


Figure 6. Simulink model for incremental time line power $\Delta P_{12}$

## 7. QPSO ALGORITHM FOR OPTIMAL EED SOLUTION

Quantum behaved particle swarm optimization (QPSO) intends to enhance traditional PSO making use of alternate particle creation formulae. Quantum behaved PSO supported trajectory analysis being a worldwide convergence technique updates the particle position (8) and (9):

$$X_i^{t+1} = P_i^t + \alpha|x_i^t - mbest^t|ln\frac{1}{u_i^t}, ifrandv \le 0.5 \quad (8)$$

$$X_i^{t+1} = P_i^t - \alpha|x_i^t - mbest^t|ln\frac{1}{u_i^t}, ifrandv < 0.5 \quad (9)$$

where, $P_i^t$ is local attractor of particle $i =$ iteration number, *mbest*$^t$ denotes magnificent mean positions in the $i^{th}$ iteration and $\alpha$ is the contraction expansion coefficient for regulating the concurrence rate of the QPSO adopted at par with Tahyudin and Nambo [24], Giri *et al.* [25], Sui *et al.* [26]. Identities $u_i^t$ and rand $v$ are functions of uniform probability distribution in the range [0, 1]. The local point is processed (10):

$$P_i^t = f^t \times Pbest^t + (1 - f^t)gbest^t \quad (10)$$

where, $\phi^t$ is a random parameter with a uniform distribution in the interval [0, 1], and are personal best of the particle and universal best of swarm respectively.

$$mbest^t = \frac{1}{N}\sum_{i=1}^{N} Pbest_i^t \quad (11)$$

QPSO does not alone become useful for complex engineering problems on EED following more and more numbers of search iterations. It works together with ABC technique for obtaining fast convergence that is required solving complex multi-objective nonlinear problems.

## 8. IMPLEMENTATION OF QABCOPID METHOD

This part of the article describes an improved hybrid algorithm for solving the ED problem. This hybrid technique recognized by Hullender *et al.* [27], is a combination of two strategies described through steps 1-13 that finds use in solving complex multi-objective problems subjected to complex nonlinearities necessitating fast convergence. First strategy uses incremental fuel cost to decide the real power generations of the generating units involving the quantum behaved algorithm and the second strategy acknowledges these real generations as initial values for training the artificial bee colony optimization to ascertain the favorable value of the initial neighborhood. This hybrid strategy is named as QUABCO. The constraints of ED experimented by Semlyen and Deri [28] and Deb [29] are transmission losses, power demands and the practical limits associated with alternators to demonstrate the effectiveness of the QUABCO algorithm as presented. we take two test cases one 6unit 30 bus system subjected to QUABCO approach and other one a 3-unit 15 bus system subjected to quantum behaved evolutionary algorithm based PID controller involving MATLAB/Simulation with and without transmission losses.

The QUABCO algorithm to train the PID controller is summarized as follows:

Step 1: Assume initial values for the key elements of QUABCO as referred in Table 1.

Step 2: Compute the incremental fuel costs ($\lambda$) differentiating (1) using the Pd value and making use of *mbest*$^t$ value from the QPSO algorithm.

Step 3: Compute the real power of the $i^{th}$ alternator (*Pi*) using $\lambda$ equation as under:
$\lambda - b_i - 2c_iP_i - 3f_iP_i^2 + |d_i cose_i(P_i^{min} - P_i)| = 0$

Step 4: $P_{i,\,lower} = P_i$ (1-Rank) and $P_{i,\,upper} = P_i$ (1+Rank)
where, $P_{i,\,lower}$ and $P_{i,upper}$ are the minimum and maximum power output of the $i^{th}$ generating unit and rank is the rank ofreal power generation output.

Step 5: Create the population (N) of the real generations satisfying the power balance constraints and express it as;
$P_i = P_{i,\,lower} + ((P_{i,\,upper} - P_{i,\,lower}).\ rand\ (0, 1))$

Step 6: Obtain the population suit abilities in increasing order.

Step 7: Chose best solution groups for the neighborhood search and isolate them into two groups.

Step 8: Obtain the neighborhood size for each feasible solution. Mark neighborhood size equal to NQ for solution group (Q) and NP for solution group (S-Q)

Step 9: Create solutions within the selected solutions in the neighborhood sizes (NP, NQ) and obtain the suitability value from individual group. Then, choose the most feasible solution from individual group.

Step 10: Validate the stopping criteria if no, update the iteration count.

Step 11: Assign the new population (N-Q) to create new real generation of the $i^{th}$ alternator unit.

Step 12: If the stopping rule is satisfied for the quantum behaved ABC optimization, then obtain the suitable solution and utilizing the same create a proportional, derivative and integral signal to control *Kp*, *Kd* and *Ki* of the proportional integral and derivative controller involving automatic generation controller and MATLAB/Simulink model.

Step 13: Obtain $\Delta F_1$ $vs.$ $T, \Delta F_2$ $vs. T$ and $\Delta P_{12}$ $vs.$ $T$ characteristics shown in Figure 4 to 6 using QUABCOPID controller Simulink model shown in Figure 2 exploiting the flow chart of QUABCOPID controller shown in Figure 7. Finally obtain the variation of tie line power with time as shown in Figure 8 for the test case 2 comprising 3-unit 15 bus system using quantum behaved evolutionary algorithm hybridized with artificial bee colony optimization and PID controller to analyze the EED problem.

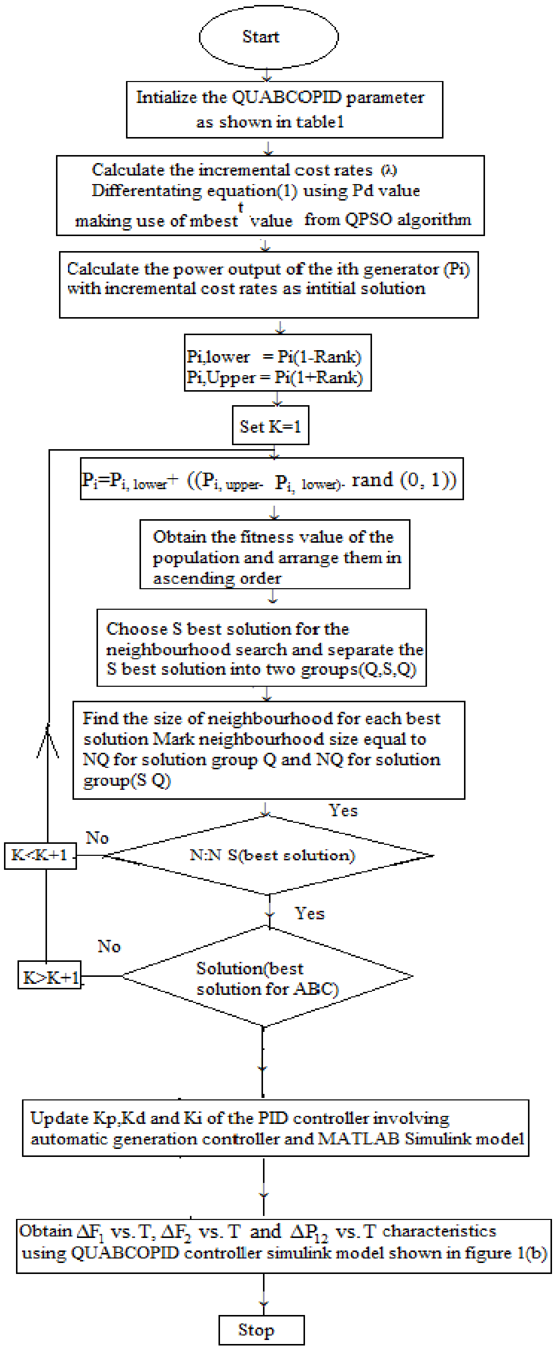


Figure 7. Flow chart for QUABCOPID optimization

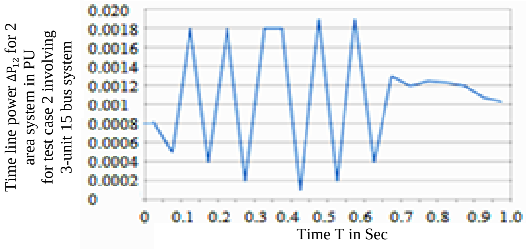


Figure 8. Simulation output for 3-unit 15 bus system

## 9. RESULTS ANALYSIS AND PERFORMANCE CHARACTERISTICS OF PROPOSED QUABCOPID CONTROLLER

To determine the viability and efficacy of the suggested hybrid quantum-behaved PSO, as well as the ABC method with a PID controller QUABCOPID, a series of experimental simulation studies, were conducted on a conflicting multi-objective EED optimization process for two different test cases, one using the QUABCOPID approach with a 6-unit 30 bus test case system and the other using a quantum behaved evolutionary computing approach with a PID controller to find the optimal value of the fuel. The second experiment incorporates a two-crossover method into the standard QEA-based ABC optimization process. The t characteristic of experiment 2 is illustrated in Figure 8. It is quite obvious that the experimental results of the QUABCOPID controller showing the variation of fuel cost and emission rate with respect to the real energy production with and without line loss, as seen in Figures 9 to 12 and tabulated in Table 3, outperform the QEA-based optimal solution results in Table 4. More precisely, the second experiment exhibits a higher frequency of transient excursion than the first. QUABCOPID controller, on the other hand, has significantly superior steady-state performance, which results in the ideal fuel economy and emission level again for economic-emission dispatch problems. When compared to the results produced using the other heuristic approaches listed in Table 3, the QUABCOPID controller's outcome is determined to be more promising. Both experimental approaches were written in MATLAB and run on a 512 MB device running on Windows 8.

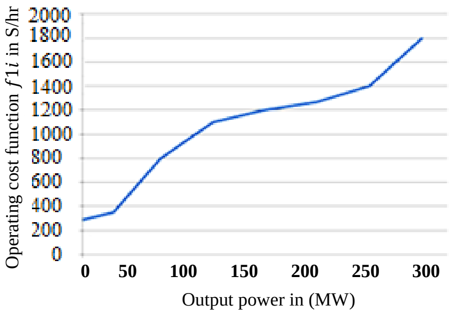


Figure 9. Operating cost function versus output power without transmission loss

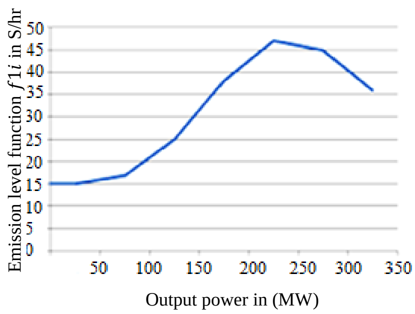


Figure 10. Emission level function versus output power without transmission loss

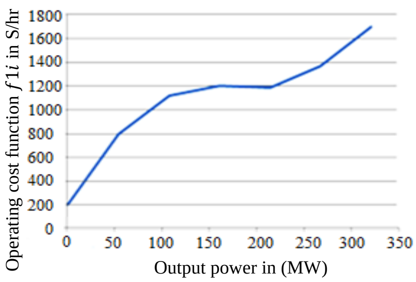


Figure 11. Operating cost function versus output with transmission loss

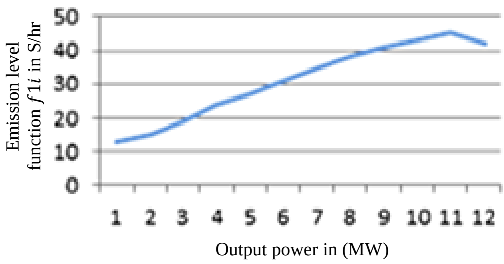


Figure 12. Emission level function versus output power with transmission loss

Table 3. Numerical and comparative results for QUABCOPID controller (30-bus system)

| Time | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Max | 19.7648 | 19.7613 | 19.7648 | 19.7648 | 19.7649 | 19.7649 | 19.7649 | 19.7680 | 19.7504 | 19.7449 |
| Average | 19.6740 | 19.6824 | 19.6999 | 19.7048 | 19.7177 | 19.7249 | 19.7249 | 18.4671 | 19.4816 | 19.7849 |
| Time | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Max | 19.6614 | 19.7794 | 19.7849 | 19.7949 | 19.7949 | 19.6737 | 19.6949 | 19.7362 | 19.7804 | 19.8823 |
| Average | 19.7432 | 19.7953 | 19.8049 | 19.8049 | 19.8048 | 19.6937 | 19.7947 | 19.6853 | 19.7902 | 19.7926 |
| Average (max)=19.7583 | | | | | | | | | | |

Table 4. Test results of experiment 2

| Power generation for a power demand of (492MW) and a transmission loss (TL) of 12.30 MW | | | | | | | Fuel Cost | Emission rate | Simulation time |
|---|---|---|---|---|---|---|---|---|---|
| Method | P1 (in MW) | P2 (in MW) | P3 (in MW) | P4 (in MW) | P5 (in MW) | P6 (in MW) | FC (in $/h) | PE (in T/h) | T in (sec) |
| QABCOPID without transmission loss (TL) | 32.6 | 12.5 | 1.50 | 1.47 | 285 | 282 | 6865.07 | 194.45 | 5.0 |
| QABCOPID with TL | 40.6 | 20.5 | 1.58 | 1.55 | 293 | 290 | 6883.08 | 194.47 | 5.1 |
| MM | 33.77 | 12.65 | 150.56 | 148.50 | 296.29 | 293.63 | 6900.05 | 196.98 | 8.2 |
| NN based PID | 32.66 | 12.7 | 152 | 149 | 287 | 285.3 | 6897.07 | 196.23 | 7.3 |
| MOCPSO | 33.71 | 12.65 | 150.56 | 148.50 | 296.30 | 293.72 | 6890.35 | 195.12 | 6.2 |

## 10. SIMULATION OF TRANSMISSION LINE

The bench line device analyses single-phase as well as 3 transmission lines operating at varied loads and subjected to fluctuating power and inserted fault circumstances. A single-phase line is composed of a series of inductive impedances that are connected asynchronously. The tapings thus provide the user with the ability to adjust the duration of the replicated line, develop nominal 'Pi' or 'Tee' techniques for identifying losses by utilizing differing capacitance values, and monitor voltage, current, and output at any point on the road. Six portions of the three-phase line are depicted diagrammatically in 'per-unit' values. It has provisions for controlling below-variable balanced or imbalanced resistive, inductive, and capacitive (RLC) masses, as well as selectable neutral provision for adjusting the length parameters. The electrical or electronic circuit and tangency variables of a 252 kilometers long unit line with such a litigating electrical circuit wattage of 275 V and a point of intersection voltage of 60 V were determined during this experiment, as well as the associated voltages of area units. Using those specifications, as well as additional information quantified in Table 5, the propagation variables of the said predicted line systems are currently are calculated as:

$$Copper\ loss = I_{os}^2\ R = \left(\frac{Ps}{phase} - \frac{Pr}{Phase}\right)$$

$$I_{os}^2 = \frac{\left(\frac{Ps}{phase} - \frac{Pr}{Phase}\right)}{R}$$

$$R/km/Phase = R/252 = (for\ 7\ sections\ over\ a\ span\ of\ 180\ km).$$

From Short circuit test, $Ps = 47.49\ w$, $Pr = Vr\ x\ Ios\ x\ cos\Phi r = 117.2x0.45x0.917 = 45.12\ ws\ Ios = 0.456\ A, R = 12.69\ \Omega, R/phase/kilometer = 12.69/3x252 = 0.0167$. Calculation of the line's impedance per km section (z). $2\pi fL = 0.0569\ L$, so $L = 0.00016\ H$ from data on open circuit. $I0S/V0S = 2\ fC\ C = 7.66\ f$ (this value should be for all seven sections). $C = 7.66\ f/252\ C = 0.03\ f$ is the capacitance/part per kilo meter. As with medium conductors, the long line can be split into similar segments within the shielded conductor. The series electrical phenomenon is denoted by $Z'$, and the shunt admittance is denoted by $Y'$. As a consequence, the ABCD components of this huge line will be specified analogous to that of a medium line, i.e. in terms of transport protocol, and will be arranged as:

$$y = 2 \times \pi \times f \times C = 2 \times \pi \times 49.82 \times 0.030 \times 10^{-6} = 9.39 \times 10^{-6}$$

where, $y$ is the capacitive susceptance in Mho/Phase/km

As with the intermediate power line, an analogous representation can be used to approximate the long string. The series impedance is denoted by $Z'$ in the long power line's-equivalent, but the shunt admittance is denoted by $Y'$.

where, $\gamma = \sqrt{zy}, Z_c = \sqrt{\frac{z}{y}}, Z = z \times 1, and\ Y = y \times 1$

As a consequence, the ABCD components of this massive line can be stated in the same way as that of a medium transmission line:

$$Z' = Z\_c \sinh\gamma l = \sqrt{(z/y)} \times \sinh\sqrt{yz} \times l = zl\sinh\gamma l/(l\sqrt{yz}) = (Z\sinh\gamma l)/\gamma l \quad (12)$$

$$\cosh\gamma l = 1 + (Z^{\wedge\prime} Y^{\wedge\prime})/2 = Y'/2 \times Z\_c \sinh\gamma l + 1 \quad (13)$$

We obtain by rearranging the elements in the preceding (14) to (17).

$$\Rightarrow Y'/2 = 1/Z\_c \ (\cosh\gamma l - 1)/\sinh\gamma l = \sqrt{(y/z)} \tanh yl/2 = yl/2 \times (\tanh \gamma\_l/2)/ (l/2\sqrt{yz}) = Y/2 \times (\tanh \gamma\_l/2)/(l/2\sqrt{yz})\ \text{Þ}Y' = Y \times (\tanh \gamma\_l/2)/(\gamma\_l/2) \quad (14)$$

$$\Rightarrow A = D = 1 + \frac{Y'Z'}{2} \text{per unit} \quad (15)$$

$$B = Z'\Omega \quad (16)$$

$$C = Y\left(1 + \frac{Z'Y'}{4}\right)J \quad (17)$$

$$\Rightarrow A = 1.0160, B = 13.5793\ \Omega, C = 0.0024\ \mho \text{ and } D = 1.0160$$

Table 5. Transmission line test case data and simulation result for simulating a 252 km HVAC transmission line

| Sending end voltage on open circuit (V0s) in Volts | Sending end current on open circuit (I0s) in Ampere | Sending end voltage on short circuit (Vsc) in Volts | Receiving end current on short circuit (Isc) in Ampere | Line Length in km | Analys is method | Number of π sections utilized | Sending end Power Ps In Watts per phase | Receiving end Power Pr in Watts per phase | A=D | B In Ω | C In Mho |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 175 | 0.456 | 60 | 4.44 | 252 | Nominal π | 7 | 47.49 | 45.12 | 1.0160 | 13.5793 | 1.0160 |

## 11. SCOPE FOR FUTURE WORK

The QUABCOPID optimization algorithm will be applied to realistic systems with many objectives and constraints. The proposed technique will be hybridized with completely different techniques such as symbolic logic, DE, EP, PSO, artificial neural network (ANN), and good grid observance to address the inadequacy of the MOELD solution discovered by Ghasemi *et al.* [30]. This technology can be implemented to ship climate routing systems with acceptable initial conditions, as demonstrated by Vettor and Soares [31] as well as smart grids incorporating distributed generations (DGs) [32].

## 12. CONCLUSION

A proportional integral and derivative (PID) controller tuned through QUABCO has been hotly proposed as a solution to the ALFC's multi-area disadvantage. The results revealed that a PID based on QUABCO is capable of ensuring high stability and performance under a variety of load conditions and parameter changes for a variety of pricing functions. The proposed controller was successful in dampening all oscillations, limiting subsidence time, and eliminating overshoot, all of which resulted in decreased wear on high-speed valves and gates. We will extend the QUABCO rule to renewable energy power plants such as wind turbines in the future. Additionally, we frequently employ it to set the upper limit on load disruptions that can result in the ability system's instability downside. The transmitting parameters obtained through QUABCOPID advancement during this proposed work by combining real power generation, real power demand, and power loss area unit are really quite adequate for meeting the erection demand for power lines inside the selected as well as proclaimed great areas and alternate solution busy cities. Thus, these optimized values of real power generations fulfil the fundamental objective of the simulation of conductor demand for meeting out the transmission and distribution necessities of varied recent and good cities.

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