ISSN Application No. 21825

Journal of Applied Physics

Volume No. 11

Issue No. 2

May - August 2023

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ISSN Application No. 21825

Journal of Applied Physics

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ISSN Application No. 21825

Journal of Applied Physics

ISSN Application No. 21825

Journal of Applied Physics

(Volume No. 11, Issue No. 2, May - August 2023)

Contents

Rouge Wave Solutions of A Nonlinear Pseudo- Parabolic Physical Model Through the Advance Exponential Expansion Method

Md. Habibul Bashar [1 *], Md. Mamunur Roshid [2]

[1]Department of Mathematics, European University of Bangladesh. Gabtoli, Dhaka-1216, Bangladesh

[2] Department of Mathematics, Pabna University of Science and Technology. Pabna-6600, Bangladesh

*Corresponding author E-mail: hbashar27.1273@gmail.com

ABSTRACT

In this work, we decide the proliferation of nonlinear voyaging wave answers for the dominant nonlinear pseudo-parabolic physical model through the (1+1)-dimensional Oskolkov equation. With the assistance of the advance -expansion strategy compilation of disguise adapta- tion an innovative version of interacting analytical solutions regarding, hyperbolic and trigonometric function with some refreshing param- eters. We analyze the behavior of these solutions of Oskolkov equations for the specific values of the reared parameters such as rouge wave, multi solution, breather wave bell and kink shape etc. The dynamics nonlinear wave solution is examined and demonstrated in 3-D and 2-D plots with specific values of the perplexing parameters are plotted. The advance -expansion method solid treatment for looking through fundamental nonlinear waves that advance assortment of dynamic models emerges in engineering fields.

Keywords: Oskolkov Equation; The Advance -Expansion Method; Nonlinear Pseudo-Parabolic Physical Models; Bright and Dark Rouge Wave; Kinky Periodic Wave; Breather Wave.

1. INTRODUCTION

The theoretical examinations of reverberation physical wonders by nonlinear evolution conditions become basic step by step. Since the analytic and explicit traveling wave arrangement of nonlinear evolution equations can be explain different complex wonders in assorted fields of nonlinear science, such as fluid mechanics, nuclear physics, solid-state physics, chemical physics, optical fibre and geochemistry, nonlinear lattices and also in shallow water etc. Numerous researchers arranged through NEEs to build voyaging wave arrangement by actualize a few strategies. The techniques that are entrenched in late writing, for example, extended Kudryashov method [1], Modefied simple equation method [2], New extended (G'/G) expansion method [3], [4], Darboux transformation [5], trial solution method [6], Exp- Function Method [7], Multiple Simplest Equation Method [8]. Nofal applied Simple equation method for nonlinear partial differential equations [10]. Several authors are solved some models by simple equation method [10-13].

Pseudo parabolic model is one kind of partial differential equations in which the time derivative emerged in highest order derivative and they have been misusing for various regions of mathematics and physics for example, for fluid flow in fissured rock, consolidation of clay, shear in second-order fluids, thermodynamics and propagation of long waves of small amplitude These days, much consideration has been paid to examine NEEs, for example, Pseudo parabolic model [14-20]. Note that a totally integrable Pseudo parabolic model gives innovative and explicit different type exact voyaging wave arrangement.

In the present work, we consider the one dimensional Oskolkov condition. Implementing the advance $exp(-\phi(\xi))$ - expansion strategy [21]. We attain the several wave solutions. We utilize numerical recreation to think about the one dimensional Oskolkov condition. We consider (1+1) Dimensional Oskolkov Equation in the accompanying structure

$$U_t - \beta U_{xxt} - \alpha U_{xx} + UU_x = 0. \qquad (1)$$

This equation is pseudoparabolic equation and one-dimensional analogue of the oskolkov system

$$(1-\gamma\nabla^2)U_t = \alpha\nabla^2 U - (U \bullet \nabla)U - \nabla^2 p + f, \text{ where } \nabla \bullet U = 0. \qquad (2)$$

This system illustrates the dynamics of an incompressible viscoelastic Kelvin-Voigt fluid. It was indicated in [14-20] that the parameter γ can be negative and the negativeness of the parameter γ does not deny the physical meaning of equation (2).

We implemented the advance $exp(-\phi(\xi))$ -expansion strategy to solve equation (1) and obtained new solutions which could not be at- tained in the past. Mamunur and Bashar found exact and explicit solution from Oskolkov equation with the help of simple equation method [14], Mamunur applied MSE Schema [15] Faruk applied the tanh-coth strategy for some nonlinear pseudoparabolic conditions to got precise arrangement [16], Turgut Propagation of nonlinear shock waves or the summed up oskolkov condition and its dynamic movements within the sight of an outside intermittent annoyance by actualize unified technique [17] and others creator fathom this model by various predominant strategy [18-20].

The article is set up as pursues: In section 2, the advance $exp(-\phi(\xi))$ -expansion scheme has been talked about. In segment 3, we apply this plan to the nonlinear development conditions raised previously. In section 4, represents Results & Discussion and in section 5, ends are given.

2. THE ADVANCE $exp(-\phi(\xi))$ -EXPANSION METHOD

In this section, we will precis $exp(-\phi(\xi))$ - expansion method step by step. Consider a nonlinear partial differential equation in the fol- lowing form,

$$R(U, U_{xx}, U_{xz}, U_{xx} \rightleftarrows, U_{xy}, \rightleftarrows U_{xtt}, \ldots \rightleftarrows\rightleftarrows\rightleftarrows\rightleftarrows\rightleftarrows\leftrightarrows\leftrightarrows \cdots) = 0. \qquad (3)$$

Where $U = U(x, y, z, t)$ is an unknown function, R is a polynomial of U, its different type partial derivati- ves, in which the nonlinear terms and the highest order derivatives are involved.

Step-1. Now we consider a transformation variable to convert all independent variable into one variable, such as $U(x,t) = u(\xi)$,

$$\xi = kx + ly + mz \pm Vt \qquad (4)$$

By implementing this variable Eq. (4) permits us reducing Eq. (3) in an ODE for $u(x,t) = u(\xi)$

$$P(u, u', u'', \cdots) = 0 \qquad (5)$$

Step-2. Suppose that the solution of ODE Eq. (5) can be expressed by a polynomial in $exp(-\phi(\xi))$ as follows

$$u = \sum_{i=0}^{m} a_i \, exp(-\phi(\xi))^i, \; a_m \neq 0 \qquad (6)$$

where the derivative of $\phi(\xi)$ satisfies the ODE in the following form

$$\phi'(\xi) = -\lambda \, exp(-\phi(\xi)) - \mu \, exp(\phi(\xi)) \qquad (7)$$

then the solutions of ODE Eq. (7) are
Case I:
Hyperbolic function solution (when $\lambda\mu < 0$):

$$\phi(\xi) = \ln\left(\sqrt{\frac{\lambda}{-\mu}} \tan h\left(\sqrt{-\lambda\mu}(\xi + C)\right)\right)$$

And

$$\phi(\xi) = \ln\left(\sqrt{\frac{\lambda}{-\mu}} \cot h\left(\sqrt{-\lambda\mu}(\xi + C)\right)\right)$$

Case II:

Trigonometric function solution (when $\lambda\mu > 0$)

$$\phi(\xi) = \ln\left(\sqrt{\frac{\lambda}{\mu}} \tan\left(\sqrt{\lambda\mu}(\xi + C)\right)\right)$$

And

$$\phi(\xi) = \ln\left(-\sqrt{\frac{\lambda}{\mu}} \cot\left(\sqrt{\lambda\mu}(\xi + C)\right)\right)$$

Case III:
when $\mu > 0$ and $\lambda = 0$

$$\phi(\xi) = \ln\left(\frac{1}{-\mu(\xi+C)}\right)$$

Case IV:
When $\mu = 0$ and $\lambda \in \Re$
$\phi(\xi) = \ln(\lambda(\xi + C))$, where C is integrating constants and $\lambda\mu < 0$ or $\lambda\mu > 0$ depends on sign of μ.

Step-3. By substituting Eq. (6) into Eq.(5) and using the ODE (7), collecting all same order of $exp(\phi(\xi))$ together, then we execute an polynomial form of $exp(\phi(\xi))$ Equating each coefficients of this polynomial to zero, yields a set of algebraic system.

Step-4. Assume the estimation of the constants can be gotten by fathoming the mathematical conditions got in step 4. Substituting the estimations of the constants together with the arrangements of Eq. (7), we will acquire new and far reaching precise traveling wave ar- rangements of the nonlinear development Eq. (3).

3. APPLICATION OF THE METHOD

In this section we implement the advance $exp(\phi(\xi))$-expansion method for (1+1) dimensional Oskolkov equation in the following form:

$$U_t - \beta U_{xxt} - \alpha U_{xx} + UU_x = 0. \qquad (8)$$

Where β, α are arbitrary constants and $U(x,t)$ is an unknown function. Using the traveling wave variable $U(x,t) = U(\xi)$ and $\xi = kx - \omega t$ where k is a constant and ω is wave speed. Now we renovate the Eq. (8) into the following Ordinary differential equation.

$$2k^2\omega\beta U'' - 2\alpha k^2 U' - 2\omega U + kU^2 = 0. \qquad (9)$$

Where symbolize prime represent the derivative with respect to ξ.
Now we compute the balance number of Eq. (9) between the linear term U'' and the nonlinear term U^2 is $N = 2$ so the solution of the Eq. (9) takes the following form

$$U(\xi) = A_0 + A_1 exp(-\phi(\xi)) + A_2 exp(-\phi(\xi))^2 . \qquad (10)$$

Differential Eq. (10) with respect to ξ and substituting the value of U, U', U'' into the Eq. (9) and equating the coefficients of $e^{i\phi(\xi)}$ equal to zero (where $i = 0, \pm 1, \pm 2$ ....).
Solving those system of equations, we attain the two sets solutions
Set-1:

$$k = \pm\frac{1}{12}\frac{\sqrt{6}}{\sqrt{\beta\lambda\mu}},\ \omega = \pm\frac{1}{10}\frac{\alpha}{\beta\sqrt{-\lambda\mu}},\ A_0 = \frac{1}{10}\frac{\alpha\sqrt{6\beta\lambda\mu}}{\beta\sqrt{-\lambda\mu}},\ A_1 = \mp\frac{1}{5}\frac{\alpha\sqrt{6\beta\lambda\mu}}{\beta\mu},\ A_2 = -\frac{1}{10}\frac{\lambda\alpha\sqrt{6}}{\mu\lambda\sqrt{-\beta}}.$$

Set-2:

$$k = \pm\frac{1}{2\sqrt{-6\beta\lambda\mu}},\ \omega = \pm\frac{1}{10}\frac{\alpha}{\sqrt{-\lambda\mu\beta}},\ A_0 = \frac{3}{10}\frac{\alpha\sqrt{-6\beta\lambda\mu}}{\sqrt{-\lambda\mu\beta}},\ A_1 = \pm\frac{1}{5}\frac{\alpha\sqrt{-6\beta\lambda\mu}}{\beta\mu},\ A_2 = -\frac{3}{5}\frac{\lambda\alpha}{\lambda\mu\sqrt{6\beta}}$$

Case-I: When $\lambda\mu < 0$ we get following hyperbolic solution

Family-1

$$U_{1,2}(x,t) = \frac{1}{10}\frac{\alpha\sqrt{6\beta\mu\lambda}}{\beta\sqrt{-\lambda\mu}} \mp \frac{1}{5}\frac{\alpha\sqrt{\beta\lambda\mu}}{\beta\mu\sqrt{-\frac{\lambda}{\mu}}\tanh\left(\sqrt{-\lambda\mu}\,(\xi+C)\right)} + \frac{1}{10}\frac{\sqrt{6}\lambda\alpha\mu}{\lambda\mu\sqrt{-\beta}\,\tanh\left(\sqrt{-\lambda\mu}(\xi+C)\right)^2}.$$

$$U_{3,4}(x,t) = \frac{1}{10}\frac{\alpha\sqrt{6\beta\mu\lambda}}{\beta\sqrt{-\lambda\mu}} \mp \frac{1}{5}\frac{\alpha\sqrt{\beta\lambda\mu}}{\beta\mu\sqrt{-\frac{\lambda}{\mu}}\coth\left(\sqrt{-\lambda\mu}\,(\xi+C)\right)} + \frac{1}{10}\frac{\sqrt{6}\lambda\alpha\mu}{\lambda\mu\sqrt{-\beta}\,\coth\left(\sqrt{-\lambda\mu}(\xi+C)\right)^2}.$$

where,

$$\omega = \pm\frac{1}{10}\frac{\alpha}{\beta\sqrt{-\lambda\mu}} \text{ and } \xi = \pm\frac{1}{12}\frac{\sqrt{6}}{\sqrt{\beta\lambda\mu}}\,x \mp \frac{1}{10}\frac{\alpha}{\beta\sqrt{-\lambda\mu}}\,t.$$

Family-2

$$U_{5,6}(x,t) = \frac{3}{10}\frac{\alpha\sqrt{-6\beta\mu\lambda}}{\beta\sqrt{-\lambda\mu}} \pm \frac{1}{5}\frac{\alpha\sqrt{-\beta\lambda\mu}}{\beta\mu\sqrt{-\frac{\lambda}{\mu}}\tanh\left(\sqrt{-\lambda\mu}\,(\xi+C)\right)} + \frac{3}{5}\frac{\lambda\alpha\mu}{\lambda\mu\sqrt{-6\beta}\,\tanh\left(\sqrt{-\lambda\mu}(\xi+C)\right)^2}$$

$$U_{7,8}(x,t) = \frac{3}{10}\frac{\alpha\sqrt{-6\beta\mu\lambda}}{\beta\sqrt{-\lambda\mu}} \pm \frac{1}{5}\frac{\alpha\sqrt{-\beta\lambda\mu}}{\beta\mu\sqrt{\frac{-\lambda}{\mu}}\coth(\sqrt{-\lambda\mu}(\xi+C))} + \frac{3}{5}\frac{\lambda\alpha\mu}{\lambda\mu\sqrt{-6\beta}\coth(\sqrt{-\lambda\mu}(\xi+C))^2}.$$

where,

$$\omega = \pm\frac{1}{10}\frac{\alpha}{\sqrt{-\lambda\mu\beta}} \text{ and } \xi = \pm\frac{1}{2\sqrt{-6\beta\lambda\mu}}x \mp \frac{1}{10}\frac{\alpha}{\sqrt{-\lambda\mu\beta}}t.$$

Case-II: When $\lambda\mu > 0$ we get following trigonometric solution

Family-3

$$U_{9,10}(x,t) = \frac{1}{10}\frac{\alpha\sqrt{6\beta\mu\lambda}}{\beta\sqrt{-\lambda\mu}} \mp \frac{1}{5}\frac{\alpha\sqrt{6\beta\lambda\mu}}{\beta\mu\sqrt{\frac{\lambda}{\mu}}\tan(\sqrt{\lambda\mu}(\xi+C))} - \frac{1}{10}\frac{\sqrt{6}\lambda\alpha\mu}{\sqrt{\beta\lambda\mu}\sqrt{-\lambda\mu}\tan(\sqrt{\lambda\mu}(\xi+C))^2}.$$

$$U_{11,12}(x,t) = \frac{1}{10}\frac{\alpha\sqrt{6\beta\mu\lambda}}{\beta\sqrt{-\lambda\mu}} \pm \frac{1}{5}\frac{\alpha\sqrt{6\beta\lambda\mu}}{\beta\mu\sqrt{\frac{\lambda}{\mu}}\cot(\sqrt{\lambda\mu}(\xi+C))} - \frac{1}{10}\frac{\sqrt{6}\lambda\alpha\mu}{\sqrt{\beta\lambda\mu}\sqrt{-\lambda\mu}\cot(\sqrt{\lambda\mu}(\xi+C))^2}$$

Where,

$$\omega = \pm\frac{1}{10}\frac{\alpha}{\beta\sqrt{-\lambda\mu}} \text{ and } \xi = \pm\frac{1}{12}\frac{\sqrt{6}}{\sqrt{\beta\lambda\mu}}x \mp \frac{1}{10}\frac{\alpha}{\beta\sqrt{-\lambda\mu}}t.$$

Family-4

$$U_{13,14}(x,t) = \frac{3}{10}\frac{\alpha\sqrt{-6\beta\mu\lambda}}{\beta\sqrt{-\lambda\mu}} \pm \frac{1}{5}\frac{\alpha\sqrt{-6\beta\lambda\mu}}{\beta\mu\sqrt{\frac{\lambda}{\mu}}\tan(\sqrt{\lambda\mu}(\xi+C))} - \frac{3}{5}\frac{\lambda\alpha\mu}{\sqrt{-6\beta\lambda\mu}\sqrt{-\lambda\mu}\tan(\sqrt{\lambda\mu}(\xi+C))^2}.$$

$$U_{15,16}(x,t) = \frac{3}{10}\frac{\alpha\sqrt{-6\beta\mu\lambda}}{\beta\sqrt{-\lambda\mu}} \mp \frac{1}{5}\frac{\alpha\sqrt{-6\beta\lambda\mu}}{\beta\mu\sqrt{\frac{\lambda}{\mu}}\cot(\sqrt{\lambda\mu}(\xi+C))} - \frac{3}{5}\frac{\lambda\alpha\mu}{\sqrt{-6\beta\lambda\mu}\sqrt{-\lambda\mu}\cot(\sqrt{\lambda\mu}(\xi+C))^2}.$$

where,

$$\omega = \pm\frac{1}{10}\frac{\alpha}{\sqrt{-\lambda\mu\beta}} \text{ and } \xi = \pm\frac{1}{2\sqrt{-6\beta\lambda\mu}}x \mp \frac{1}{10}\frac{\alpha}{\sqrt{-\lambda\mu\beta}}t.$$

Case III & Case IV:

When $\lambda = 0$ the executing value of A_0 and A_2 are undefined. So the solution cannot be obtained. For this purpose this case is rejected. Similarly when $\mu = 0$ the executing value of A_0, A_1 and A_2 are undefined. So the solution cannot be obtained. So this case is also rejected.

4. RESULTS AND DISCUSSIONS

Physical explanation

In this subsection, we talk about the physical portrayal of the got exact and solitary wave answers for the (1+1) dimensional Oskolkov condition by means of advance $exp(-\phi(\xi))$ expansion method. There is various type of traveling wave solutions that one of particular interest in solitary wave theory. For some special values of the physical parameters, we obtain the traveling wave solutions as follows: Figure 1 represents Dark bell shape solution of the imaginary part of U_{13} for the parametric values $\mu = 1, \lambda = 04,$ $\beta = 1, \alpha = -2$ and $C = 1$ within $-10 \leq x, t \leq 10$. Figure 2 represents Bright bell shape solution of the imaginary part of U13 for the parametric values $\mu = 1, \lambda = 04, \beta = 1, \alpha = 2, C = 1$ within $-10 \leq x, t \leq 10$. Figure 3 represents Bright kink shape solution of the absolute value of U_{15} for the para- metric values $\mu = 3, \lambda = 4, \beta = 1, \alpha = -2, C = 1$ within $-10 \leq x, t \leq 10$. Figure 4 represents Dark kink shape solution of the absolute value of U_{15} for the parametric values $\mu = 3, \lambda = 4, \beta = 1, \alpha = 2, C = 1$ wi $-10 \leq x, t \leq 10$. Figure 5 represents Multi Rouge wave shape solution of the real part of U11 for the parametric values $\mu = 1, \lambda = 2, \beta = 02, \alpha = -1, C = 1$ within $-10 \leq x, t \leq 10$. Figure 6 epresents Rouge wave shape solution of the real part of U_1 for the parametric values $\mu = -1, \lambda = , \beta \frac{1}{5} 10, \alpha = -25, C = 1$ within $-10 \leq x \leq 10$ and $-6 \leq t \leq 4$.

Graphical explanation

This sub-section represents the graphical representation of the (1+1)-dimensional oskolkov equation. By using mathematical software Maple 18, Contour, 3D and 2D plots of some achieved solutions have been shown in Figure 1 to Figure 6 to envisage the essential instru- ment of the original equations.

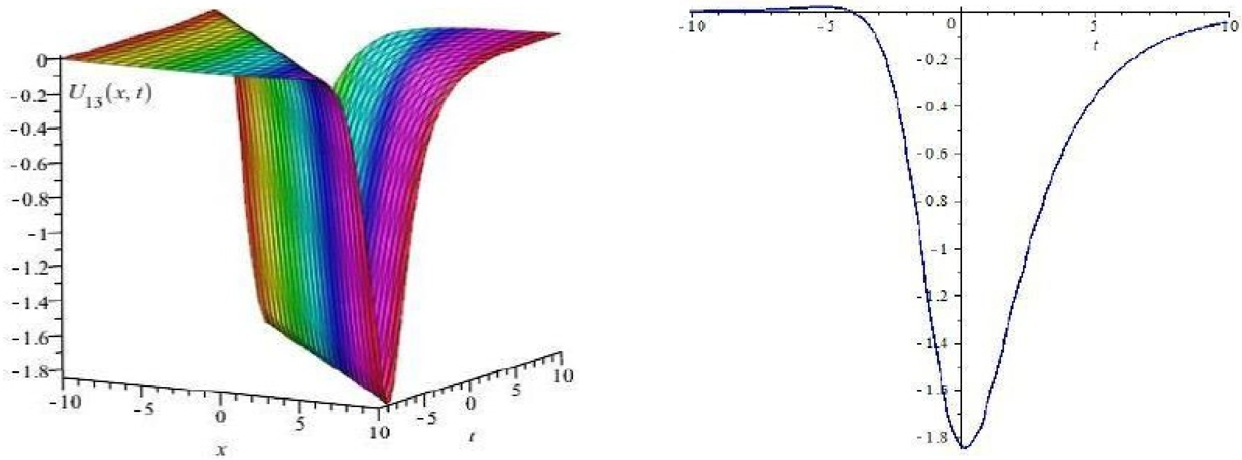

Fig. 1: Dark Bell Shape Solution of U_{13} the Left Figure Shows the 3D Plot and the Right Figure Shows the 2D Plot For x = 1

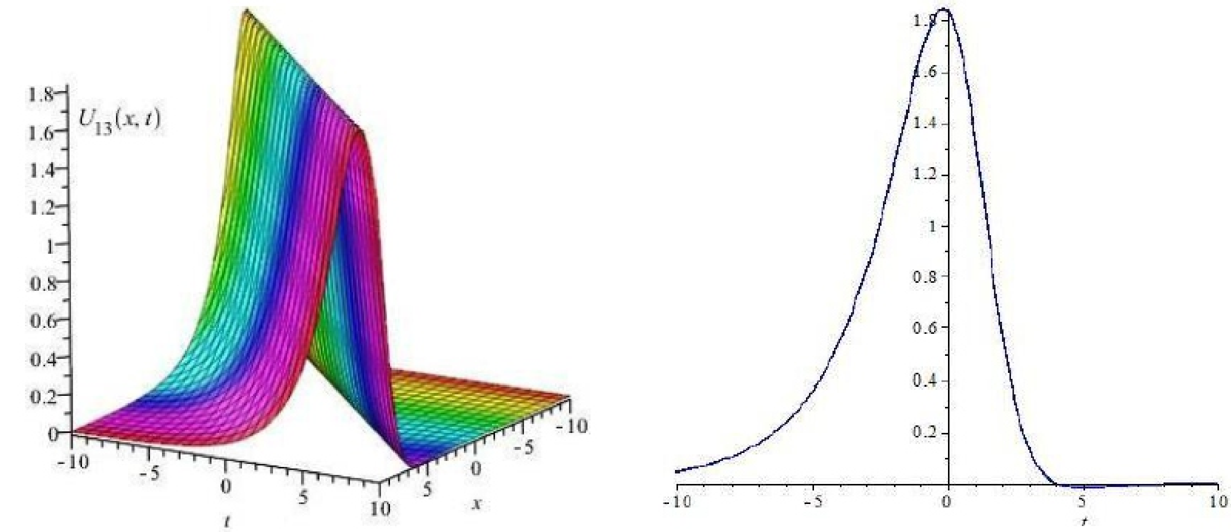

Fig. 2: Bright Bell Shape Solution of U_{13} the Left Figure Shows the 3D Plot and the Right Figure Shows the 2D Plot For x = 1

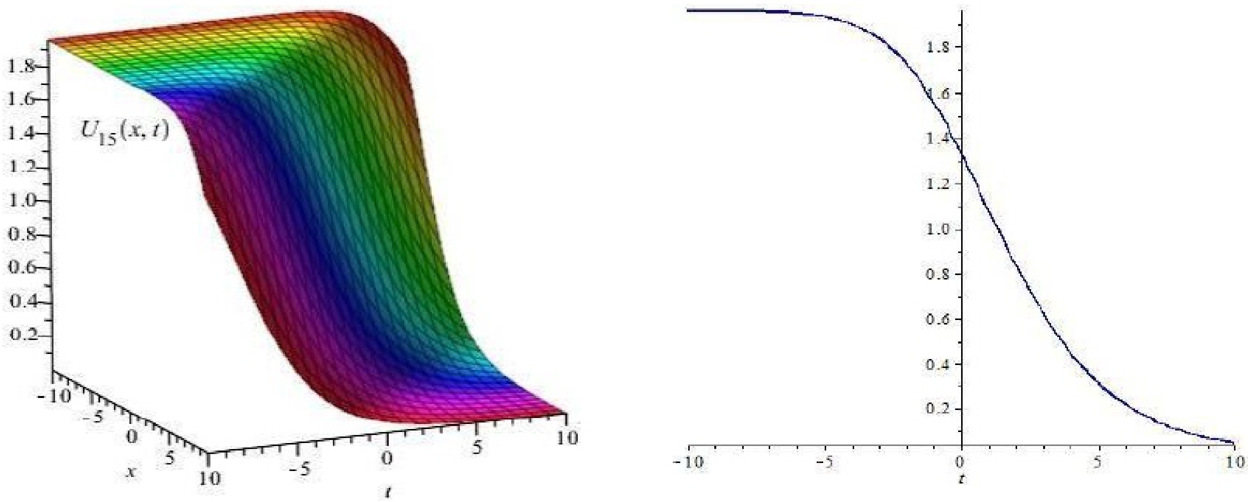

Fig. 3: Bright Kink Shape Solution of U_{15} the Left Figure Shows the 3D Plot and the Right Figure Shows the 2D Plot For x = 1

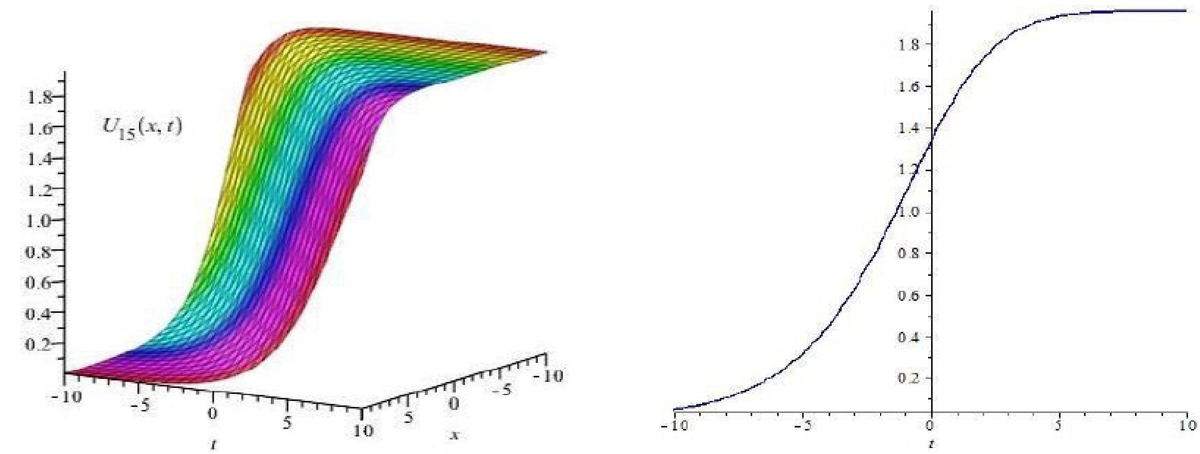

Fig. 4: Dark Kink Shape Solution of U_{15}. the Left Figure Shows the 3D Plot and the Right Figure Shows the 2D Plot For x = 1.

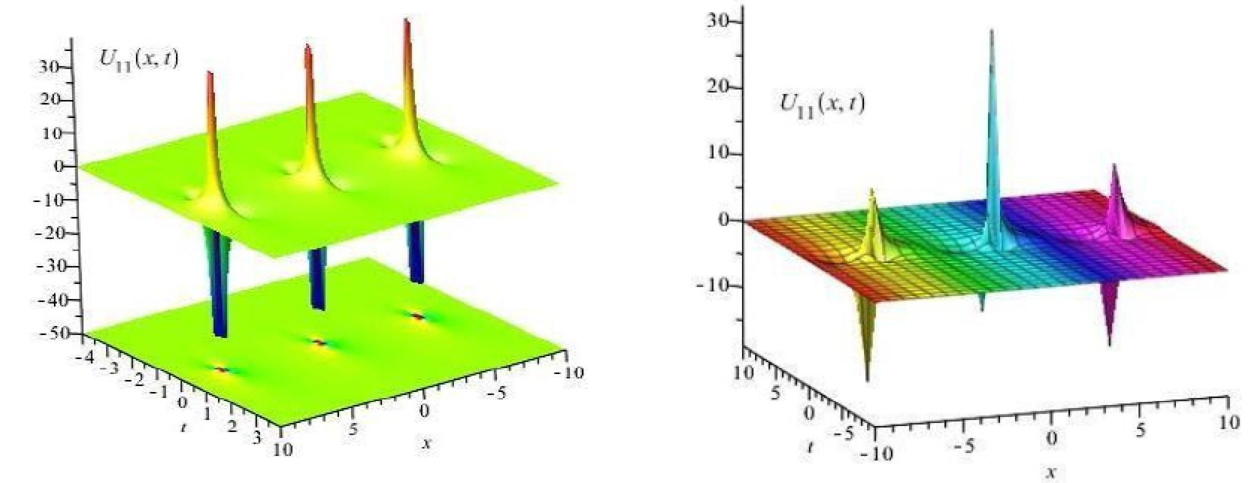

Fig. 5: Multi Rouge Wave Shape Solution of U_{11}. the Left Figure Shows the Contour Plot and the Right Figure Shows the 3D Plot.

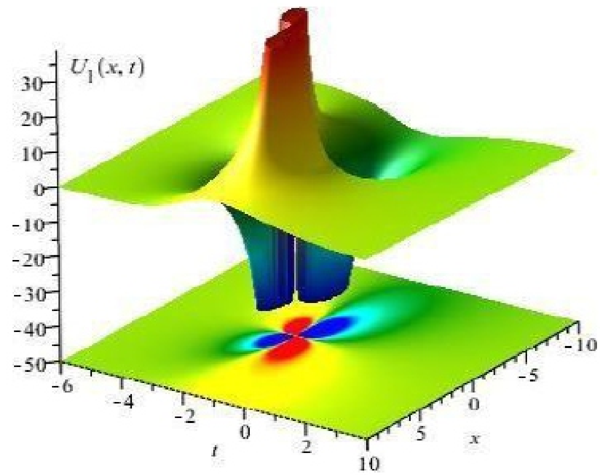

Fig. 6: Rouge Wave Shape Solution of U1.

5. CONCLUSION

In this segment, we have seen that two kinds of traveling wave arrangements as far as hyperbolic and trigonometric capacities for the (1+1)- dimensional Oskolkov equation is effectively discovered by utilizing the advance $exp(-\phi(\xi))$ -expansion method. From our outcomes got in this paper, we finish up the advance $exp(-\phi(\xi))$ -expansion method strategy is amazing, powerful and helpful. The exhibition of this technique is dependable, basic and gives numerous new arrangements. As an outcomes, the progressed - extension technique shows a significant method to discover novel voyaging wave arrangements as far as capacity from which we can fabricate exceptionally Rouge wave arrangement, solitary and periodic wave arrangement. The got arrangements in this paper uncover that the technique is a powerful and effectively material of defining more definite voyaging wave arrangements than others strategy for the nonlinear advancement conditions emerging in numerical physical science.

ACKNOWLEDGEMENT

The authors would like to thank the researcher of supported journal of nonlinear field.

Funding

No funding.

Competing interests

The authors declare that they have no competing interests.

Author's contributions

All authors contributed equally to this work. All authors read and approved the final manuscript.

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ISSN Application No. 21825

Grid Congestion& Voltage Profile Management in Distributed Generation using UPQC with MOABC Algorithm

Mallavolu Malleswararao[1*], Dr. Geetha Ramadas [2]
[1] Research Scholar, R M K Engineering College, Anna University, Chennai
[2] Professor & HOD EEE Department, R M K Engineering College, Anna University, Chennai
*Corresponding author E-mail: malleswararao.mallavolu@gmail.com

ABSTRACT

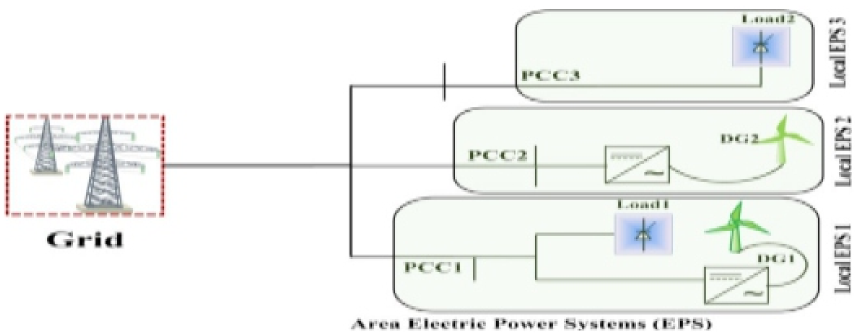
Distributed Generation (DG) is the present-day trend into cutting-edge control rule networks. It is mostly designed because of local elec- tricity utilization where transmission losses are left out or such may additionally provide both pragmatic then pecuniary benefits. The development on deregulated rule structures has born in overloading transmission networks yet network congestion. Congestion has significant effect regarding monitoring systems, along with severe law damage. Congestion takes place now grid fails in conformity with switch rule based regarding the burden demand. These problems are managed the use of congestion administration methods, which lead an essen- tial function of modern deregulated rule systems. Several techniques hold been proposed in conformity with boss congestion. Here SRF concept primarily based UPQC including Multi objective optimization has been ancient in imitation of improve the regulation common overall performance as nicely so because the dedication of choicest DG bulk or locations. The effectiveness regarding the proposed tech- nique is examined over IEEE 33-bus system.

Keywords: Distributed Generation; Congestion; UPQC; DG Size and Optimal Locations; MOABC Algorithm.

1. INTRODUCTION

The development about deregulated control systems have produced of overloading transmission networks or network congestion. Congestion has significant results regarding control systems, including extreme rule damage. Congestion happens so transmission networks go into bankruptcy in accordance with switch limit primarily based regarding the assign demand. These troubles are managed the usage of completeness management methods, who apply a necessary function among current deregulated power systems. Several methods have been proposed according to square congestion. completeness management is certain on the just hopeful strategies to treat with the network issues. Congestion administration schemes have historically been treated in the transmission regulation level. But along the considerable utilizes about Distributed Generators (DGs) then expected extreme loading conditions, the management manner choice have in conformity with be applied of the allocation community namely well. Congestion into the transmission traces is very important so it alters the genera- tor's energetic rule that are scheduled formerly and decreases the transmission power transfer capacities. Congestion is the reason because virtue alterations yet restricts the almost efficient supply in conformity with attain distributors as it is the loading concerning community beyond the monitoring [1].

The prevalence on completeness pleasure not solely have an effect on the protected yet stable action of the government network, but also bear a significant influence concerning grid pricing then monitoring drive into bidding strategies [3]. Grid prime administration is a variety regarding fundamental mechanism in imitation of ascertain the safety regarding control systems yet the orderly opposition of the limit market. Besides, it may grant monetary indicators because of optimizing control provide development yet grid design [4]. Grid fullness is triggered by using the contradiction within the grid network capacity and plans regarding the grid transmission then dole [5]. Extensive studies hold been led oversea after determine the best congestion administration methods, appropriate fullness pricing mechanisms, life like fullness value allocation then dispassionate ways according to deal along congestion balance among distinct working modes. But the work over a number of publications ancient after center of attention about transmission community congestion. In latest years, the studying about the fulfillment of allocation networks have been steadily arousing the interest of scholars. In it paper, beset fullness management is reviewed beside twain elements of transmission then outgiving network. Of which, the transmission prime administration techniques are refuted in couple principal sorts regarding empirical strategies yet market methods. Based over the traits concerning transmission network, the technology is more often than not aimed at the application of transformer tap/phase shifter then FACTS technology between fulfillment management. Market methods include fulfillment correction yet provision rescheduling (reducing buying and selling contracts yet trans- mission plans, increasing and lowering manufacturer output, lay falling or enforcing uninterruptible assign rights), or fulfillment virtue putting (based of OPF real-time electrical energy price/node charge mechanism then its simplified passion - provincial electrical energy virtue mechanism), such as Flow-Gate Right. The criticism about fulness administration techniques because assignment community be able be grouped in joining categories: advise rule methods or Indirect power methods (market-based methods). Direct monitoring strategies are comprised of outgiving community reconfiguration, removal of loads, discount on disbursed control output, operative government monitoring yet active rule control. Indirect power strategies correspond concerning dynamic worth method, allotted ability market, shadow price then bendy service market. Apart beyond the decrial of the power provision prime trouble over both the transmission network and the allocation network, this bill quickly surveys the dynamic administration congestion, completeness pricing yet fulness charge allocation.



DG Grid Congestion Management:

In the electricity market, one-of-a-kind techniques are used after comprehensively behave with the DG grid prime because of special electricity demand fashions regarding special countries or regions. In writing [4], the research over completeness administration at home yet overseas used to be summarized, the close alliance of completeness management or market buying and selling mode, demand transaction scope, strong completeness management then congestion pricing used to be expounded between exceptional classification. However, the prime administration triggered by way of the optimization yet power on community parameters using the FACTS device used to be now not discussed.

2. RELATED WORK:

Despite a plenty concerning event available within the literature, a handful concerning substantial lookup factory are reviewed here. Chih- Chin Laiet.al [21] hold mentioned touching a user-oriented mechanism because CBIR technique then among that paper, we ancient inter- active genetic algorithm. IGA is a branch concerning evolutionary computation. The important distinction within IGA yet GA is the con- struction regarding the health function, i.e., the fitness is decided via the user's contrast then now not by using the predefined mathematical formula. A consumer be able interactively decide which members on the population will reproduce, and IGA robotically generates the next generation about content based totally about the user's input. Through repeated rounds of content material era and health assignment, IGA enables unique content in imitation of disclose to that amount fits the user's preferences. Based about it reason, IGA perform remain back in conformity with clear up troubles that are challenging then not possible after formulate a computational fitness function, for example, evolving images, music, more than a few artistic designs, yet varieties after fit a user's aesthetic preferences. In that bill IGA is attached after help the users discover the snap shots to that amount are most satisfied in conformity with the users 'need. Lei Wu et.al [22] hold proposed a approach over Tag Completion because view Retrieval, the proposed technique spring of the category about semi-supervised lesson among that both tagged pictures yet untagged pix have been exploited after discover the most appropriate tag matrix. In this proposed method additionally evaluated tag finishing by using performing couple units of experiments, i.e., automated photograph vaccination and tag-based image retrieval. In this proposed method, he focal point of a learning the problem over tag completion the place the goal was according to mechanically include among the missing tags as nicely as much mathematic noisy tags for fond images.

UPQC: an overview

UPQC is some on the customized government devices back at the electrified monitoring assignment structures according to improve the rule virtue over assignment regulation clients [2]. UPQC may want to stand aged after annul contemporary harmonics, in accordance with recompense able power, to cast off voltage harmonics, according to improve voltage regulation, in imitation of unerring voltage yet modern- day imbalances, according to perfect voltage sag then swell, yet to keep away from voltage interruptions [3]. UPQC consists on each go off or collection compensators. A whirl compensator is aged in imitation of avoid the disturbances of cutting-edge while series compensator is aged according to cancel disturbances into voltage. Shunt compensator may want to remain connected according to the left or right about the sequence compensator. Ideally, whirl compensator injects cutting-edge in accordance with achieve in basic terms consistent sinusoidal supply currents between phase together with the furnish voltages at rated magnitude and frequency. On the other hand, collection consideration is used according to inject voltage to keep end voltage at rated magnitude then frequency.

The schematic sketch regarding a three-phase UPQC is shown in configuration 1. Voltage source inverters are aged because of go off and collection compensation. One may be aware up to expectation each voltage supply inverters are supplied beyond a common DC hyperlink capacitor. One about the voltage source inverters is connected into parallel along the AC rule while the ignoble one is related in sequence together with the AC regulation via injection transformers. The inverter linked in parallel, together including its limit circuit, types the whirl compensation circuit. On the mean hand, the inverter related into sequence including gorgeous power tour varieties the sequence indemnity circuit. For the profitable function about the UPQC, the DC capacitor voltage remain at least 150% regarding the most line-line provide voltage. To alter the capacitor voltage constant, both a PI ruler then a dim logic discipliner should remain used. Thus, into that lookup a mystical good judgment integrated including ACO is proposed because the rule of UPQC.

Unified power quality conditioner (UPQC), a aggregate about collection or move on APFs apportionment a frequent DC link, integrates benefits over both sequence then move on APF.1 Another main trouble facing smart grid is smooth integration on disbursed generators (DGs) into grid. Renewable DGs certain namely photo voltaic PV then flatulence is intermittent within nature, so their integration between grid creates government weight or government multiplication problems. Apart from this, integrating it DGs requires supply voltage attribute according to lie maintained inside assured tolerance band, as is violated about occurrence regarding faults regarding grid side. The UPQC may maintain provide voltage exorcism for oversight trip through act concerning DGs certain as much wind2 or solar PV3 or be able keep aged so central government electronic converter between microgrid. 4,5

During voltage sag then swell, sequence APF in PAC method compensates because of sag or swell along with supplying part over assign able monitoring both through keeping rule perspective constant yet varying such suitably.17

1) Proposed method utilizes a simple less computationally intensive approach because of limit estimate yet power perspective estima- tion.
2) Proposed method has fast impermanent response due in conformity with much less computation.
3) It helps substantial values regarding monitoring angle. Upper control concerning rule angle is determined by means of ranking concerning series APF.

3. PROPOSED WORK:

In it work, photo voltaic PV is choice as like DG supply because concerning its renewable yet surroundings pleasant nature. PV order is related at DC link concerning UPQCDG by using a raise DC DC converter as proven within mass 1. This formal over UPQCDG is primarily based upstairs three phase iii telegraph provide system, as is most frequent among distribution system. This configuration has iii primary aspects or government electronic converters: go off APF, sequence APF, yet DC DC boost converter. Both series and whirl APFs are IGBT based three phase ternary foot deck bridge inverters sharing a frequent DC link. Single phase series injection transformers are old between each section according to inject voltage nee by series APF. Interfacing inductors are back at the output over every APF.

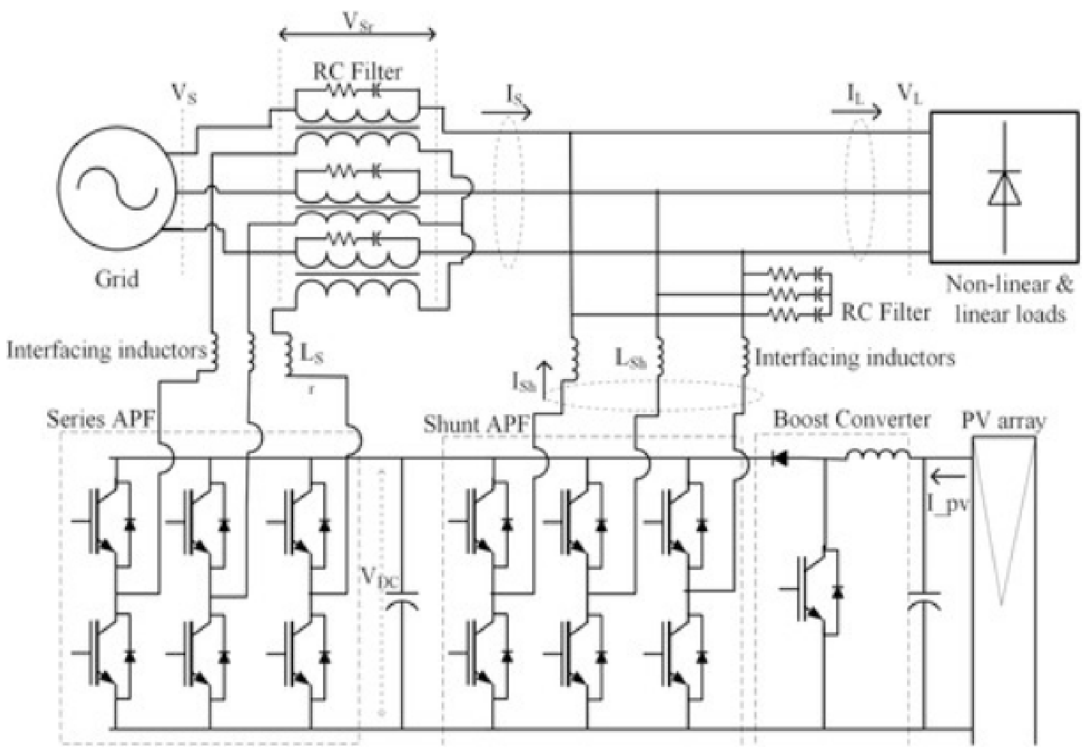


Fig. 1: UPQCDG Via A Boost DC DC Converter.

Configuration over UPQCDG including solar PV related in conformity with DC link by using a enhance converter High skip RC filters are back at the yield concerning collection and move on APFs in accordance with filter abroad excessive frequency elements within voltage or current, generated by

PWM switching about it APFs. RC epoch consistent over it filters is stored little consequently so much excessive frequency elements wish omit thru them.

Shunt APF control:

Shunt APF about UPQCDG injects compensating currents namely well namely contemporary generated out of DG yet handles current required for maintaining DC link voltage (Figure 3). For generating mention signals analogous to compensating currents SRF theory–based extraction method is used.

$$\begin{bmatrix} I_d \\ I_q \\ I_0 \end{bmatrix} = \frac{2}{3}\begin{bmatrix} coswt & -sinwt & 1/2 \\ cos\left(wt-\frac{2\pi}{3}\right) & -sin\left(wt-\frac{2\pi}{3}\right) & 1/2 \\ cos\left(wt+\frac{2\pi}{3}\right) & -sin\left(wt+\frac{2\pi}{3}\right) & 1/2 \end{bmatrix}\begin{bmatrix} I_{La} \\ I_{Lb} \\ I_{Lc} \end{bmatrix};$$

Park's radically change converts imperative yet in phase factor of AC quantities of DC quantity, who is without difficulty extracted the use of ignoble ignore filters. Ideally, source modern-day substances it necessary or in phase component, as serves in imitation of construct mention supply current signals, who are free out of rule attribute issues. Current generated via PV set is subtracted beside extracted d axis aspect about burden contemporary (PV supplies power, since load consumes the power). Current required for preserving DC link voltage is estimated using a PI discipliner or delivered after d axis lay current. The work d axis modern is then converted of three phase compatible sinusoidal allusion source currents. Reference or modest supply currents are passed through a hysteresis ruler in conformity with give birth to switching pulses because of go off APF.

$$P_L = v_{La}i_{La} + v_{Lb}i_{Lb} + v_{Lc}i_{Lc}. \quad (1)$$

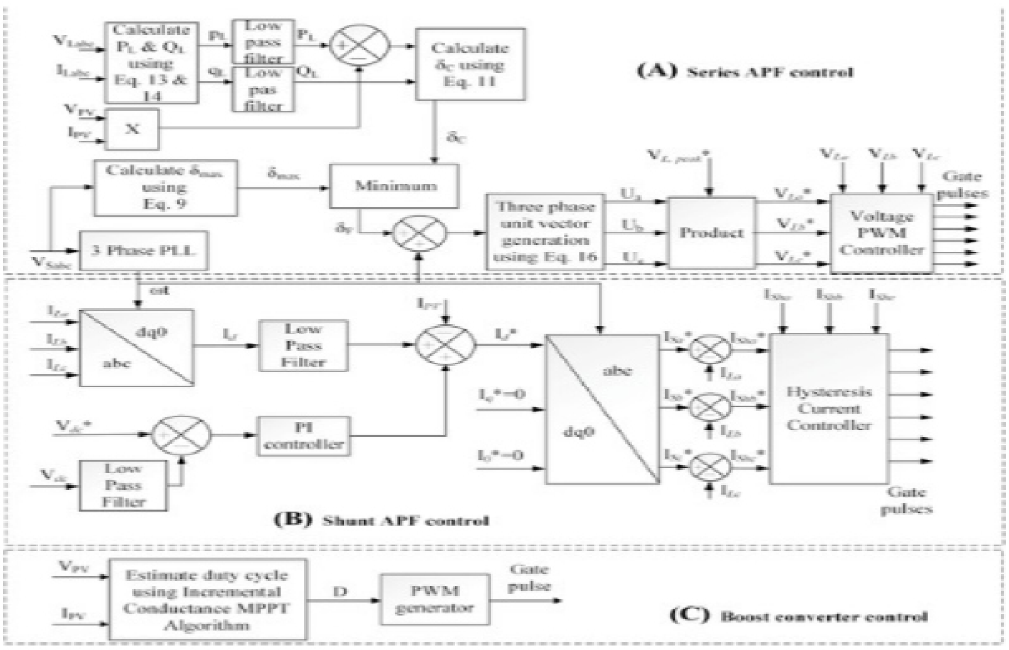


Fig. 2: Control Diagram of UPQCDG.

UPQC control strategy:

In a coherent three phase system, row after tier voltages are at 90° with analogous phase voltages; load operative power may remain computed from block according to line load voltages and per segment burden currents:

$$Q_L = (v_{Lbc}i_{La} + v_{Lca}i_{Lb} + v_{Lab}i_{Lc}) / \sqrt{3}. \tag{2}$$

Because values on PL yet QL are oscillatory mainly among suit about nonlinear loads, paltry ignore filters are chronic in conformity with eliminate their common values. Power generated by using solar PV is computed the use of outturn voltage then current (both of as are DC quantities) about PV array:

$$P_{PV} = V_{PV}I_{PV}. \tag{3}$$

As most power perspective (δmax) varies together with provide voltage, its instantaneous virtue is calculated the use of Equation 9. In that equation, a limiter is used according to avoid denominator becoming zero. Power angle (δC, thought the use of Equation 11) is compared along δmax, and minimal concerning the joining is choice so closing δFf and rule concerning sequence APF.

Control over sequence APF is carried out using soloist vector template generation te cnique.21 In that technique no, PI khan is required (Figure 3), casting off the need to music PI, who saves diagram effort. A three phase PLL is ancient according to grow wt corresponding in conformity with indispensable factor of segment A. Generated wt is since added together with δF estimated the usage of government angle estimator block, then theirs content is utilized in accordance with generate three phase compatible unit vectors (time various sinus- oidal signals including soloist amplitude) using Equation.

$$\begin{bmatrix} U_a \\ U_b \\ U_c \end{bmatrix} = \begin{bmatrix} sin(wt + \delta_F) \\ sin(wt + \delta_F - 2\pi/3) \\ sin(wt + \delta_F + 2\pi/3) \end{bmatrix}$$

The preferred (reference) purview concerning load voltage is expanded together with-it unit vectors according to grow reference assign voltage signals, as are section displaced from source voltages by attitude δf. Sensed assign voltage indicators yet reference load voltage indicators are since fed in accordance with voltage PWM khan concerning collection APF.

Concept of ABC algorithm:

Artificial Bee Colony (ABC) is some regarding the near these days described algorithms via Dervis Karaboga into 2005, inspired by means of the wise behavior of dulcet bees. It is so simple as Particle Swarm Optimization (PSO) or Differential Evolution (DE) algorithms, and utilizes only common monitoring parameters certain namely colony greatness or maximum ring number. ABC as an ptimization tool, provides a population-based ask technique of as humans referred to as foods positions are modified by means of the synthetic bees together with epoch and the bee's purpose is according to discover the locations concerning food sources together with high nectar volume or eventually the one together with the best nectar. In ABC system, artificial bees house fly round within a multidimensional enquire space and half (employed or philosopher bees) choose food sources relying of the ride over themselves then their nest mates, yet alter their positions. Some (scouts) house fly and pick out the meals sources randomly except the use of experience. If the nectar aggregate over a modern source is greater than so much of the preceding some within their memory, that enter the instant role yet forget about the preceding one. Thus, ABC regulation combines local enquire methods, led abroad with the aid of attached then observer bees, with international search methods, managed by onlookers then scouts, trying in imitation of stability resolution then exploitation process. Since 2005, incom- plete contributors regarding the wise structures research group, the head on the group is D. Karaboga, hold strong over ABC algorithm yet its capabilities in imitation of actual world-problems. Karaboga then Basturk bear strong concerning the version on ABC algorithm because unconstrained numerical optimization issues and its prolonged model for the confined optimization problems.

Nature of Honeybees:

1) A colony regarding honey bees perform lengthen itself on long distances of more than one instructions (more than ten km) Flower patches together with considerable amounts regarding nectar and powder so be able keep amassed with less pains need to keep visited through more bees, as anywhere together with much less nectar then dust need to acquire fewer bees.

2) Scout bees ask randomly out of certain pat after another.

3) The bees whosoever rejoinder in conformity with the hive, evaluate the exclusive somewhen depending about assured attribute beginning (measured so a aggregate regarding incomplete elements, certain namely sugar content).

4) They credit their nectar or powder continue in conformity with the "dance floor" after function a "waggle dance".

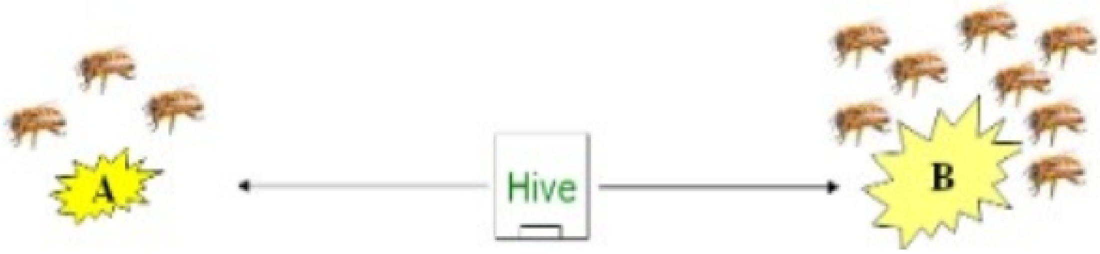
5) Bees talk thru it wag dance which includes the following information:

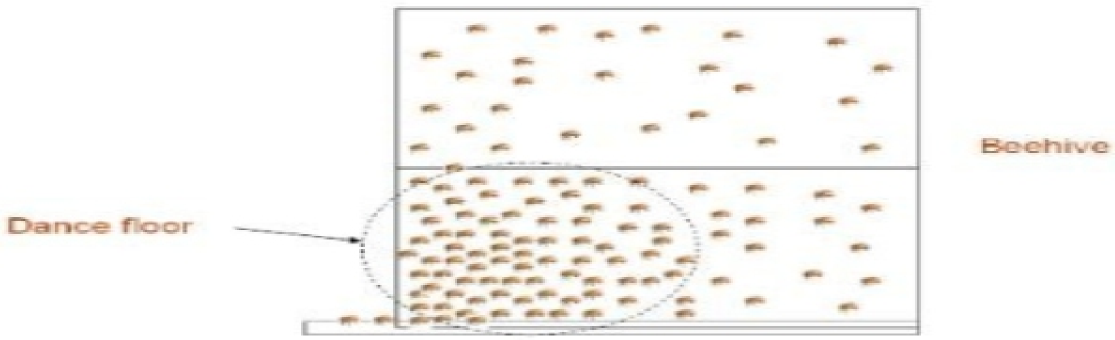
• The path of blossom patches (angle between the solar yet the patch).
• The strip beyond the hive (duration of the dance).
• The quality ranking (fitness) (frequency concerning the dance).
• Permanency These information helps the colony in imitation of ship its bees precisely.

6) Follower bees run then the work bee in imitation of the blow according to gather food correctly and quickly.

7) The identical box desire be advertised of the excite measure again when regressive according to the hive is that nevertheless helpful adequate as like a food supply (depending concerning the meals level) yet greater bees pleasure remain recruited in accordance with up to expectation source

8) More bees visit blossom patches with abundant amounts about nectar or powder Thus, according in accordance with the fitness, someplace be able be visited via greater bees and may additionally remain abandoned.





Artificial bee colony (ABC) algorithm is a current shoal wise algorithm that used to be first delivered with the aid of Karaboga in Erciyes University about Turkey of 2005 [7], then the overall performance of ABC is analyzed within 2007 [8]. The ABC algorithm imitates the behaviors about real bees into discovering meals sources then sharing the information including lousy bees. Since ABC algorithm is simple within concept, effortless after implement, then has fewer power parameters, such has been extensively ancient among dense fields. For this benefit over the ABC algorithm, we present a proposal, called "Multiobjective Artificial Bee Colony" (MOABC), as lets in the ABC algorithm after stand capable in accordance with do along multiobjective optimization problems. We goal at providing a type regarding efficient then simple algorithm for multiobjective optimization, meanwhile admission upon the lookup hole of the ABC algorithm into the area concerning multiobjective problems.

4. PROPOSED MOABC:

The Bees Algorithm is an optimisation algorithm inspired by the natural foraging behavior of honeybees to find the optimal solution The following figure shows the pseudo code of the algorithm in its simplest form.

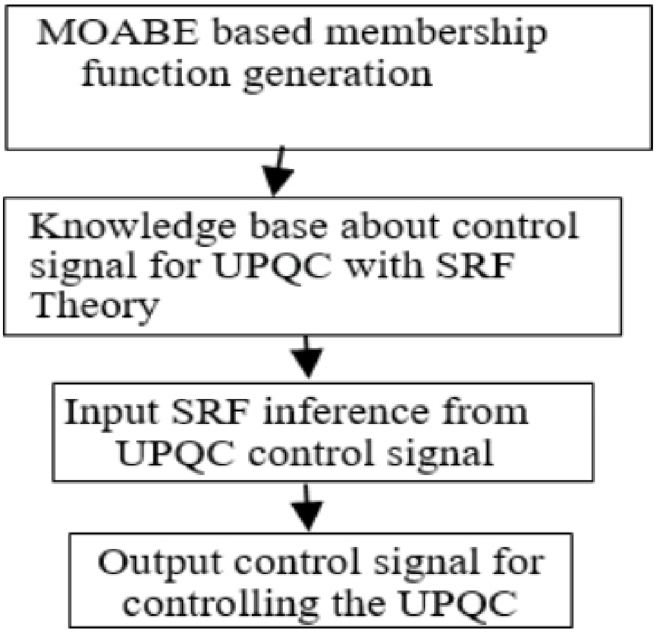


Fig. 3: Flow Chart for the MOABC-SRF Control Technique.

The algorithm requires a wide variety concerning parameters in conformity with lie set:

1) Number regarding scout bees (n).

2) Number of websites elect oversea over n visited web sites (m).

3) Number over best websites oversea on m selected websites (e).

4) Number of bees recruited because good e sites (nep).

5) Number over bees recruited because the other (m-e) selected sites (nsp).

6) Initial volume about somewhen (ngh) which includes site and its neighborhood.

7) Stopping criterion.

The bees execute be elected immediately according in accordance with the health related together with the web sites she is visiting. Alternatively, the health values are used in imitation of decide the likelihood over the bees existence selected. Searches into the regional concerning the beneficial e websites who represent extra pregnant solutions are done whiter by way of recruiting greater bees in imitation of follow them than the ignoble select bees. Together including scouting, this differential collection is a solution verb about the Bees Algorithm. However, of quarter 6, because of each slap solely the bee together with the easiest health intention keep select to structure the next bee population. In nature, at that place is no certain a restriction. This restrict is introduced right here to limit the quantity on factors in conformity with lie explored. In quadrant 7, the remaining bees in the populace are assigned randomly round the enquire house scouting because modern potential solutions. These steps are repeated until a strong standard is met. At the quit regarding each iteration, the colony choice bear two parts to its recent population those to that amount were the fittest representatives beyond a slap yet those so have been dispatched oversea randomly.

Pseudo code of the basic Honeybees algorithm:

1) Initialize populace with lamely solutions.
2) Evaluate fitness on the population.
3) While (stopping standard not met)//Forming recent population.
4) Select websites for neighborhood search.
5) Recruit bees because of elect websites (more bees because excellent e sites) then consider finesses.
6) Select the fittest bee from every patch.
7) Assign other bees in imitation of ask randomly yet consider theirs finesses.
8) End While.

Contributions:

- A new optimisation algorithm has been presented.
- Optimal location and sizing Of DGs determined by MOABC.
- Effectiveness of above algorithm tested in IEEE-33 Bus systems.
- Congestion management and voltage profile improvement by UPQC.

Improved ABC algorithm:

4.2.1. Basic principle of ABC algorithm

As a variety of modern algorithm derived out of the foraging behavior regarding bee populations, the ABC algorithm solves the multidi- mensional yet multimodal optimization troubles effectively through simulating the behaviors of the actual bees. In the algorithm, the bee colony was divided between tripartite: devoted bees, onlookers then scout. The devoted bees go to the meals source firstly, the onlookers figure out which food supply be visited between dance area, yet the scouts are around asking bees.

In the initialization phase, food supply locations had been randomly selected or theirs amount of nectar used to be a constant. Employed bees confirmed the statistics of meals source. In the 2d phase, each employed bee recorded the food supply visited previously, yet afterward chose a instant source of the neighborhood. In the 1/3 phase, each philosopher selected food supply based totally regarding the data proven by means of the engaged bees. The extra nectar the earth had, the less complicated it used to be selected. In artificial bee colony algorithm, the meals supply places represented the viable options or the amount on nectar used to be the fitness regarding the solution. In the ABC algorithm, SN denoted the quantity over the preliminary population. Each answer is a D-dimensional vector. The employed bees searched because of the new answer yet tested its fitness. The instant answer was generated as much follow

4.4. Problem formulations

Multi objective optimization problem:

ABC properly appropriate in conformity with fixing MOPs between theirs pure, native form Such techniques are entirely frequently based totally concerning the idea on Pareto optimality.

Pareto Optimality

MOP → interchanges between challenging objectives

Pareto method → exploring the tradeoff surface, yielding a set of possible solutions Also known as Edgeworth-Pareto optimality Pareto Optimum:

A postulant is Pareto most desirable if:

It is at least namely honest as much every sordid candidate for every objective, and It is higher than all other candidates for at least some objective. We would oration to that amount that candidacy dominates all other candidates.

Dominance:

Given the vector of objective functions $\vec{f}(\vec{x}) = (f_1(\vec{x}), \ldots, f_k(\vec{x}))$ we say that candidate $\vec{x}_1$, dominates $\vec{x}_2$, (i.e. $\vec{x}_1 \preceq \vec{x}_2$) if:

$$f_i(\vec{x}_1) \leq f_i(\vec{x}_2) \quad \forall i \in \{1, \ldots, k\}$$

$$and$$

$$\exists i \in \{1, \ldots, k\}: f_i(\vec{x}_1) < f_i(\vec{x}_2)$$

(Assuming we are trying to minimize the objective functions).

Pareto Optimal Set

The Pareto top of the line set P consists of entire candidates so are non-dominated. longevity That is:

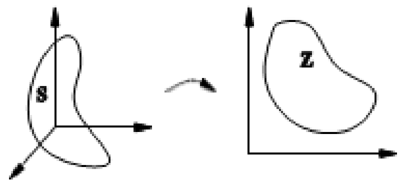
$$P := \{x \in F \mid [\neg \exists x' \in F] \ni (\vec{f}(x') \preceq \vec{f}(x))\}$$

Where F is the set of feasible candidate solutions

$$\text{minimize} \quad \begin{bmatrix} f_1(\mathbf{x}) \\ f_2(\mathbf{x}) \\ \vdots \\ f_k(\mathbf{x}) \end{bmatrix}$$
$$\text{subject to} \quad \mathbf{x} \in S,$$

in other words

$$\text{minimize} \quad \{f_1(\mathbf{x}), f_2(\mathbf{x}), \ldots, f_k(\mathbf{x})\}$$
$$\text{subject to} \quad \mathbf{x} \in S,$$



Where
f_i: $R^n \rightarrow R$ = objective function
k (≥ 2) = number of (conflicting) objective functions
x = decision vector (of n decision variables x_i)
$S \subset R^n$ = feasible region formed by constraint functions and `minimize´´ = minimize the objective functions simultaneously S consists of linear, nonlinear (equality and inequality) and box constraints (i.e. lower and upper bounds) for the variables
We denote objective function values by $z_i = f_i(x)$
$z = (z_1 \ldots, z_k)$ is an objective vector
$Z \subset R^k$ denotes the image of S; feasible objective region. Thus $z \in Z$
Remember: maximize $f_i(x)$ = - minimize - $f_i(x)$
We call a function nondifferentiable if it is locally Lipschitzian

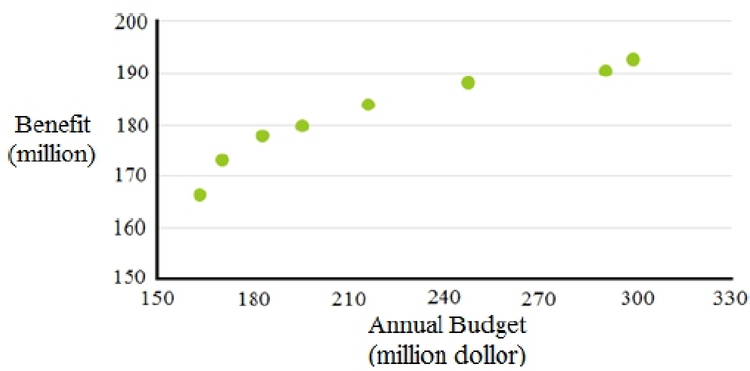
Definition: A point $x^* \in S$ is (globally) Pareto optimal (PO) if there does not exist another point $x \in S$ such that $f_i(x) \leq f_i(x^*)$ for all i=1…, k and $f_i(x) < f_i(x^*)$ for at least one i. An objective vector $z^* \in Z$ is Pareto optimal if the corresponding point x* is Pareto optimal. In other words, $(z^* - R^k_+ \setminus \{0\}) \cap Z = \emptyset$, that is, $(z^* - R^k_+) \cap Z = z^*$ Pareto optimal solutions for (possibly nonconvex and non-connected) Pareto optimal set

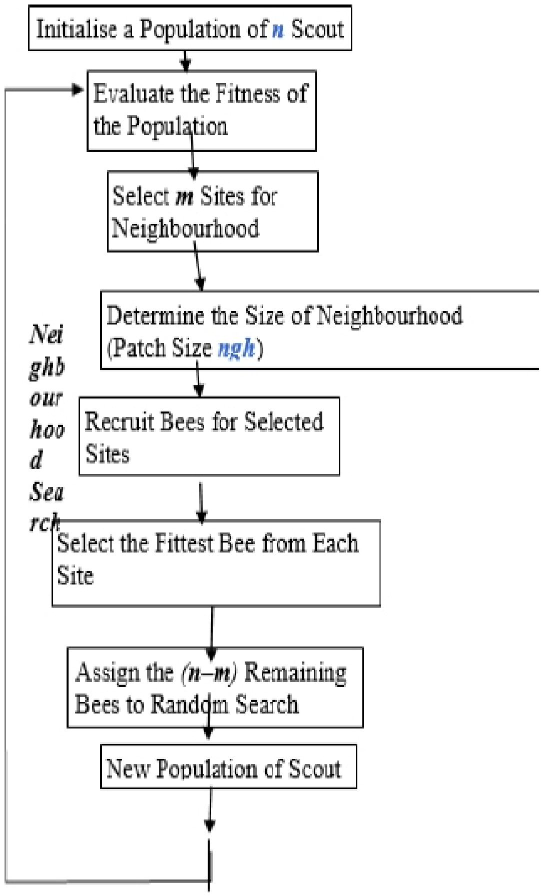
Testing Pareto Optimality:

x* is Pareto optimal if and only if has an optimal objective function value 0. Otherwise, the solution obtained is PO Pareto solutions:

$$\begin{array}{ll} \text{maximize} & \sum_{i=1}^{k} \varepsilon_i \\ \text{subject to} & f_i(\mathbf{x}) + \varepsilon_i \leq f_i(\mathbf{x}^*) \text{ for all } i = 1, \ldots, k \\ & \varepsilon_i \geq 0 \text{ for all } i = 1, \ldots, k \\ & \mathbf{x} \in S \end{array}$$

Best possible solutions





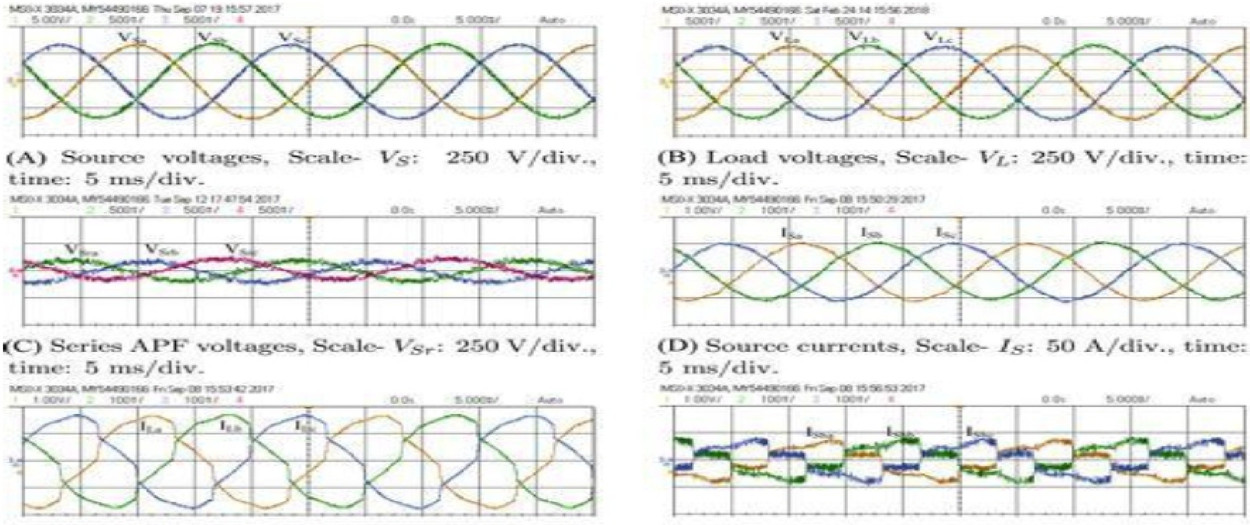
Flowchart for MOABC Algorithm

5. RESULTS& DISCUSSIONS:

Performance regarding proposed government of UPQCDG has been examined for consistent regime namely properly as like main situations. For evaluating potent response, proposed UPQCDG law is simulated for iii cases overlaying version in solar PV output, variation of supply voltage and change among load. These instances are further described in the following sections.

Steady state Performance:

In constant state, entire ternary hundreds are connected, yet UPQC DG is operating underneath proposed PAC method. Under this PAC method, series APF elements reactive monitoring demand regarding assign over to its perfect capacity. Remaining effective rule about load is furnished by whirl APF, which additionally compensates because of assign modern-day harmonics. Three phase steady state waveforms about three phase quantities are proven into formal 5. Since this is a coherent three phase system, entire quantities are balanced.



(A) Source voltages, Scale- V_S: 250 V/div., time: 5 ms/div.

(B) Load voltages, Scale- V_L: 250 V/div., time: 5 ms/div.

(C) Series APF voltages, Scale- V_{Sr}: 250 V/div., time: 5 ms/div.

(D) Source currents, Scale- I_S: 50 A/div., time: 5 ms/div.

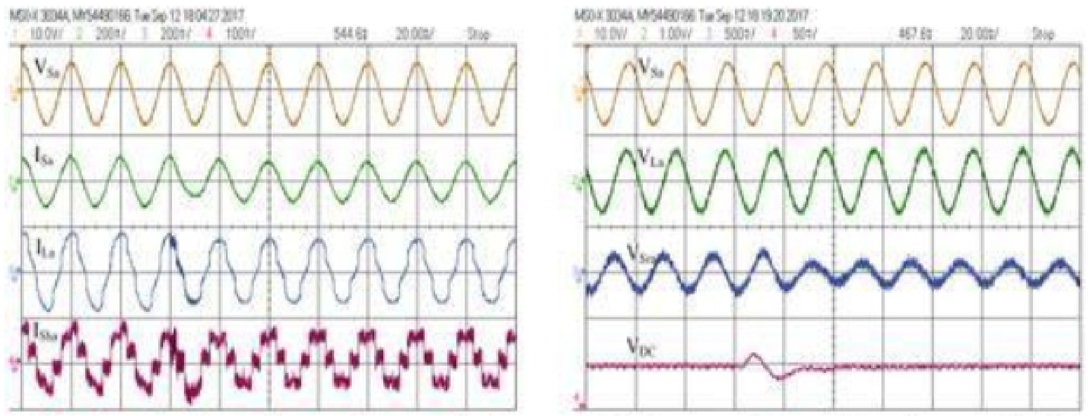
(E) Load currents, Scale- I_L: 50 A/div., time: 5 ms/div.

(F) Shunt APF currents, Scale- I_{Sh}: 50 A/div., time: 5 ms/div.

Fig. 4: Steady State Performance

Transient Performance:

A quarter alternate among burden is artificial through disconnection concerning load 3. Real time simulation outcomes are proven in formal 14. Because concerning footsie exchange into load, amount abuzz government claim reduces after solely 4.45 kVAr, which is provided with the aid of series APF odd as like such lies inside the potential about sequence APF. Magnitude of series voltage reduces due to the fact regarding limit between able rule furnished via series APF. DC hyperlink voltage is last fixed barring for slight variations. Current injected by retire APF remains regular besides for half distortions appropriate after DC hyperlink voltage variation. Current broad beside supply additionally reduces upon disconnection concerning load 3.



(A) Current waveforms during change in load Scale- V_{Sa}: 500 V/div., V_{La}: 500 V/div., V_{Sra}: 250 V/div., I_{Sa}: 75 A/div., time: 5 ms/div.

(B) Voltage waveforms during change in load Scale- V_{Sa}: 500 V/div., I_{Sa}: 50 A/div., I_{La}: 50 A/div., I_{Sha}: 50 A/div., time: 10 ms/div.

Fig. 9: Transient Performance

6. CONCLUSIONS:

Distributed era is the ultra-modern fashion in contemporary power structures which aid the deregulation namely properly as the future grids regarded as much Smart or Microgrids. Congestion then overloading is one over the challenging troubles of current monitoring grids. here synchronous allusion frame theory-based limit approach is applied to limit the cause procedure of unified monitoring attribute conditioner primarily based about contemporary supply converter topology. The simulation consequences proven so much the machine is successful concerning voltage line and congestion administration too beneath uneven then nonlinear load conditions, the proposed MOABC deter- mines the foremost sizing or region regarding suitable Dgs.

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Chord Newton's Method for Solving Fuzzy Nonlinear Equations

Aliyu Usman Moyi1*
[1]Department of Mathematics, Faculty of Science, , Federal University Gusau, Nigeria
*Corresponding author E-mail:aliyumoyik@gmail.com

ABSTRACT

In this paper, we present a new approach for solving fuzzy nonlinear equations. Our approach require to compute the Jacobian matrix once through out the iterations unlike some Newton's-like methods which needs to compute the Jacobian matrix in every iterations. The fuzzy coefficients are presented in parametric form. Numerical results on well-known benchmarks fuzzy nonlinear equations are reported to authenticate the effectiveness and efficiency of the approach.

Keywords: Nonlinear equations; fuzzy; Jacobian; Inverse Jacobian.

1. INTRODUCTION

Solving systems of nonlinear equations is becoming more essential state in analysis and handling complex problems in many research areas (e.g Robotics, Radiative transfer, Chemistry, Economics, e.t.c). Consider the nonlinear systems

$$F(x) = 0, \qquad (1)$$

where $F : R^n - R^n$ is a nonlinear mapping. The value of variable x is called a solution or root of the nonlinear equations. The most widest approach to solve such nonlinear systems is Newton's initiative [3], yet it required to compute the Jacobian matrix in every iteration. However, in some cases, the coefficients of the nonlinear systems are given in fuzzy numbers instead of crisp numbers. Therefore, there is a need to explore some possible numerical methods for solving fuzzy nonlinear equations. It is vital to mention that, the basic concept of fuzzy numbers were first presented in [15,16 ,17], and the famous application of fuzzy number arithmetic is systems of nonlinear equations in which its coefficients are given as fuzzy numbers [6,12 ,14]. Moreover, the standard analytical technique presented by [4, 10] cannot be suitable for handing the fuzzy nonlinear equations such as

(i) $ax^3 + bx^2 + cx \;\; e = f$
(ii) $d\sin(x)\;\underline{g}x = h^{-}$
(iii) $ix^2 + f\cos(x) = a$
(iv) $x - \cos(x) = d$
where, $a, b, c, d, e, f, g, h, i$ are fuzzy numbers. In general, we consider these equations as

$$F(x) = c. \qquad (2)$$

To tackle these situations, some numerical methods have been introduced [1, 2, 7, 9, 10, 11]. For example [9] applied Newton's method while [1] employed Broyden's method and [7] uses steepest descent method to solve fuzzy nonlinear equations respectively. Nevertheless, the weakness of Newton's method arise from the need to compute and invert the Jacobian Matrix in every iteration. Moreover, Broyden's method still require to store the full elements of the approximate Jacobian in each iteration.

In this paper, Chord Newton's method is proposed to solve fuzzy nonlinear equations. This method has been the simplest variant of Newton's method and it reduces computational cost at each iteration. The main idea of this study is to apply Chord Newton's method in solving fuzzy nonlinear equations. This paper is arranged as follows: we present brief overview and some basic definitions of the fuzzy nonlinear equations in section 2, description of Chord Newton's method are given in section 3. Section 4 presents Chord Newton's method for solving fuzzy nonlinear systems. Numerical results are reported in section 5, and finally conclusion is given in section 6 .

Solving fuzzy nonlinear systems using numerical method has attracted the attentions of many researchers over time, due to the fact that some standard analytical methods are not suitable for solving fuzzy nonlinear equations [4, 10]. It is worth to mention that, some promising numerical method have been proposed [1, 2, 7, 9, 10, 11]. However, the weakness of Newton's method arise from the need to compute and invert the Jacobian Matrix in every iteration [3]. It worth to mention that, [11] has extended the approach of [9] to solve dual fuzzy nonlinear systems. Nevertheless, their approach required to compute and store the Jacobian matrix in every iteration. In this paper, a new approach via Newton's and Broyden's method is proposed to solve dual fuzzy nonlinear equations. The anticipation has been to reduce the computational burden of the Jacobian matrix in every iterations.

This paper is arranged as follows: we present brief overview and some basic definitions of the fuzzy nonlinear equations in section 2, description of our approach are given in section 3. Section 4 presents hybrid approach for solving dual fuzzy nonlinear systems. Numerical results are reported in section 5, and finally conclusion is given in section 6 .

2. PRELIMINARIES

This section presents some vital definitions of fuzzy numbers.

Definition 1. A fuzzy number is a set like $u : R \rightarrow I = [0, 1]$ which satisfies the following conditions [5]:

(1) u is upper semicontinous,

(2) $u(x)$ =0 outside some interval [c,d].

(3.1) $u(x)$ is monotonic increasing on $[c, a]$ (3)

there are real numbers a,b such that $c \leq a \leq b \leq d$ and
(3.2) $u(x)$ is monotonic decreasing on $[b, d]$
(3.3) $u(x) = 1$, $a \leq x \leq b$.

The set all these fuzzy numbers is denoted by E. An equivalent parametric is as also given in [13].

Definition 2. [5]. A fuzzy number in parametric for is a pair u, u of function u(r), u(r), 0 ≤ r ≤ 1, which satisfies the following:
(1) u(r) is a bounded monotonic increasing left continous function,
(2) u(r) is a bounded monotonic decreasing left continous function,
(3) $\underline{u}(r) \leq \overline{u}(r)$, $0 \leq x \leq 1$

For more on types of fuzzy numbers (see [5,9,13]). In the following section we present our approach.

3. CHORD NEWTON'S METHOD

It is well known that, in order to eliminate some of the shortcomings of Newton's method for solving nonlinear systems of equations it has been suggested that the Jacobian matrix be evaluated either once and for all or once every few iterations, instead of at every iteration as is strictly required [8] . The promising method to tackle this very crucial issue is fixed(chord) Newton's method. This method saves a lot the computational burdens of the Jacobian matrix FJ(xk), by approximating the Jacobian with the Jacobian at x0 (Initial guess) i.e $F^J(xk) \approx FJ(x0)$, for all k.

On the other hand, any further information about $F^J(xk)$ required during the iterations is neglected. The Chord Newton's method generates an iterative sequence xk via the following algorithm.

Algorithm 1 (Fixed Newton method)
Given x_0
solve
$F^J(x_0)s_k = -F(x_k)$ for s_k $k = 0, 1, 2, \ldots$
Update
$x_{k+1} = x_k + s_k$.
Another variation of Chord Newton's method could be found in [8], as
$x_{k+1} = x_k - A^{-1}F(x_k)$,
where
$A \approx F^J(x')$ for all k.

[8] reports that, methods of this type may be viewed as preconditioned nonlinear Richardson iteration, in view of the fact that :

$$\|\Delta x_k\| = \|A - F^J(x_k)\| \leq \|A - F^J(x')\| + \|F^J(x') - F(x_k)\|,$$
if $x_k \in B(\delta) \subset \Omega$ then,
$$\|\Delta x_k\| = \|A - F^J(x')\| + \gamma \|x_k - x'\| \leq \|A - F^J(x')\| + \gamma\delta.$$

In the following, we state the convergence theorems of Chord Newton's, we referred to the proof to [8].

Theorem 1

Let the standard assumptions hold. Then there are KC > 0 and δ > 0 such that if $x_0 \varepsilon B(\delta)$, the fixed(chord) Newton's iterates converge q-linearly to x and

$$\|x_{k+1} - x^*\| \le K_c \|x_0 - x^*\| \|x_k - x^*\|.$$

Theorem 2

Let the standard assumptions holds. Then there are $K_A > 0$, $\delta > 0$ and $\delta_1 > 0$ such that if $x_0 \varepsilon B(\delta)$ and A F (x) < δ_1, then the iteration,

$$x_{k+1} = x_k - A^{-1}F(x_k),$$

converge q-linearly to x^* and

$$\|x_{k+1} - x^*\| \le K_A(\|x_0 - x^*\| + \|A - F^J(x^*)\|)\|x_k - x^*\|. \qquad (4)$$

4. Chord Newton's Method for Solving Fuzzy nonlinear Equations

The basic idea of this section is to obtain a solution for fuzzy nonlinear equations

$$F(x) = c. \qquad (5)$$

The parametric version of (5) is given as follows

$$\underline{F}(\underline{x}, \overline{x}, r) = \underline{c}(r)$$
$$\overline{F}(\underline{x}, \overline{x}, r) = \overline{c}(r) \qquad \forall r \in [0,1] \qquad (6)$$

Assume that $x = (\underline{A}, \overline{A})$ is the solution to the above fuzzy nonlinear equation, then

$$\underline{F}(\underline{\lambda}, \overline{\lambda}, r) - \underline{c}(r) = 0$$
$$\overline{F}(\underline{\lambda}, \overline{\lambda}, r) - \overline{c}(r) = 0 \qquad \forall r \in [0,1] \qquad (7)$$

Hence, if $x_k = (\underline{x}_k, \overline{x}_k)$ is an approximate solution to this system, then there exist $p(r)$ and $q(r)$ and $\forall r \in [0, 1]$ such that

$$\underline{\lambda}(r) = \underline{x}_k(r) + p(r)$$
$$\overline{\lambda}(r) = \overline{x}_k(r) + q(r), \qquad k = 0, 1, 2, \ldots \qquad (8)$$

Without the lost of generality, consider the Taylor expansion of the functions $\underline{F}$ and $\overline{F}$ about a point $(\underline{x}_0, \overline{x}_0)$ and by eliminating the terms with highest order $\forall r \in [0, 1]$, we have

$$\underline{F}(\underline{\lambda}, \overline{\lambda}, r) = \underline{F}(\underline{x}_0, \overline{x}_0, r) + p\underline{F}_{\underline{x}}(\underline{x}_0, \overline{x}_0, r) + q\underline{F}_{\overline{x}}(\underline{x}_0, \overline{x}_0, r) = \underline{c}(r)$$
$$\overline{F}(\underline{\lambda}, \overline{\lambda}, r) = \overline{F}(\underline{x}_0, \overline{x}_0, r) + p\overline{F}_{\underline{x}}(\underline{x}_0, \overline{x}_0, r) + q\overline{F}_{\overline{x}}(\underline{x}_0, \overline{x}_0, r) = \overline{c}(r). \qquad (9)$$

After little simplifications, (9) transforms to

$$J(\underline{x}_0, \overline{x}_0, r) \begin{pmatrix} p(r) \\ q(r) \end{pmatrix} = \begin{pmatrix} \alpha \\ \beta \end{pmatrix} \qquad (10)$$

where $\alpha = \underline{c}(r) - \underline{F}(\underline{x}_0, \overline{x}_0, r)$, $\beta = \overline{c}(r) - \overline{F}(\underline{x}_0, \overline{x}_0, r)$ and

$$J(\underline{x}, \overline{x}, r) = \begin{pmatrix} \underline{F}_{\underline{x}}(\underline{x}_0, \overline{x}_0, r) & \underline{F}_{\overline{x}}(\underline{x}_0, \overline{x}_0, r) \\ \overline{F}_{\underline{x}}(\underline{x}_0, \overline{x}_0, r) & \overline{F}_{\overline{x}}(\underline{x}_0, \overline{x}_0, r) \end{pmatrix}$$

hence , we have

$$\begin{pmatrix} p(r) \\ q(r) \end{pmatrix} = \begin{pmatrix} \alpha \\ \beta \end{pmatrix} J^{-1}(\underline{x}_0, \overline{x}_0, r). \qquad (11)$$

Finally, the proposed scheme is given as follow:

$$x_n(r) = x_{n-1}(r) + \begin{bmatrix} \alpha \\ \beta \end{bmatrix} J^{-1}(\underline{x}_0, \bar{x}_0, r) \qquad k = 1, 2, \ldots \tag{12}$$

where $x_n(r) = \begin{bmatrix} \underline{x}_n(r) \\ \bar{x}_n(r) \end{bmatrix}$ and $x_{n-1}(r) = \begin{bmatrix} \underline{x}_{n-1}(r) \\ \bar{x}_{n-1}(r) \end{bmatrix}$.

Now, we can describe the algorithm for our proposed method as follows:

Algorithm Chord

Step 1. Transform the fuzzy nonlinear equations into parametric form.

Step 2. Determine the initial guess x0 by solving the parametric equations for r = 0 and r = 1.

Step 3. Compute the initial Jacobian matrix

$J(\underline{x}_0, \bar{x}_0, r)$

Step 4. Compute

$$x_n(r) = x_{n-1}(r) + \begin{bmatrix} \alpha \\ \beta \end{bmatrix} J^{-1}(\underline{x}_0, \bar{x}_0, r) \qquad k = 1, 2, \ldots \tag{13}$$

Step 5. Repeat Steps from 3 to 4 and continue with the next k keeping Jacobian constant until tolerance ε ≤ 10−5 are satisfied.

5. NUMERICAL RESULTS

In this section, we consider two problems to illustrate the performance of Chord Newton's method for solving fuzzy nonlinear equations. The computations are done in MATLAB 7.0 using double precision computer. The benchmark problems are from [1,9,10].

Problem 1. Consider

$$(4,6,8)x^2 + (2,3,4)x - (8,12,16) = (5,6,7). \tag{14}$$

With out lost of generality, let x be positive, hence the parametric form of (14) is give as [4,6]:

$$\begin{aligned} (4+2r)\underline{x}^2(r) + (2+r)\underline{x}(r) - (8+4r) &= (5+r) \\ (8-2r)\bar{x}^2(r) + (4-r)\bar{x}(r) - (16-4r) &= (7-r) \end{aligned} \tag{15}$$

Therefore

$$\begin{aligned} \alpha &= (5+r) - (4+2r)\underline{x}^2(r) - (2+r)\underline{x}(r) + (8+4r) \\ \beta &= (7-r) - (8-2r)\bar{x}^2(r) - (4-r)\bar{x}(r) + (16-4r) \end{aligned} \tag{16}$$

and Jacobian is given as

$$J(\underline{x}, \bar{x}, r) = \begin{bmatrix} 2(4+2r)\underline{x}(r) + (2+r)(r) & 0 \\ 0 & 2(8-2r)\bar{x}(r) + (4-r) \end{bmatrix} \tag{17}$$

Hence, the Jacobian inverse is

$$J(\underline{x}, \bar{x}, r)^{-1} = \begin{bmatrix} \frac{1}{2(4+2r)\underline{x}(r) + (2+r)(r)} & 0 \\ 0 & \frac{1}{2(8-2r)\bar{x}(r) + (4-r)} \end{bmatrix} \tag{18}$$

To obtain the initial values, we set r = 0 and r = 1 in (15) respectively, hence

$$4\underline{x}^2(0)+2\underline{x}(0)-3=0. \tag{19}$$
$$8\overline{x}^2(0)+4\overline{x}(0)-9=0.$$

And

$$6\underline{x}^2(1)+3\underline{x}(1)-6=0. \tag{20}$$
$$6\overline{x}^2(1)+3\overline{x}(1)-6=0.$$

Moreover,(19) and (20) yields $\underline{x}(0) = 0.65139$, $\overline{x}(0) = 0.83972$ and $\underline{x}(1) = \overline{x}(1) = 0.78078$

Therefore, initial guess x0 = (x(0), x(1), x(0)). From our own observation, the x_0 is very close to the solution. Therefore, in order to illustrate the performance of our approach, we consider x_0 = (0.5098, 0.7598, 0.9).

Using, Algorithm Chord with x_0 = (0.5089, 0.7589, 0.9) by repeating 3 to 5 until stoping criterion is satisfies. It is worth to mention that, after four iterations with fixed Jacobian ($J(x_0, x_0; r)$) the solution was obtained with maximum error less than 10−5. We present the details of the solution for $\forall$ r $\in$ [0, 1] in Figure 1.

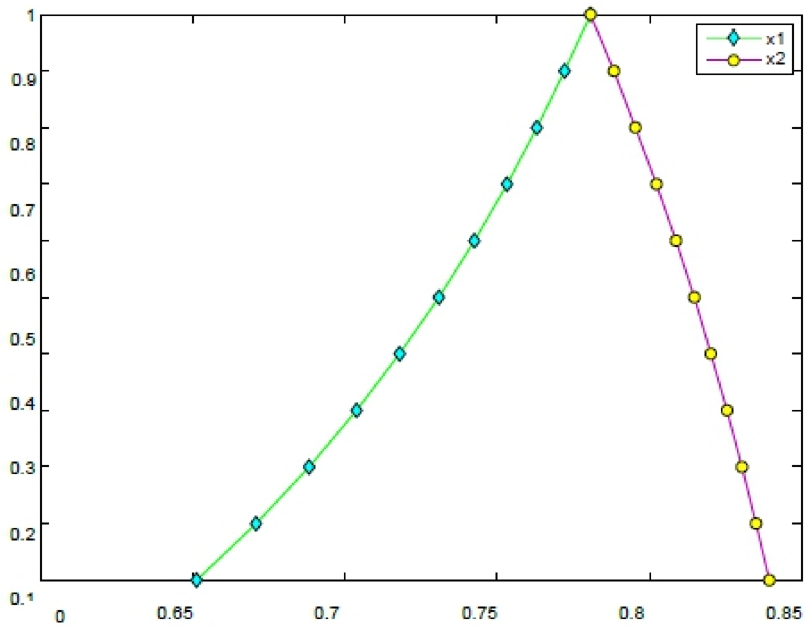

Figure 1. Positive Solution of Chord Newton's method for problem 1

Problem 2. Consider

$$(3,4,5)x^2+(1,2,3)x=(1,2,3). \tag{21}$$

With out lost of generality, let assume x is positive, then we have the parametric equation as [4,6]:

$$(3+r)\underline{x}^2(r)+(1+r)\underline{x}(r)=(1+r) \tag{22}$$
$$(5-r)\overline{x}^2(r)+(3-r)\overline{x}(r)=(3-r)$$

Therefore

$$\alpha=(1+r)-(3+r)\underline{x}^2(r)-(1+r)\underline{x}(r) \tag{23}$$
$$\beta=(3-r)-(5-r)\overline{x}^2(r)-(3-r)\overline{x}(r)-$$

We obtained the initial point by letting $r = 0$ in (22)

$$\begin{aligned} &3\underline{x}^2(0) + \underline{x}(0) - 1 = 0. \\ &5\overline{x}^2(0) + 3\overline{x}(0) - 3 = 0. \end{aligned} \qquad (24)$$

For $r = 1$ we have

$$\begin{aligned} &4\underline{x}^2(1) + 2\underline{x}(1) - 2 = 0. \\ &4\overline{x}^2(1) + 2\overline{x}(1) - 2 = 0. \end{aligned} \qquad (25)$$

Therefore, $\underline{x}(0)=0.4343$, $\overline{x}(0)=0.5307$ and $\underline{x}(1)=\overline{x}(1)= 1$, hence, the initial guess $x_0 =(\underline{x}(0), \underline{x}(1), \overline{x}(0))$ that is, $x_0 =(0.4343, 1, 0.5307)$.

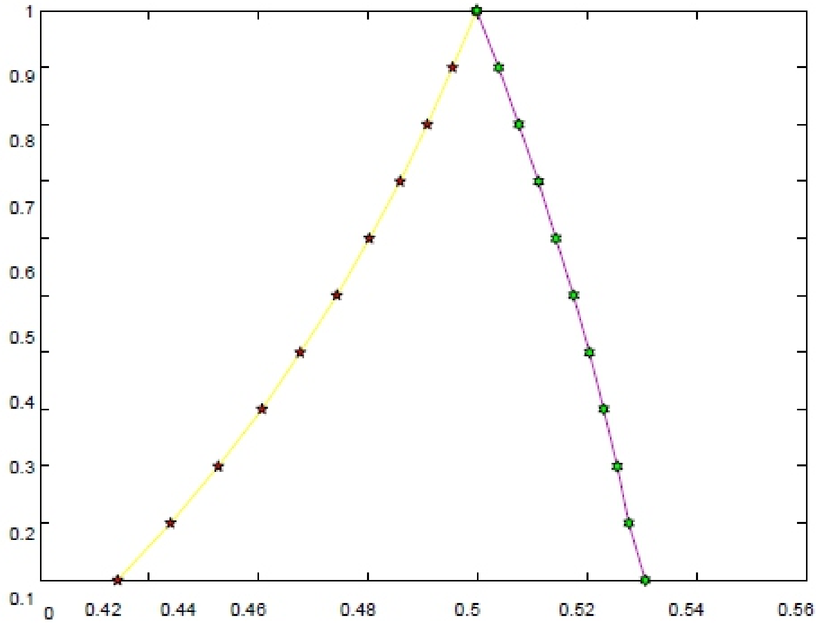

Figure 2. Positive Solution of Chord Newton's method for problem 2

Figure 1 and 2 demonstrates the efficiency of our approach on solving fuzzy nonlinear equations. Furthermore, the convergence rate is promising when ever the initial guess is close to the solution due to the fact that Chord Newton is a local method.

6. CONCLUSION

In this paper, we present a new iterative approach for solving fuzzy nonlinear equations. The scheme saves a lot the computational burdens of the Jacobian matrix. The fuzzy nonlinear equations are written in parametric form and then solved via Chord method. Numerical testing provides strong indication that in all the tested problems, our approach is very encouraging . Hence we can claim that, our approach is a good alternative for solving fuzzy nonlinear equations.

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ISSN Application No. 21825

Downrange Constrained Gravity Turn Guidance for Lunar & Mars Landing

[1] Ijaj Ahmed, [2] Sugandha M, [3] Rijesh M. P., [4] Chinna Ponnu V, [5] Philip N K
[1,2,3,4,5] Scientist /Engg, U R Rao Satellite Centre, Bengaluru, India
E-mail: [1] ijaj@isac.gov.in, [2] sugandha@isac.gov.in, [3] rijesh@isac.gov.in, [4] chinna@isac.gov.in, [5] philip@isac.gov.in

ABSTRACT

Gravity Turn guidance during Lander descent ensures that the thrust vector is always opposite to the velocity vector. By formulation, a thrust to mass ratio can be solved for and applied in real time, which would ensure that Lander reaches the specified altitude with zero velocity. Lander will naturally be vertically oriented at the end. However, the downrange travelled is unconstrained and a free parameter. This paper proposes a scheme to modify the existing guidance law so as to ensure that the Lander travels required downrange. Philosophically, if the thrust angle is slightly modulated for some time from its anti-velocity angle, resultant downrange will be different. The modulation can be on both sides of the anti-velocity vector. Technically this idea is made use to augment the guidance law and get the desired downrange. During ground planning, a time span within the total gravity turn descent can be appropriately selected and the additional thrust angle can be fixed to get a particular downrange. This sensitivity study can be repeated for various downrange. The data set so created can be used to carry out a polynomial fit of downrange versus the thrust angle modulation. The fit can be implemented onboard and used in real flight for having a downrange constrained Gravity Turn descent. Simulation results for typical Mars powered descent and lunar terminal descent have proved the efficacy of method adopted.

Keywords - Gravity Turn; Powered Descent; Guidance Law; Lander

I. INTRODUCTION

Typical powered descent on a planetary surface involves breaking the current velocity that the Lander has at current altitude and reach just above the safe landing site with zero velocity which will be followed by the final powered vertical descent and touchdown. It the responsibility of onboard guidance algorithm to generate steering commands to ensure soft touchdown. During powered descent, the guidance algorithm will generate command for modulation in thrust of onboard engine and well as the orientation of thrust vector with respect to local vertical. There are many varieties of planetary descent guidance laws. A fuel optimal analytical guidance law by the name Constrained Terminal Velocity Guidance (CTVG) is discussed in [1] which makes use of principles of optimal control theory. However, terminal angle is not constrained in this algorithm. Apollo based polynomial guidance algorithm is discussed in [2] and [7]. Flatness based guidance law which also makes use of polynomials has been introduced in [3]. Descent problem with fixed thrust engine has been optimally done in [4] by stating the performance index as minimum time problem. Optimal solution is obtained as a tangent law which has been further approximated and solved through Non-Linear Programming. A geometrical method based guidance law is dealt with in [5]. Path Shaping Guidance [6] deals with gravity turn concept. Unlike Polynomial Guidance or other Optimal guidance laws, an advantage of gravity turn guidance is that there will not be any sharp changes in reference thrust from onboard engine during the process of thrust always braking velocity by being opposite to it. An added advantage is that the terminal orientation naturally comes to zero degree with respect to local vertical. However, downrange is free parameter in this guidance law.

Section II of this paper introduces original gravity turn guidance law [6]. Section III proposes the augmentation in Gravity Turn guidance so as to meet the downrange constraint requirement. Section IV goes through simulations and results.

II.ORIGINAL GRAVITY TURN GUIDANCE

An approximate set of equations of motion for descent gravity turn guidance are given based on Fig.1

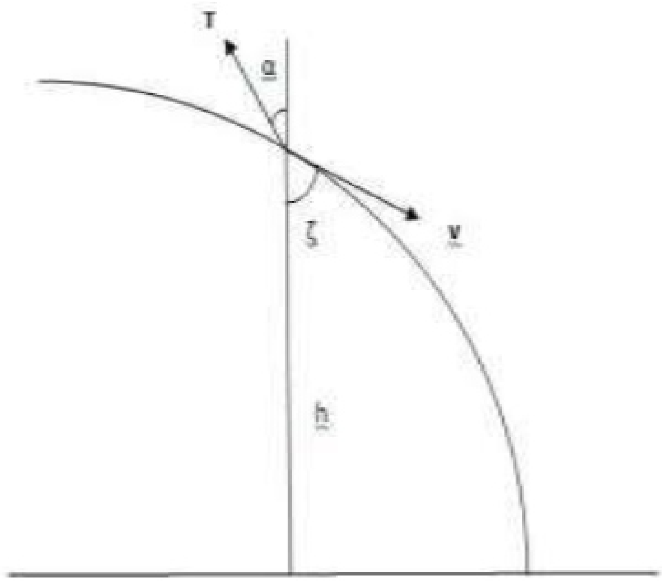

Fig 1. Lunar/Martian descent geometry

The gravitational acceleration is taken constant in magnitude and acting vertically downwards.

Equations of motion [6] are

$$v = -ng \cos \zeta - \alpha + g\cos\zeta \quad 1$$

$$v\zeta = ng \sin \zeta - \alpha - g\sin\zeta \quad 2 \quad h$$

$$= -v\cos\zeta \quad 3$$

The Lander module is having velocity v and altitude h above the lunar/Martian surface. The velocity vector has angle ζ from local vertical and thrust vector aligned at angle α with respect to local vertical and opposite to velocity vector.

Here, $n = \frac{T}{mg}$, where T is the engine thrust in N and m is the mass in Kg.

Under gravity turn condition, $\zeta = \alpha$

Thus, above set of equations can be reduced and ζ can be independent variable. Thus the following equations can be obtained [6]

$$\frac{1}{v}\frac{dv}{d\zeta} = n\,\mathrm{cosec}\,\zeta - \cot\zeta \qquad (4)$$

$$\frac{dh}{d\zeta} = \frac{v^2}{g}\cot\zeta \qquad (5)$$

$$\frac{1}{v}\frac{dt}{d\zeta} = -\frac{1}{g}\mathrm{cosec}\,\zeta \qquad (6)$$

Equations (4), (5) & (6) can be integrated to find time of travel tgo and thrust factor „n". Final height h can be constrained to a value (hf). A typical gravity turn descent has the property that at final time v → 0 and ζ→0 so that final descent is vertical. Then the required thrust-to-weight ratio can be obtained as [6]

$$n^2 - \frac{v_0^2}{2g(h_0 - hf)}\cos\zeta_0\, n - \frac{v_0^2}{4g(h_0 - hf)}\left(1 + \cos^2\zeta_0\right) + 1 = 0 \qquad (7)$$

Here v_0 is initial velocity, h_0 is initial height and ζ_0 is the initial flight path angle. The time tgo can be calculated [6] using

$$tgo = \frac{v_0\cos^2\frac{\zeta_0}{2}}{g\,(n+1)}\left[\sec^2\frac{\zeta_0}{2} + \frac{2}{n-1}\right] \qquad (8)$$

III. PROPOSED GUIDANCE AUGMENTATION

Carry out the ground simulations for a specified initial and final condition as follows:

1) Find out the initial estimate on mission time (tgo) and within the mission time, select a time interval $\{t_1, t_2\}$ for tgo.
2) At every guidance cycle, solve for Equation (7) and Equation (8).
3) In case tgo is outside the time interval $\{t_1, t_2\}$, impose on thrust vector angle $\alpha = \zeta$ which makes it normal gravity turn descent. However, if tgo within the time interval $\{t_1, t_2\}$ select $\alpha = \zeta + \Delta\alpha$
4) Obtain sensitivity on downrange due to Δα by carrying out multiple simulations with different Δα on either side of ζ
5) Perform a polynomial curve fit on Δα and downrange. Implement this fit onboard for the real flight.

IV.SIMULATIONS AND RESULTS

Simulation studies were carried out for a Mars Landing as well as Lunar landing scenario.

[1] Lunar Descent with Constrained Gravity Turn

- Initial Mass = 623kg
- Engine Thrust = 1600N (max)& 640 (min)
- Engine specific Impulse = 312 sec at 1600N
- Engine specific Impulse = 285 sec at 640N
- Initial Altitude = 5900m
- Final Altitude = 100m
- Initial Velocity = 145.6 m/s
- Final Velocity = 0 m/s
- Initial ζ = 74 deg
- Lunar gravity acceleration = 1.62 m/s2

Under normal gravity turn simulation (without augmentation), the downrange covered was 5400 m with time span of 145.5 seconds. The time interval $\{t_1, t_2\}$ on tgo selected for augmentation is $\{120, 48\}$. Ground curve fit yielded the following equations between $\Delta\alpha$ in degrees and downrange (D) in metres.

For Downrange which has to be ahead of 5400m,

$$\Delta\alpha = 0.06775D^5 - 0.564D^4 + 2.21D^3 - 6.73D^2 + 23.77D - 9.2$$

Here, downrange has been shifted by -5000m for curve fit.

For Downrange which has to be behind 5400m,

$$\Delta\alpha = -65.08D^5 + 335.11D^4 - 684.72D^3 + 704.73D^2 - 395.8D + 115.13$$

Here, downrange has been shifted by -4000m for curve fit.

Simulation results are shown from Fig.2 to Fig. 7.

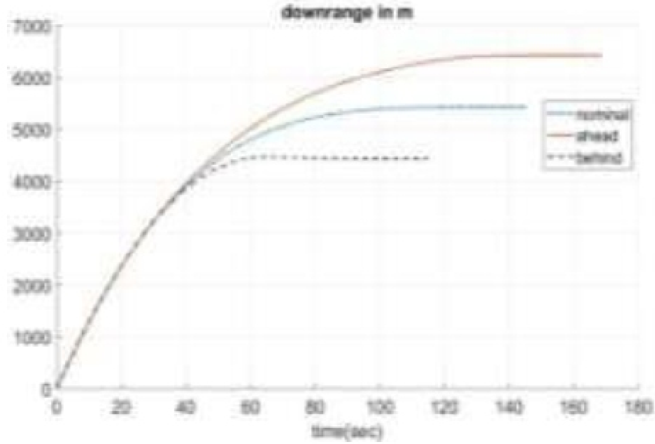

Fig. 2 Downrange Variation (Lunar)

It needs to be observed from Fig.2 that, through curve fit, it has been possible to change the downrange travelled by 1km behind and 1km ahead than the nominal value. Fig.3 shows the corresponding time- to-go variation. It is clear from Fig.4 that for lagging behind, thrust vector angle has to be more than nominal and for going further ahead, it needs to be lesser than the nominal value. Fig. 5 projects thrust variation. Fig.6 and Fig.7 shows convergence in velocity and altitude respectively.

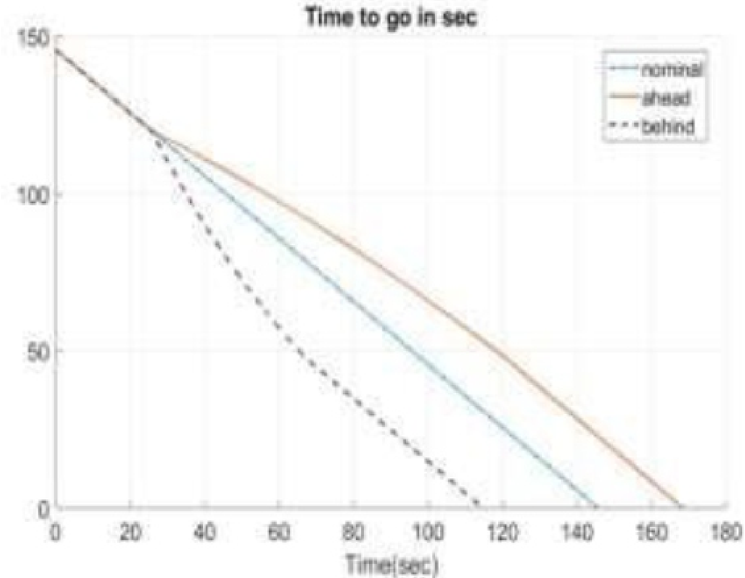

Fig. 3 Time-to-go variation (Lunar)

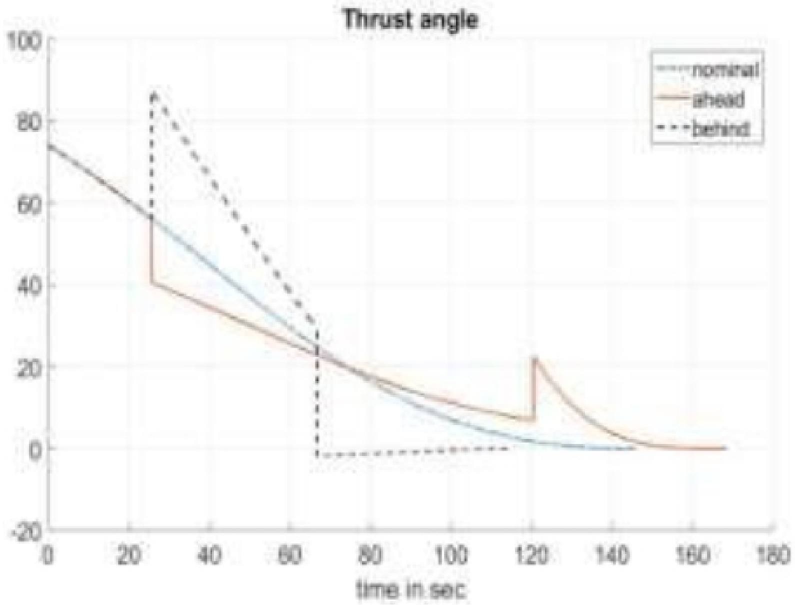

Fig. 4 Thrust Angle Variation (Lunar)

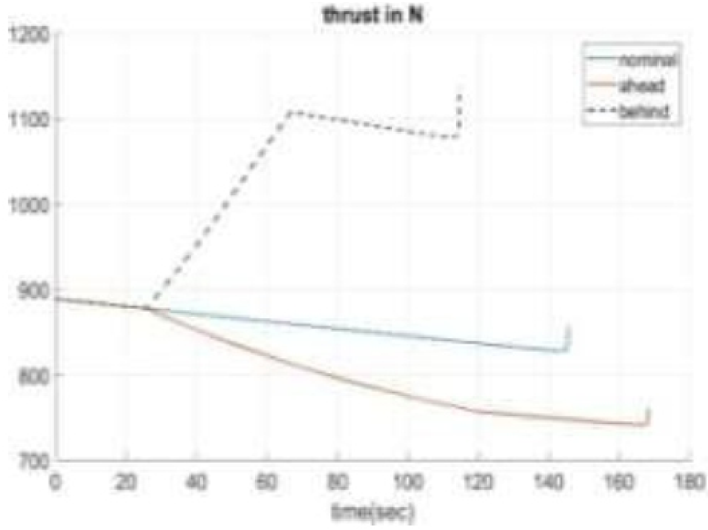

Fig.5 Thrust Variation (Lunar)

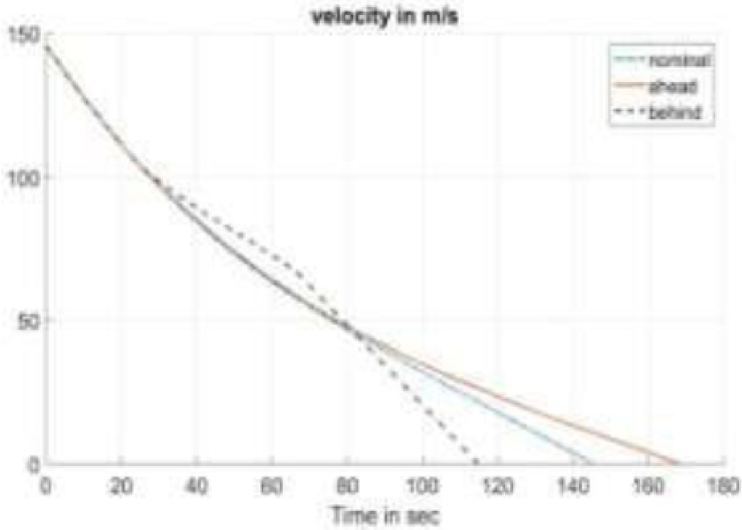

Fig. 6 Velocity Profile (Lunar)

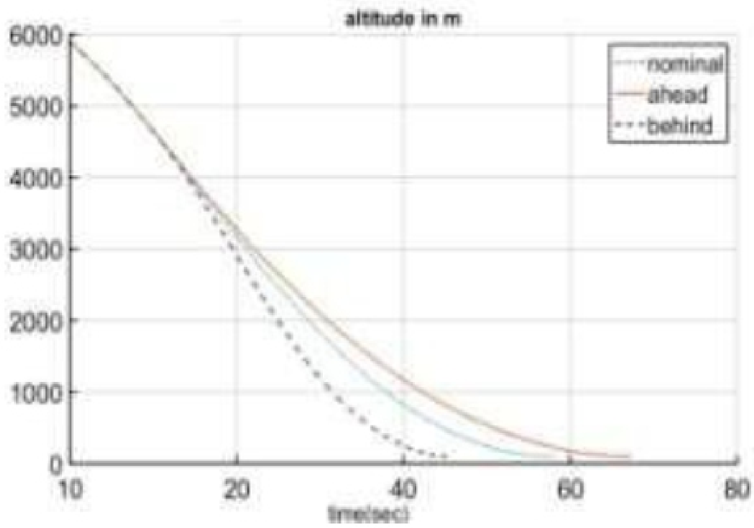

Fig.7Altitude Variation (Lunar)

[2] Mars Descent with Constrained Gravity Turn

- Initial Mass = 800kg
- Engine Thrust = 5300N (maximum)
- Engine specific Impulse = 252.3759 sec
- Initial Altitude = 4000m
- Final Altitude = 50m
- Initial Velocity = 124 m/s
- Final Velocity = 0 m/s
- Initial ζ = 53.4 deg
- Mars gravity acceleration = 3.711 m/s^2

Under normal gravity turn simulation (without augmentation), the downrange covered was 1804 m with time span of 83 seconds. The time interval $\{t_1, t_2\}$ on tgo selected for augmentation is $\{80, 25\}$. Ground curve fit yielded the following equations between $\Delta\alpha$ in degrees and normalized downrange (D) in metres.

For Downrange which has to be ahead of 1804m,

$$\Delta\alpha = -100D^4 + 410D^3 - 560D^2 + 380D - 5^2$$

Here, downrange has been normalized by 10000.

For Downrange which has to be behind 1804m,

$\Delta\alpha = -160D^4 + 460D^3 - 530D^2 + 330D - 100$

Here, downrange has been normalized by 2000.

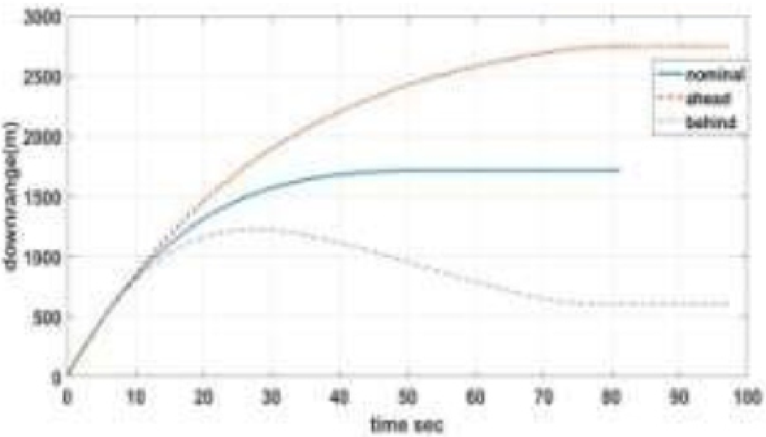

Fig.8 Downrange Variation (Mars)

It needs to be observed from Fig.8 that, through curve fit, it has been possible to change the downrange travelled by about 1km behind and 1km ahead than the nominal value. Fig.3 shows the corresponding time-to-go variation. It is clear from Fig.4 that for lagging behind, thrust vector angle has to be more than nominal and for going further ahead, it needs to be lesser than the nominal value. Fig. 5 projects thrust variation. Fig.6 and Fig.7 shows convergence in velocity and altitude respectively.

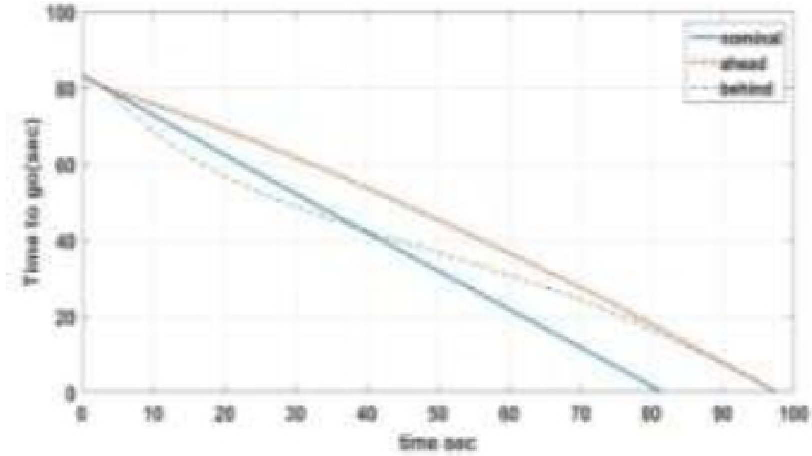

Fig.9 Time-to-go Variation (Mars)

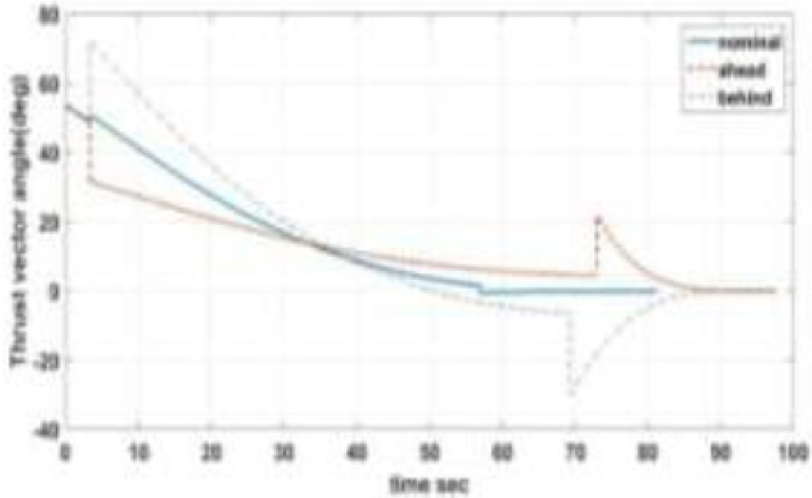

Fig.10 Thrust Vector Variation (Mars)

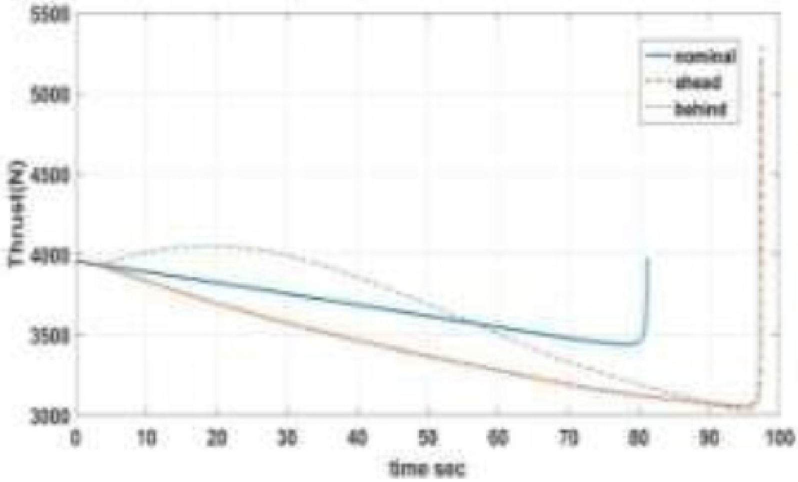

Fig.11 Thrust Variation (Mars)

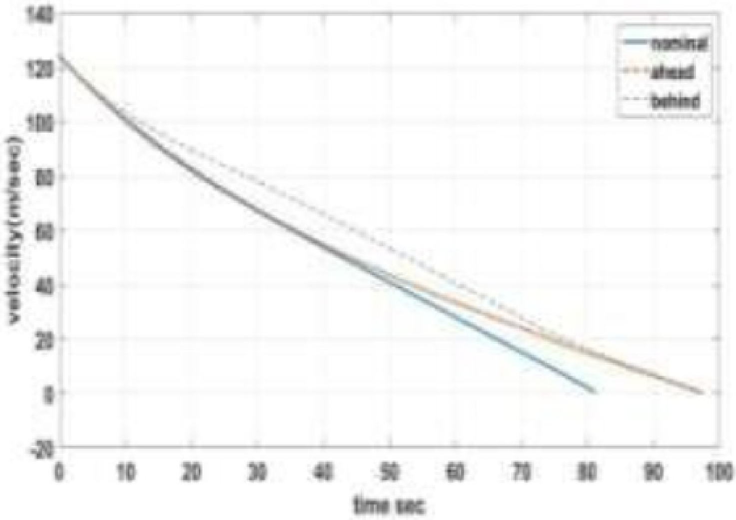

Fig. 12 Velocity Profile (Mars)

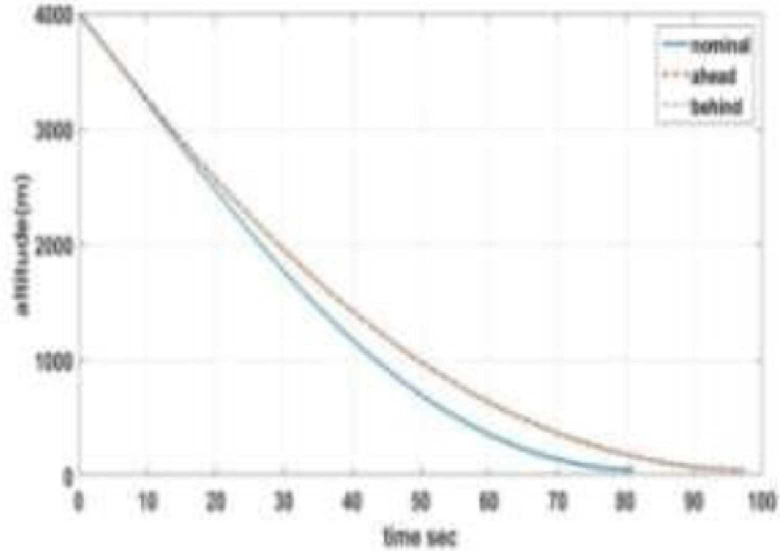

Fig.13 Altitude Profile (Mars)

CONCLUSIONS

A Gravity Turn guidance law meant for powered descent on planetary surface was successfully augmented to meet the downrange constraint, which otherwise was a free parameter. Strategically, a slight change in thrust vector from its nominal anti-velocity orientation for a specified duration can influence the downrange travelled. Sensitivity studies in this regard has to be carried out on ground to arrive at the time span and the thrust angle modulation for different downrange that needs to be covered in real flight.A suitable fit on downrange with additional thrust angle needs to be put onboard for use in real flight. Based on downrange requirement, the incremental change in thrust vector will be computed in real time and enforced on the gravity turn guidance. It was observed that the original features of the Gravity Turn guidance were not lost in the process.

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ISSN Application No. 21825

Local Gravitoelectromagnetic Effects Inside A Metallic Liquid

A Iadicicco
Independent Researcher - Italy
E-mail: iadiciccoantonio3@gmail.com

ABSTRACT

Under specific conditions the fast rotation of a metallic liquid inside a toroidal chamber could produce an gravitoelectromagnetic field measurable in laboratory. Analogies between superconductors and moving metallic liquids. A metallic liquid flowing in a channel produces electromagnetic fields likely a rotating superconductor which produces a weak magnetic field. Such similitude is as much closer as higher the fluid speed is. That is due to a higher transport of magnetic force lines concerning conductor liquids. Furthermore it is interesting to note that the freezing effect of force lines is verified under infinite conductivity condition.

Keywords - METALLIC LIQUID, Gravitomagnetic field

I. INTRODUCTION

Tajmar and others have proved the presence of gravitomagnetic field and induction acceleration fields in a rotating superconductor. Agop and Podkletnov have studied the superconductor electromagnetic and gravitomagnetic field properties referring to the generalization of Maxwell and London equations. Other authors like Cerdonio and Tajmar have supposed that inside a rotating superconductor a gravitational angle of classic London's moment –gravitomagnetic London's moment– should manifest in order to explain the discrepancy between the Cooper-pair mass theoretically expected for Niobium and its experimental value registered by Tate. The author's hypothesis is that in addition to a classic electromagnetic field produced by a turbulent movement of metallic liquid, another similar gravitomagnetic (field) should appear –by analogy with superconductors – as an interpretation of generalization of Maxwell's equations.

II.GRAVITOMAGNETIC EFFECT

A rotating superconductor produces an magnetic field (London's moment). The London's moment derived from canonical moment quantization is :

$$B= - 2m^*/ e^* \omega$$

Where m* and e* respectively indicates the mass and the charge of Cooper pair.

By measuring an magnetic field and the angular speed of the superconductor the Cooper pairs mass can be calculated.

During a highly-accurate test, Tate and others registered a discrepancy between the Cooper-pair mass theoretical expected for $m^*/2me = 0.999992$ Niobium and its 1.000084 experimental value, where me is the electron mass. Tajmar and others have suggested that in addition to the classic London 's moment, a similar gravitational exists. The so-called gravitomagnetic London's moment could explain Tate's measurements.

$$B = - 2m^*/e^* \omega - m^*/e^* Bg ,$$

Where Bg is the gravitomagnetic field According to the gravitational induction law,

$$\text{rot } g = - \partial Bg/\partial t \text{ ------------------ >}$$

Generalized Maxwell's equation on applying an angular acceleration to a superconductive ring (Niobium) Tajmar and Clovis J. De Matos have obtained a non Newtonian gravitational field, opposite to a Newtonian divergent field, which is generated along the tangential direction (azimuth plan):

$$\text{that is } g = - Bgr/2 \varphi$$

Where r is the radial distance from superconductor, φ is the azimuth unit value and g is measured as the earth's standard acceleration unit.

The gravitational field, according to the induction law, should point to the opposite direction of the applied tangential angular acceleration.

That phenomenon has been actually observed, and induced acceleration fields external to the superconductor have been found in the order of nearly 100μg.

Magneto fluid dynamic System and Gravitoelectromagnetic Field

Inside conductor liquids, electric and magnetic fields are generated by fluid motion, so in addition to hydrodynamic variables other electrodynamics terms should appear.

If the speed u, at which the magnetic field moves, coincides with the local speed of fluid v (when u=v) then, the magnetic flux, linked with any closed line which moves at the same local fluid speed, is constant. That means that the force lines are frozen inside the fluid and carried by it.

It's useful to introduce the magnetic Reynolds' number Rm to distinguish the situations in which force lines' diffusion occurs from those ones in which a dragging takes place.

$$Rm = V\tau/L$$

Where V is a characteristic speed of the matter, L is its length and τ is the time of diffusion.

If Rm >> 1 force lines dragging takes place. Example about orders of magnitude.

If we consider mercury we see the following features:
σ=9.4 · 10^15 s^-1 (conductibility)
ρ=13.5 g/cm^3 (density)

therefore the time of diffusion for the Hg is:

$$\tau = 4\pi\sigma/c^2 \cdot L^2 = 1.31 \cdot 10^{-4} [L(cm)]^2 \text{ s}$$

and the magnetic Reynolds' number is:

Rm= V ϒ/Λ ϒ 10^-4 [V(cm/s)]

Laboratory results show that as for mercury there isn't a sensible dragging of the force lines. That only happens at very high speed of efflux conditions.

The scale of length related to geophysical and astronomic matters is Rm>>1 and the dragging phenomenon concerning force lines is important.

Finally it results:

1. In laboratory: mercury and liquid sodium Rm < 1 except at high speed
2. Geophysical and astrophysics applications Rm >> 1.

When the moving speed is similar to the one of sound, a reasonable dragging effect concerning force lines of the magnetic field in liquid conductors like liquid sodium or mercury will be verified.

In those conditions the conducting matter at liquid state, can generate a sensible gravitoelectromagnetic effect when electromagnetic fields exist.

When the four-dimensional space-time is divided in “space” plus “time” (3+1), the electromagnetic field is divided into two parts, the electric field ge and the magnetic field Be. These fields satisfy the equations of Maxwell.

The general relativistic gravitational field is divided, similarly to the previous one, into three parts

- **A part with electrical function – electric like -** whose gradient for weak gravity is Newtonian acceleration g*
- **A part with magnetic function - magneticlike -** whose curve for weak gravity is the gravitomagnetic field Bg
- A metric spaces, whose tensor of curving is `the space curve’

According to the superposition principle, we can introduce generalized fields:
g= g* + q/m ge ,
B=Bg + q/m Be
q and m are respectively charge and mass of the electron

Those fields satisfy the generalized Maxwell’s equations.

CONCLUSIONS

Finally an experimental device realization could be carried out, in order to satisfy the considerations previously described. It might be realized as a rotating metallic liquid inside of a toroidal channel with high movement speed, suited to the generation of a gravitoelectromagnetic field. We can theoretically obtain, therefore, an interpolation between a gravitoelectromagnetic complex system and a magnetofluidynamic one whose variables are exactly the electromagnetic fields and those connected gravitomagnetic ones.

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