JOURNAL OF CRITICAL REVIEWS

ISSN- 2394-5125 VOL 6, ISSUE 07, 2019

Dim Wolf analyzer method for two-terminal HVDC frameworks ideal power stream

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Abstract. *Using published findings from other optimization approaches, the suggested algorithm's reliability is proved. It has been shown that compared to other optimization strategies, the GWO algorithm may achieve significantly reduced CPU time and total cost. The GWO algorithm is proven to be effective by this conclusion. As compared to GA, BSA, ABC, and NRM with quicker convergence, GWO had lower overall costs and CPU time. There are OPF equality and inequality restrictions in pure AC power systems. Integrated AC-DC power systems is addressed using a mechanism known as GWO, which includes HVDC connections and regulates power transmission. Design and behavior of this algorithm was inspired by wild grey wolves. The proposed technique is tested using a WSCC 9-bus test system and modified 5-bus and.*

1. Introduction

AC electricity is converted to DC by an inverter station in a transmission system for high-voltage direct current (HVDC) power. Electrical power that has been sent is converted back to AC by a rectifier once it is received. In a back-to-back HVDC system, the converters are connected in series, whereas in a long-distance transmission line or an un-derground cable, the converters are connected in parallel. It is optimal to use HVDC systems as a supplement to current AC power systems. Utilizing HVDC systems has a number of advantages, including the ability to transmit electrical power over long distances in an environmentally friendly and efficient manner, the ability to connect networks that operate at different frequencies, the ability to control the direction of power flow, and the ability to access onshore and offshore renewable energy generation sources [2].

The first commercial application of HVDC transmission between the Swedish mainland and Gotland was said in literature to have happened in 1954, when mercury-arc valves were in use. When it comes to AC power systems, OPF is defined by equations that are neither linear nor convex. Preliminary characteristics of the intended system alterations need to be determined via feasibility studies... More in-depth investigations are required to take into account data from power flow and other parameters. To ensure that the HVDC plant is effectively integrated into the electrical grid, operational studies are required [4]. OPF is less complicated but still nonlinear if reactive power is not utilised. Nonlinear equations may be solved using a variety of techniques.

Automation of two-area power systems using PI controllers was used in 2010 to deal with economic emission dispatch problems [8, 9]. For smart grids, GWO has been utilized in recent years to predict the parameters of the PI controller to avoid blackouts. [2 and 3] The

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ISSN- 2394-5125 VOL 6, ISSUE 07, 2019

OPF issue [2 and 3] and load frequency management of connected power systems [4] have all been handled using it. The use of wide-area power system stabilizers has also proved advantageous. Multi-area thermal power systems' automated generation management may benefit from the SSSC (Static Synchronous Series Compensation) technology's ability to reduce oscillations across regions [6]. Using GWO, two-terminal HVDC OPF is possible. On modified 5-bus and WSCC 9-bus system testing, the algorithm's potential is tested. Backtracking Search Algorithm [4], Artificial Bee Colony [12], Genetic Algorithm [3], and Newton-Raphson Method [7] are used to assess the recommended algorithm's validity and efficacy.

1. Two-Terminal HVDCModeling

A two-terminal HVDC transmission connection basic schematic design is shown in Fig. 1.

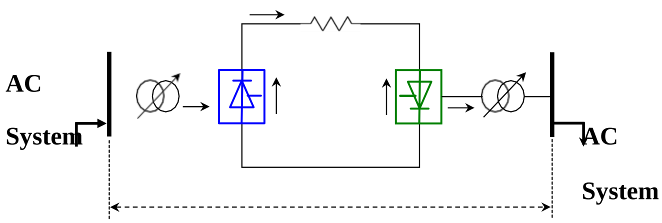


Fig. 1: A two-terminal HVDC transmission connection is shown in this simple schematic illustration.

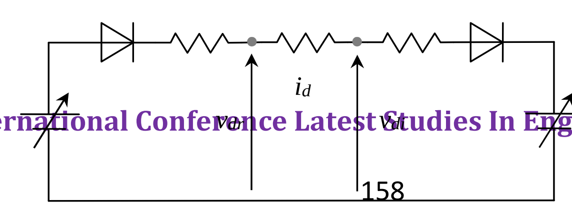
Figure 1 depicts the converter transformer primary AC voltages (rms), as well as the rectifier and inverter's AC current flows. The bus voltage phase angle (r) and the current phase angle (r and I) as well as the DC link resistance may be calculated using these formulae. r (rdc). Id, or inductance, is equal to the product of the inductances and active and reactive powers for each of the rectifier and inverter components of a direct current HVDC connection, respectively. Using the rectifier terminal as a starting point, we may construct four basic converter equations:

$$v_{dor} = k \cdot t_r \cdot v_r, \qquad (1)$$

$$v_{dr} = v_{dor} \cos\alpha - r_{cr} \cdot i_d, \qquad (2)$$

$$p_r = v_{dr} \cdot i_d, \qquad (3)$$

$$\varphi = \cos^{-1} \frac{v_{dr}}{\;}, \qquad (4)$$



$k{\cdot}t_r{\cdot}v_r{\cdot}\cos\alpha$ $k{\cdot}t_r{\cdot}v_r{\cdot}\cos\alpha$

Fig. 2: One way HVDC connection with two terminals comparable circuitry

1. Constraints and Problem Definition

The OPF is a mathematical optimization problem with the following equations:

$$\text{Minimize } f(x,u). \quad (12)$$

$$\text{Subject to: } g(x,u) = 0,$$

$$h(x,u) \leq 0. \quad (13)$$

Control Variables

A good rule of thumb is to use variables that are identical to those found in the problem being studied. Different variables are utilized for the AC and DC system states of each individual unit:

$$x = [x_{AC}, x_{DC}], \quad (14)$$

Objective Function

Lowering the total production costs of a power system is essential (Fcost). That is to say, the objective is to minimize the quantity of energy that is wasted across the system as a whole. Under conditions of equality and inequality, the whole system's objectivity suffers.

Best replies are preserved in GWO and other search agents are encouraged to update their positions based on their position as a result. There are four wolf groups: beta (β), delta (δ) and omega (ω), alpha (α),. When designing the GWO algorithm, these groups must be taken into account.

They're known as and after the first three best solutions were found. How to update the positions of, as shown in Figure 4, in the two-dimensional space is shown in Figure 4.

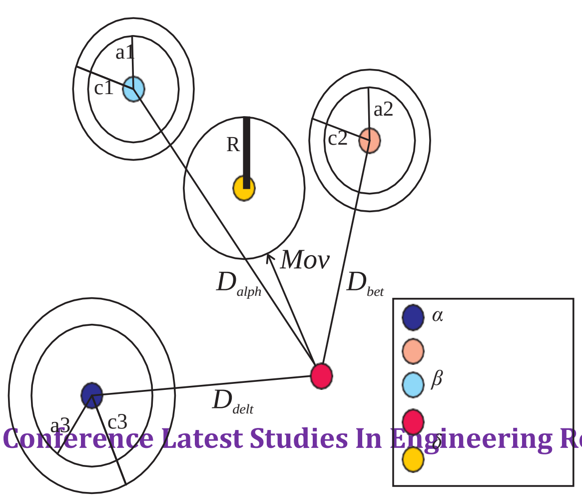


Fig. 4: Position updating in GWO [8].

4. Simulation Results

Two test systems were used to demonstrate that a two-terminal HVDC system's OPF problem can be solved using the GWO technique provided here. There are 100 iterations of the algorithm for each of the two systems tested, and the application is running in the computer's memory with 4GB of RAM and the processor at 2.1GHz on an Intel Core i3-5010U.

AC power flow algorithm uses Newton-Raphson approach, whereas DC uses linear current-balancing method.

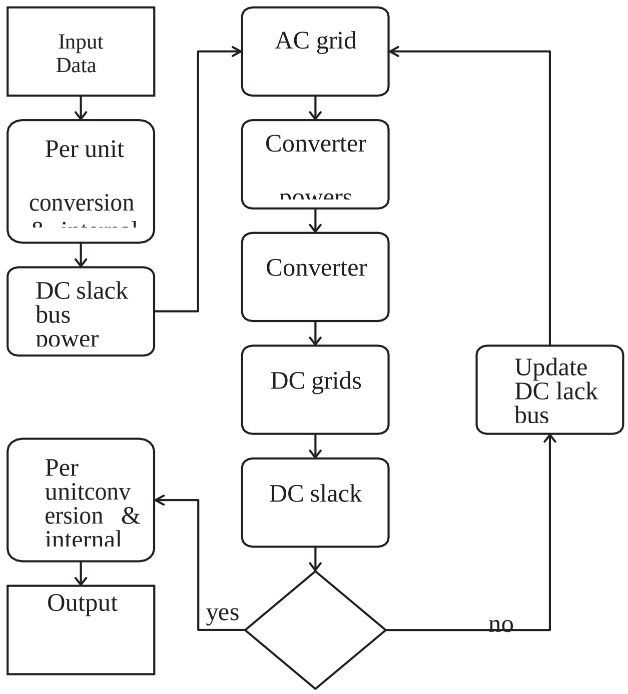
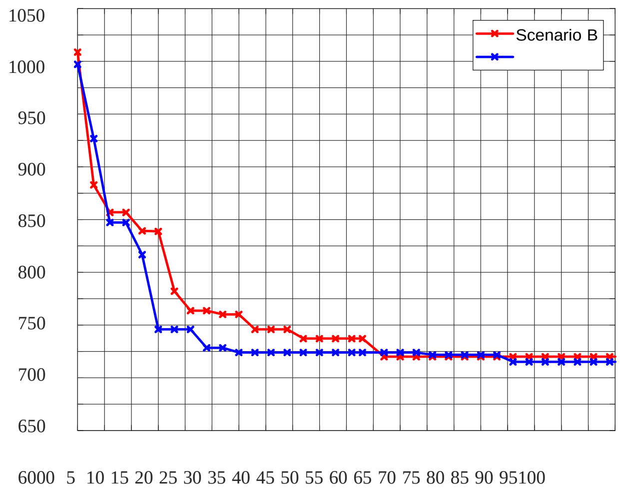


Fig. 5: VSC AC/DC power transfer algorithm flow diagram

As a result of the lower DC current, the number of repeats in Scenario A is less than in Scenario B.Figure 7 shows the GWO optimization method's convergence characteristics for the first two case studies.

ISSN- 2394-5125 VOL 6, ISSUE 07, 2019



Tab. 1: Simulation results for the NRM and GWO algorithms in Scenario A.

Variable	Limit (p.u.)		NRM [7]	GA [13]	BSA [14]	ABC [12]	GWO
	Min	Max					
Generator Active Outputs 1							
p_{g1}	0.10	2.00	0.8012	0.7946	0.8001	0.7932	0.8030
p_{g2}	0.10	2.00	0.8794	0.8854	0.8805	0.8874	0.8702
Generator Reactive Outputs2							
q_{g1}	−3.01	3.04	0.2029	−0.1403	−0.1503	−0.1397	−0.1499
q_{g2}	−3.03	3.02	0.0315	0.0649	0.0742	0.0863	0.0743
Nodal Voltages2							
v_1	0.91	1.11	1.109	1.0996	1.1000	1.1000	0.9975
v_2	0.92	1.11	1.100	1.0941	1.0950	1.0946	1.0932
v_3	0.89	1.11	1.071	1.0686	1.0692	1.0686	1.0706
v_4	0.90	1.11	1.075	1.0772	1.0781	1.0756	1.0819
v_5	0.92	1.11	1.071	1.0718	1.0727	1.0716	1.0743
DC System							
p_{dr}	0.11	0.15	0.1371	0.1493	0.1499	0.1458	0.1321
p_{di}	0.09	0.15	0.1371	0.1492	0.1499	0.1457	0.1321
q_{dr}	0.08	0.10	0.0230	0.0277	0.0279	0.0330	0.0264
q_{di}	0.098	0.10	0.0389	0.0409	0.0407	0.0575	0.0421
i_d	0.111	0.10	0.1000	0.1000	0.1000	0.1000	0.1000
t_r	0.901	1.10	0.940	1.0525	1.0566	1.03591	1.0532
t_i	0.921	1.10	0.962	1.0640	1.0673	1.0788	1.0701
α (°)	10	20	10.839	10.3995	10.2856	12.5486	10.3481
γ (°)	15	25	16.735	15.2674	15.1004	21.4680	16.0023
v_{di}	1.00	1.50	1.337	-	1.4999	-	1.4037
v_{di}	1.00	1.50	1.336	-	1.4996	-	1.4037

Tab. 2: Simulated outcomes for the BSA, ABC and NRM algorithms are shown in Scenario B. This is the first instance of a case study.

Variable	Limit (p.u.)		GWO	GA [13]	BSA [14]	ABC [12]	NRM [7]
	Min	Max					
Generator Active Outputs							
p_{g1}	0.11	2.00	0.7099	0.8101	0.8012	0.7979	-
p_{g2}	0.11	2.00	0.8711	0.8708	0.8795	0.8828	-

Generator Reactive Outputs							
q_{g1}	−3.01	3.00	−0.1353	−0.1889	−0.1376	−0.2426	-
q_{g2}	−3.10	3.00	0.0916	0.1426	0.0903	0.1882	-
Nodal Voltages							
v_1	0.90	1.10	1.1000	1.0994	1.1000	1.1000	-
v_2	0.91	1.10	1.0951	1.0967	1.0949	1.1000	-
v_3	0.92	1.10	1.0732	1.0674	1.0667	1.0697	-
v_4	0.91	1.10	1.0942	1.0795	1.0775	1.0832	-
v_5	0.90	1.10	1.0819	1.0744	1.0725	1.0779	-
DC System							
p_{dr}	0.15	0.225	0.1956	0.1941	0.1913	0.1928	0.1945
p_{di}	0.15	0.225	0.1941	0.1940	0.1912	0.1927	0.1944
q_{dr}	0.0	0.10	0.0387	0.0370	0.0360	0.0363	0.0443
q_{di}	0.0	0.10	0.0672	0.0611	0.0603	0.0571	0.0588
i_d	0.15	0.15	0.1500	0.1500	0.1500	0.1500	0.1500
t_r	0.90	1.10	0.9051	0.9138	0.9009	0.9055	-
t_i	0.90	1.10	0.9281	0.9302	0.9187	0.9161	-
α (°)	10	20	10.1147	10.5539	10.2160	10.2463	-
γ (°)	15	25	16.3271	17.4056	17.3566	16.3448	-
v_{di}	1.00	1.50	1.2644	-	1.2754	-	-
v_{di}	1.00	1.50	1.2681	-	1.2749	-	-

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Conclusion

An OPF issue in two-terminal HVDC transmission power system is dealt with using the GWO technique. The algorithm was tested on five and nine-bus HVDC test systems to see whether it was effective.

In comparison to other optimization algorithms, such as BSA, NRM, ABC and GA the GWO technique lowered overall expenses and CPU time while also achieving a quicker rate of convergence.

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