Optimization of detection of a single line to ground fault based on ABCNN algorithm

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ABSTRACT

One of the most faults found in the electrical distribution network is a single line to ground fault (SLGF). It can be detected and rectified through many methods. The utilization of Peterson coil (PC), reduces the electrical arcs and make the distribution network safe from damage in contrast to the cost value. This paper focuses on the method for its detection on higher and lower values of the ground fault current (GFC). Moreover, it will identify the capacitance and earth leakage of earthling network lines as well as calculate the opposing inductance to compensate for the cause. It also presents the self-extinguishing of GFC by controlling PC through one of the novel optimization techniques called adaptive and artificial bee colony with network neural (ABCNN) to improve the algorithm's performance, like optimization efficiency, speed, solution, and iteration. As a result, the determination of the GFC equals the sound phase current. Also, the extinguishing of an electric arc results in a short time compared with classical methods. The significant advantage of this research is the increment in the system's reliability, protection of devices as well as saving in copper cost. MATLAB was used to carry out this research. For the validity, the proposed algorithm results were compared with the classical method by creating faults on separate phases also.

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1. INTRODUCTION

This paper presents the detection of a single line to ground fault (SLGF) in the distribution network of the power system (PS). The most common fault in the distribution network is reported to be SLGF [1-5]. It causes an electrical arc as well as transient voltage. This dangerous situation may activate the protection system. Hence, fault detection is a crucial issue to be considered in the PS; to ensure safety, to avoid accidents, to save equipment against damage, and to overcome undesired blackouts.

To control such a situation, one of the conventional techniques is by using peterson coil (PC). Various methods are used to turn off or reduce the electrical arc [6-9]. Some of the techniques include; wavelet, time-frequency method, PID, Fuzzy logic, Neural network, etc. Among multiple optimization and evolutionary methods, artificial bee colony combined with neural network (ABCNN) proves to be one of the best technique [10-12], to control the ground fault current (GFC) through PC. Compared to other techniques, ABCNN presents good results in terms safety of network/devices/human beings and increasing the reliability of the system [13-20].

This work will focus on the technique to detect the GFC at its higher and lower values. Also, to obtain the best solution for fault detection and within a short period. Also, it will identify the capacitance and earth leakage of earthling network lines and calculate the opposing inductance to compensate for the cause [21-24]. Besides other advantages, one of the major advantages is the saving cost of thousands of tons of copper [25].

2. PETERSEN COIL

The coil was first developed by [7]. It is used in 3-phase with grounding systems to limit the arcing currents during ground faults. However, the use of modern power electronics has revolutionized the performance of its classical solutions.

3. BASIC PRINCIPLE

When a phase-to-earth fault occurs in a grounded 3 phase system, the phase voltage of the faulty phase is reduced to the earth potential as the capacitance of the faulty line is discharged at the fault location, the phase-to-earth voltage of the other two phases rises by √3 times. A charging current "I_C" will be developed between phase-to-earth capacitances, which will continue to flow via the fault path and will remain there until it is discharged in an isolated distribution system. It is given by:

$$I_C = 3I = \frac{3V_{ph}}{X_C} = \frac{3V_{ph}}{1/_{\omega C}} = 3\omega C V_{ph} \tag{1}$$

The compensated system needs $-I_L = I_C$

4. ARTIFICIAL BEE COLONY (ABC) OPTIMIZATION ALGORITHM

It is one of the nature-inspired algorithms. It is derived from the behavior of honeybees and also a simulation of bees that searches for food habits.

4.1. Stages of the work:

a. Determine the source of food
b. Fitness Calculation
c. Find a better new solution
d. Evaluate the new solution and food source
e. Go back and repeat to the first step if we don't get the target

Figure 1 represents the flowchart of ABCNN. The novelty contribution of an ABC algorithm is the detection of an SLGF and its self-extinguishing in a short time has the following properties:

– Easy to interface
– Best solution tracking
– Fast response compared with any other algorithm
– Does not need modeling with nonlinear system
– Simple alteration time
– High quality

4.2. Natural bees

The ABC algorithm simulates the search behavior of honeybee colonies. The food search begins in a colony by sending scout bees to search for flower areas. The bees move randomly from one patch to another to find the best food. In the harvest, the colony continues to scout, and upon returning to the cell, those scouting bees that have found patches deposit their nectar or pollen, and go to the "dance floor" to perform a dance known as jig [13-14].

This dance is necessary to connect the colonies. It contains three parts of information about the flower's spot, such as the direction of the food source, type of food source, and evaluation of the quality or fitness of the food source. This information helps the colony to send its bees to the flower spots accurately, without using any clues or maps. More bees are sent to promising places, which allows the colony to collect the best food quickly and efficiently [3, 15].

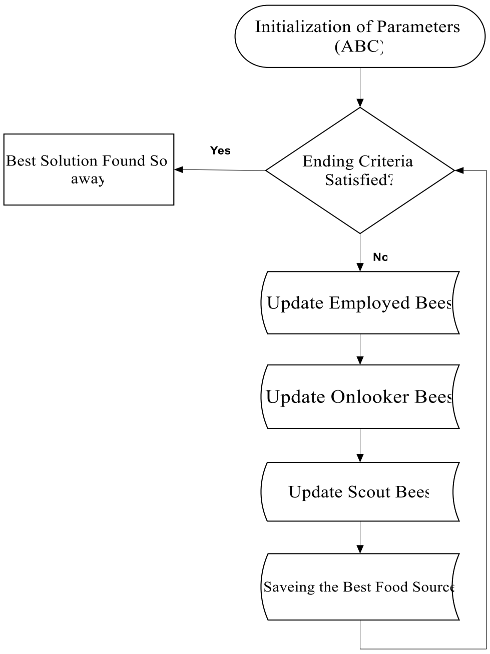

Figure 1. General flowchart of ABC

5. RESEARCH METHODOLOGY

5.1. Algorithm of an ABC

Step 1: N: The number of employed bees

U_{ij}: Food Source (solution)

Y: The distance between the food source (solution) and the bee such that j ∈ [1,2, … , Y]

$$U_{ij}=U_{minj+} rand[0,1](U_{maxj} - U_{minj}) \quad (2)$$

Step 2: An estimate based on the guesswork and calculation of the fitness of each solution is obtained by using the following method If it was: (solution value >= 0), then

$$Fi\ T_i = (\frac{1}{2 \times solution\ value+1}) \ldots \text{ else} \quad (3)$$

Step 3: Each employed bee, sited at a food source that is poles apart from others, searches in the resemblance of continuing the situation to find a better food source. For each employed bee, a new solution around its current location is obtained using the following formula:

$$S_{oij} = U_{ij} + Z_{ij} (U_{ij} - U_{kj}) \quad (4)$$

Here, k ∈ {1,2… N} and j ∈ {1,2… Y} are randomly preferred index, N is the number of employed bees, while Z_{ij} is a uniform random number from [-1,1].

Step 4: The strategy is to choose from several alternatives, carefully identifying the better ones of them. Also to determine and stabilize the likelihood values, V_{ij} for each solution, U_i using the subsequent formula:

$$V_{ij} = \frac{F_i+T_i}{\sum_{i=1}^{SN} F_i T_i} \quad (5)$$

In this case, it is selecting each onlooker bee to the best solution, U_i which is unorganized with the probability of comparative toV_{ij} . The purpose here is to engender new food positions (i.e. solutions), S_{oi} for each onlooker bee. Then it starts to calculate the fitness of every onlooker bee, U_i and the featuring new method solution, S_{oi} which applies an insatiable selection procedure to keep the fitter one and remove other bees. If a critical solution U_i has not been enhanced over a predefined number of cycles, then it will be selected for denunciation.

Step 5: Replace the result by inserting a scout bee at a food source generated randomly within the search space utilizing the following formula again.

$$\boldsymbol{U_{ij}} = U_{minj} + rand[0,1](U_{maxj} - U_{minj} \quad (6)$$

for $j = 1, 2 \ldots, Y.$

5.2. Mechanism of action colony of bees

This works if all the bees in the cell start searching for food. The straight line denotes the possible moves, and the single-headed arrow indicates a track selected by the bee among the possible moves. This figure represents the current solution of each movement as shown in Figure 2 [15].

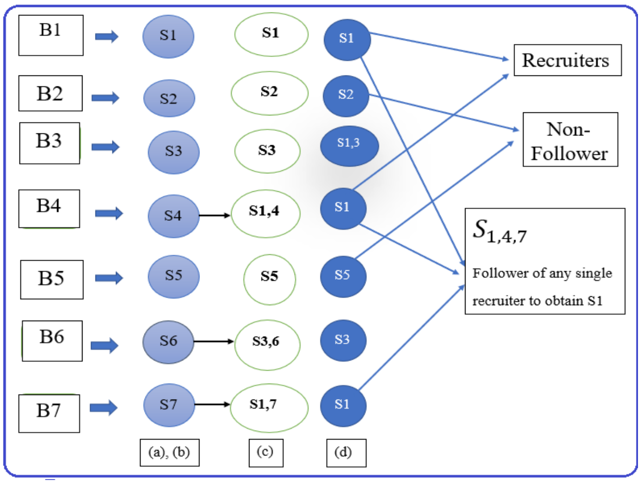

Figure 2. The mechanism of working at an ABC

$B_{1,2,3,\ldots.n}$ it means the number of groups Bees, $s_{1,2,3,\ldots.n}$ it means some solutions to followed a group bee.

In this text, all the bees will go back to its Cell with its associated solutions. Suppose there are seven bees with its associated solutions; for example, B1 has its associated solution S1, B2 has its associated solution S2, and so on. Then, the bees will decide if they want to advertise their solutions and become Recruiters. In this situation, the bees B1 and B3 have become recruiters. In parts 2(c), some of the bees decide to be the recruiters while some became followers. The bees B4 and B7 followed the bee B1 and obtained solution S1, while the bee B6 followed the bee B3 and reached the solution S3. However, the bees B2 and B5 did not follow any of the recruiters, hence works individually in the Cell [14-16].

6. SIMULATION SYSTEM

The MATLAB based Simulink model of an IEEE 33/11 kV distribution system, a single line diagram whose parameter values were replaced with real system i.e. Babylon power grid in Iraq as a test case is as given in Figure 3, and under mask Simulink model given in Figure 3.

The test case consists of a three-phase programmable voltage source, connected to the 33/11 kV main transformer, which feeding three 3-phases four-wire, 3 feeders loads represented with series RLC Y-connection loads. Each of the 3-phases loads is connected through three single-phase transformers. The winding connections of these transformers are:

Primary: (ABC terminals), Yg

Secondary: (abc terminals), Yn.

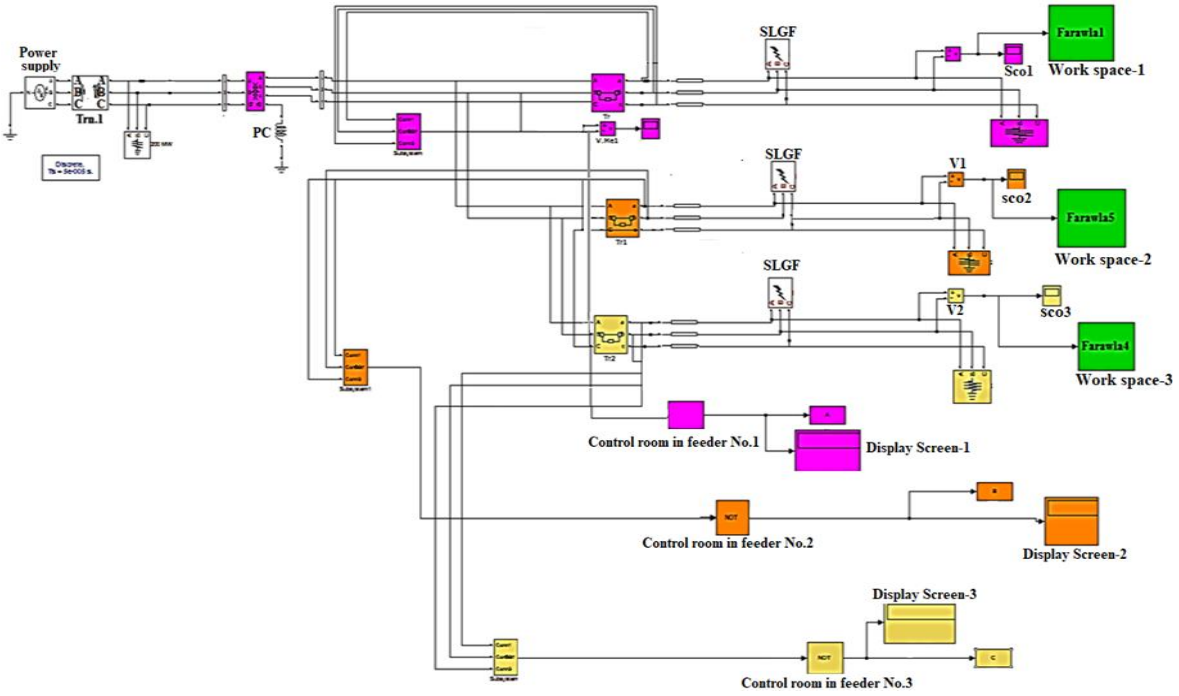

Figure 3. Simulink model of SLGF feeder configuration controlled through ABCNN

7. RESULTS AND DISCUSSION

Figure 4 depict the compared results between classical i.e. PC and ABCNN method applied to reduce the GFC in Simulink and on Oscilloscope respectively. It can be seen that the results obtained by using the ABCNN method are better than applying the classical method in terms of fault current approaching to the rated current i.e. 100A in a short period with no overshoot, no disturbance, no undershoot, high steady-state, and high efficiency.

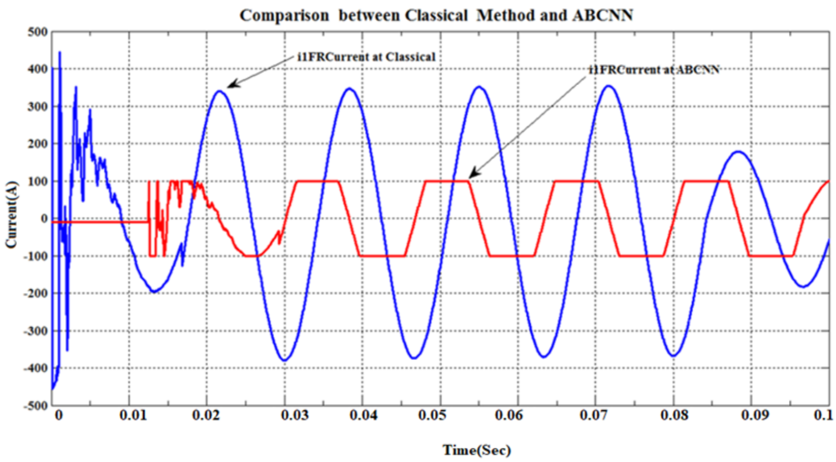

Figure 4. Comparison of classical i.e. PC and ABCNN methods applied for GFC reduction

For the validation of the ABCNN algorithm, SLGFs were generated on the same feeder number 1 but the other phase i.e. S, the results obtained confirm the validity of the proposed algorithm versus the classical PC method i.e. GFC reduction to rated value i.e. 100 A. They compared results of ABCNN vs. PC methods application to reduce the GFC are depicted in Figure 5, for S a phase respectively.

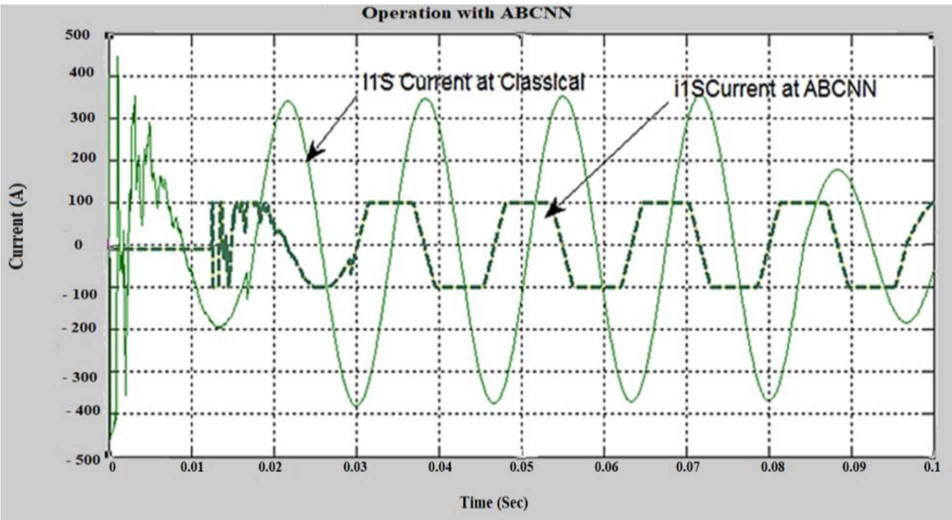

Figure 5. PC vs. ABC methods applied for GFC reduction while faulting at phase S of feeder # 1

8. CONCLUSION

This paper presents a significant contribution using this algorithm in this field and to SLGF detection, the reduction of time extinguishing electric arc by using the ABCNN algorithm. As show the outcome in terms of matching to the rated current with no overshoot, no undershoot, no disturbance, and resulting in higher efficiency, better steady-state response, and rapid compensation. The proposed algorithm results were compared with the classical method of PC. For the validity of the proposed algorithm, it was applied while creating faults on other phases individually. The results obtained show the same achievement. After utilizing the ABCNN method, the results are improved as the fault current is equal (100A), with the rated current in short time record as (0.025Sec) but in a classical method, the time extinguished electric arc is equal (0.065Sce). Besides, is another contribution to transform ABC from (m-file) and link it with Simulink working online by using NN performed by taxes instrument. This research has novelty with ideal results and has not been previously focused on previous literature. Also, this method of hybrid work interfaces between the simulation and simulink. This work is the first contribution in this area and we can use it in electrical power stations. We can able to investigate the validity of simulink results by fault detection conversion of online commissioning via the Texas instrument. Besides, this method could be used in power stations to detect malfunctions by building this program on the network. Thus, we have contributed to the process of detection of earth faults development in a way that suits the development of technology in the world and this project is considered the first of its kind.

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