Improvement of Traditional Protection System in the Existing Hybrid Microgrid with Advanced Intelligent Method

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ABSTRACT

The sustainable power sources will turn out to be a long haul future arrangement over conventional existing accessible source. Numerous specialized difficulties are ascending in the developing system of the Indian Microgrid; protection is one of it. Traditional protection framework utilized directional overcurrent transfers for the assurance against different deficiencies. These are dependent on the presupposition of the unidirectional progression of Current. The similar strategy cannot matter to the microgrid security as a bidirectional progression of current streams because of the nearness of DGs, which prompts specialized difficulties in the Microgrid. The new advanced intelligent method of DWT-differential Algorithm proposed over traditional protection system. The various parameters such as PS (Plug setting), TS (time setting), CDS(current duration setting) and operating time of relay tested. Indian Microgrid concentrated as contextual analysis, and smart system of microgrid protection prescribed to defeat all challenges got from writing contemplated. The system is designed in MATLAB software ,Double line to ground fault is simulated at different locations and DWT-DA is applied.The percentage of reduction obtained in operating time and other parameters are results in increasing reliability of microgrid.

1. Introduction

The world records indicate that till date 13% people are in dark with no acess of electrical power [1]. In India rate of electrification is 38% ,most of remote villages are still using traditional kerosene lamp for daily needs [2]. Following are few problems faced by Indian villages for electrifications[3].

a) Geographicals milestones such as dense wood,hilly region,remote location,no facility of transport would create difficulty in transmission of power.
b) Less no of population, with minimum no of houses (less than 400-500).As most of the community are farmers and prefer to live near their farms.
c) The most of loads used in household are lightning so low electricity demand.

d) The poor income so less affordability and illiteracy cause lack of knowledge for maintainance and technical skills.

The geographical location will create problem and expensive transport of power.Hence instaed of concentrating on connecting central grid to remote location microgrid can be best solution.The generation and distribution of electrical power will take place on site by using RES(renewable energy resources) [4].Microgrid can be defined as small cluster of loads and RES having its own developed sytem of protection and management [5].Microgrids are ideally suited for low power demand.The far located hamlets can use plenty of RES available around such as solar,baggase being less consumption 1 kw to 100 Kw It is possible to fulfil need and lower pollution cause by burning kerosene lamp.Once establishment of microgrid are carried out, greatest concentarion should allign towards reliability maintainance of system.The power electronics devices used such as inverters, battery and solar panel are expensive and sensitive to any disturbance cause on system.To maintain security and increase reliability of sytem protection is highly concern issue.

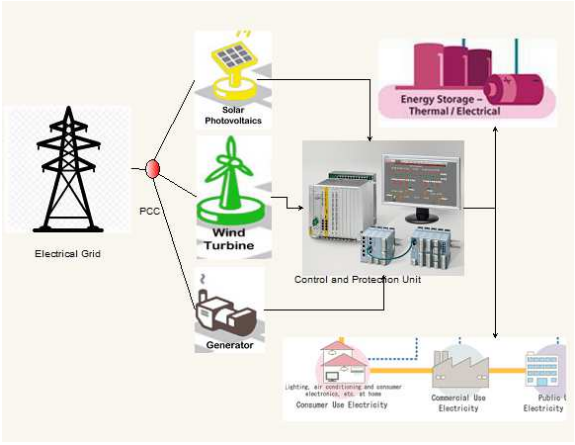

Fig 1. Architecture Of Microgrid

The Figure-(1) gives architectural view of microgrid.The central protection unit consist of relays,circuit breaker, controlling unit play vital role. The Microgrid is confronting numerous specialized issues for the executives and protection. Integration of DERs in Microgrid leads to many challenges in protection as traditional security system fails due to the bidirectional flow of Current [6]. There are many geographical as well as technical issues which are affecting growth of RES [7][8]. The various techniques are proposed before in the protection of Microgrid. Directional overcurrent protection [9] need advanced communication to pass the relay signal. The traditional differential protection system is introduced in [10], which rely on communication for fault identification and clearance. The security method depends on travelling wave is suggested in [11] when failure current decreases below customer load signal relay fails to operate. Adaptive protection scheme is proposed in [12]-[14] cost factor included in establishment of infrastructure. The Power electronics devices used in Indian Microgrid has the versatile effect of relays, switches, and circuit breaker used [15] and hence the necessity to develop cost-effectively, an advanced intelligent protection system for rural Microgrid.

In the increasing graph of development of RES this Paper contributes to identifying all technical challenges and existing techniques in one of the prominent issue of microgrid protection. Also, give a case study of Yawatmal hybrid microgrid with new Novel Adaptive technique method of protection.

2. Methodology and Validation

As stated, the equation -(1) the reliability of the hybrid microgrid is the minimization of the working time of the relay. The traditional overcurrent relay operates in a single direction as there is no provision in operation in both directions. Still, it is necessary to design relay, which sends the signal in both directions to increase the reliability of the system [16][17]. This method proposed relay with four important parameters plug setting (PS) and time setting (TS) in forward and reverse direction. Plug setting characterized as the fraction of Current from device to reference current or pick up Current. The change of transport separation of an electromechanical relay is usually known as time setting.

$$Reliabilty = Minimization(\sum_{i=1}^{N} T_{op}\ ) \tag{1}$$

Following align equation (2) and (3) gives operating time in the forward direction and reverse direction. The standard IEC 60255 [18] explain IDMT (inverse definite minimum time) characteristics 0.14 and 0.02 are values obtained from the graph. IDMT relay characteristics used in the proposed method for coordination of relay this also helps in securing solution by optimization method. In advanced protection scheme proposed here is uses all traditional protective devices such as CT, transducer, Circuit breaker. The speciality is uses of highly optimizes programmed digital relay, which further expands the unwavering quality of Microgrid.

$$T_{op}^{fw} = \frac{0.14\,TS^{fw}}{(PS^{fw})^{0.02}-1} \tag{2}$$

$$T_{op}^{rv} = \frac{0.14\,TS^{rv}}{(PS^{rv})^{0.02}-1} \tag{3}$$

Where T_{op}^{fw}, T_{op}^{rv} is operating time in forward and reverse direction

TS^{fw}, TS^{rv} Is time setting in the forward and reverse direction

PS^{fw}, PS^{rv} Is plug setting in forward and reverse direction

Equation (4), (5) and (6) defined constraint on operating time and time setting and plug setup. All estimations of time setting and attachment setting legitimately influence the working time of relay; hence min and max value are assigned as boundary elements.

$$T_{op\,Min} \leq T_{op} \leq T_{op\,Max} \tag{4}$$

$$TS^{fw} \leq TS_{min};\ TS^{rv} \leq TS_{max} \tag{5}$$

$$PS^{fw} \leq PS_{min};\ PS^{rv} \leq PS_{max} \tag{6}$$

Coordination duration setting (CDS) is the benchmark for coordination to examined. It is a setting predetermined duration meantime of communication, which hang on the category of pair of relay selected. CDS for IDMT relays varies from 0.2 to 0.5 [19].

$$T_{op}^{fw} - T_{op}^{rv} \geq CDS \tag{7}$$

Table-I gives dual setting of relay. The commonly used unidirectional overcurrent relays are made either for primary or backup protection and operate in a one direction only. On the contrary, double horizon relays designed with dual frames, each design for a particular short circuit magnitude and guidance.

Whenever current pass in forwarding direction TS_{fw} and PS_{fw} are settings for primary relay and TS_{v} and PS_{rv} are settings for the backup relay. for failure F1 as shown in fig-6, relay R1 acts as elementary (primary) protection and failure F2 same relay R1 acts as backup protection. To add on the value in the proposed research ability of dual setting relay to operate in both directions is fully utilized. As Praposed technique used dual setting relay for mitigation of any fault occur on system,Difficulties caused by traditional relay is get diminish automatically.

Table 1. Forward and reverse settings of relay

Relay Number	PSfw	PSrv	TSfw	TSrv
R1	1	0.00298	0.1	0.221
R2	2	0.0039	0.1	0.282
R3	3	0.0012	0.1	0.139
R4	4	0.004	0.1	0.344
R5	5	0.0019	0.1	0.081
R6	6	0.0030	0.1	0.364

2.1. Adaptive Novel Optimization Technique

The proposed technique used protection strategy, which shown in Figure- (2). This method is superior over traditional way because of inclusion of DWT (Discrete Wavelet transform) with differential Algorithm. When a failure happens on the system, the Current is supplied to the DWT analysis block directly through CT. The sinusoidal waveform of issue current contains unreasonable undesirable data which sets aside more effort to identify the area of the flaw. Hence to decrease the working time of relay, DWT analysis first carried out on the short-circuit signal. Fault or no-fault condition detected with the help of DWT.The Current waveform with DWT discretaization is shown in figure-(3) up to four coefficient. Fault current obtained from CT processed with 6.5 Khz sampling, the base value used is 20 MVA and 480 V for per unit calculation. The four sampling coefficient (DA1-DA4) get after scanning the signal and proceed with differential Algorithm.

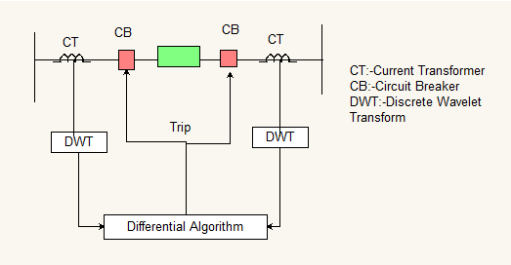

Fig 2. Adaptive Novel Optimization Technique

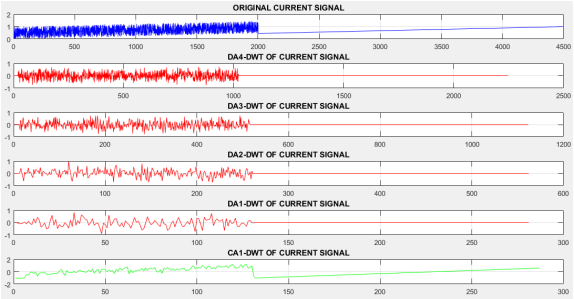

Fig 3. The Current Signal after 4 Coefficient DWT Analyses

After successful execution of DWT, the Differential algorithm detects the best pair of forward and reverse set of the relay by using Darwin's evolution theory [20] hence less chance for false tripping. PS and TS are the most critical factors in the selection of relays. At the last step of each recitation new calculated value of TS and PS is fed to Algorithm till end criteria satisfied. Figure-(4) reflect the structural outline of the DE algorithm technique.

- Proceeding 1: Objective function is set in the Algorithm, as shown in equation (1).Generation of all initial vectors carried out by setting parameters such as

- Proceeding 2: All parameters are initializing with minimum and maximum limit with fix size of the population. Here the community set to 100. Two vectors generated, first is used to create parents set and others to produce offspring.
- Proceeding 3: Evaluation processes in which each solution obtained assigned with vector X. Final vector is obtained with size n.

$$X_{i,G} = X_{1,i\,G}, X_{2,i\,G} \ldots\ldots X_{D,i\,G} \tag{8}$$

Where D is real parameters defined in proceedings 2
N is the total count of inhabitants.
G is the count of production.

- Proceeding 4: The objective function tested with all defined and evaluated parameters. If the optimization criterion is satisfied, the best vector is selected from them and end the process.

Each vector obtained has to undergo the following three processes.

- Proceeding 5: Mutation is a process which expands search vectors. For any generated vector $X_{i,G}$ randomly different vectors are assigned $X_{r\,1,G}, X_{r\,2,G}$, $X_{r\,3,G}, X_{r\,4,G}$ ……..in such way that r1,r2,r3,r4 are different indices for i.

New mutant vector generated from mutation. Where F is constant from [0,2]

$$V_{i,G+1} = X_{r\,1,G} + F(X_{r\,2,G} - X_{r\,3,G}) \tag{9}$$

- Proceeding 6: Crossover is the next process of recombination with the previous vector. New trial vector generated with the help of mutant vector by taking into account cross over probability.
- Proceeding 7: Selection, Best pair of vector selected which satisfied criteria and other values discarded. In a vector set chosen of n size if the maximum count acquired, then vector which is selected will result in the minimum amount of the objective function. Achieve X best offspring and end the process and if the maximum count not achieved, then select Vector group for the next iteration and increment iteration by one and directly bounce to proceeding three and repeat the same process of Algorithm.

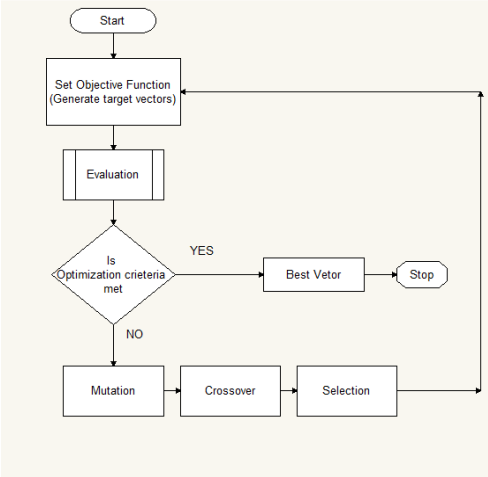

Fig 4. Structural outline of the DE algorithm technique

2.2. Validation of Proposed Method on Existing Yawatmal Microgrid

The topographically remote towns from India are still not getting the quality of power. The bounty measure of sunbeams and bagasse are accessible in a secluded spot of India which use as the best source in age of intensity. The hybrid microgrid situated at locale Yawatmal, Near taluka Wani in Maharashtra India, satisfy the request of 24 hr quality gracefully in close by towns. The Rajur Shinola, Mukutban, Hirapur are the little villa of Adivasi individuals which shaped over long very long time by gatherings of farmers who required being nearer to their homestead. Because of its remote area, there is no methodology of quality of supply to proceed with family works. Individuals complete their day by day schedule with the assistance of lamp oil light and remain far away from the rest of the world. The figure-5 gives the remote area of towns.

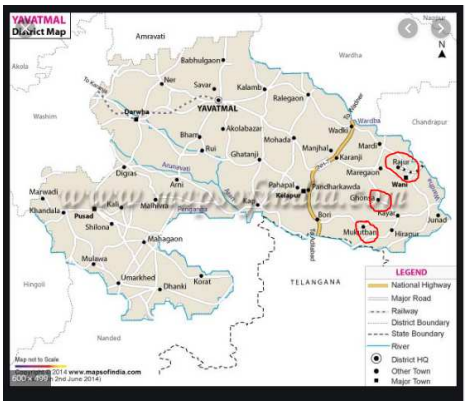

Fig 5. Remote Location of Microgrid on Map

The solar plant of 500 KW located at Maregaon 15 km from the grid which is governed by MEDA(Maharashtra energy development agency).The bagasse with generation 20 MW located at Rajur and Chanakha lead by SGEL(Shaliwahan green energy limited) and RPL Urja respectively located at distance 10km and 15 km from grid station. Figure-(6) shows Structural outline of the Yawatmal microgrid with a hybrid generation [21][22][23].Table-II describe all technical details of Microgrid components.

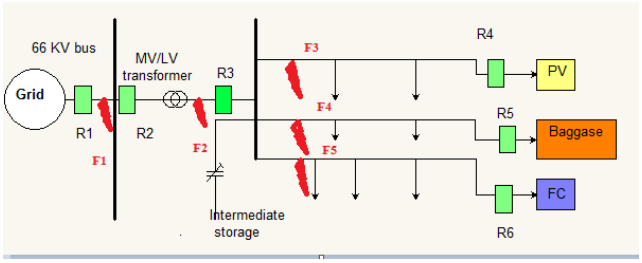

Fig 6. Structural outline of Yawatmal Microgrid

Table 2. The ratings of Microgrid Components

Sr .No	Component	Ratings
1	Total Load	18.5 MW
2	Grid Ratings	66KV
3	MV/LV transformer	20 MVA, 115kV/12.47kV
4	Line Impedance	0.1522+j0.1306 Ω/km with load power factor 0.89
5	Fixed capacitor	10MW

3. Result and Discussion

The Yawatmal microgrid modelled in software MATLAB SIMULINK with all real-time data collected; after visiting the site, various difficulties with traditional protection system noted down, which stated as below:

a) Breakdown of power supply
b) Low voltage
c) Time consumption and complicated procedure
d) Poor infrastructure of relay coordination

All problems mentioned above are responsible for the reduction of reliability of the overall system. Therefore the proposed method is suggested by taking into account all real-time issues faced by the system .Figure-(7) shows traditional protection system used to control all faults. The double Line to ground fault (DLGF) is created at five different locations, as shown in Figure-(6) and tested with the proposed system.

Fig 7. The Existing protection system of Microgrid

The proposed Algorithm extracts data from fault signal using DWT and sends it to DA as an input signal.Figure-(8) gives DWT obtained DLG fault signal at five different locations. After successful proceedings through differential evolution algorithm, best pair of relay selected. Figure (9) represents the Mitigation of DLG fault at Location F1,F2,F3,F4 and F5 .

Table-III gives Operating time of all relays. The overall reliability of the system depends on the operating time of relay, by using advanced mode it concluded that operating time reduced by 53%, which helps to improve the reliability of operation. The table-IV gives a comparative analysis of different parameters such as PS, TS, CDS 1, and CDS 2 with the traditional method. It is clear from the percentage reduction that the recommended approach surely helps in decreasing relay working time and increasing the reliability of Microgrid. The decrease in the working time results in protection of all sensitive, expensive power electronics devices used,

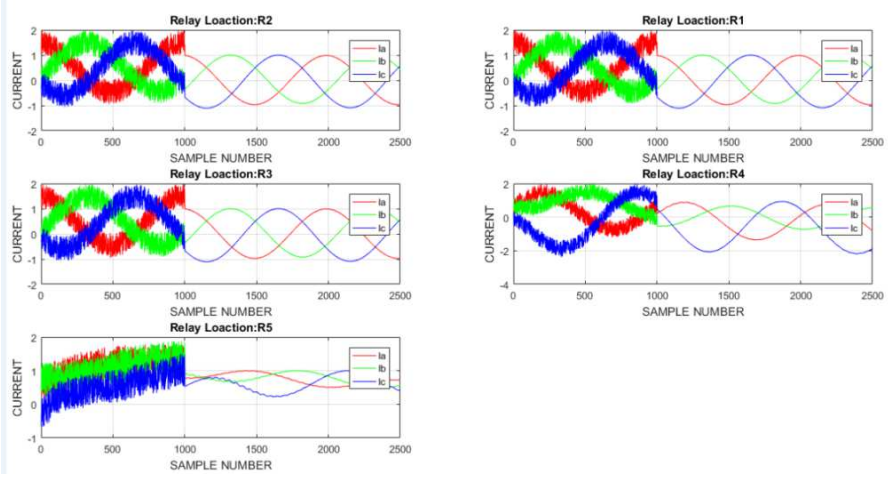

Fig 8. Double Line to a ground fault created at different Location

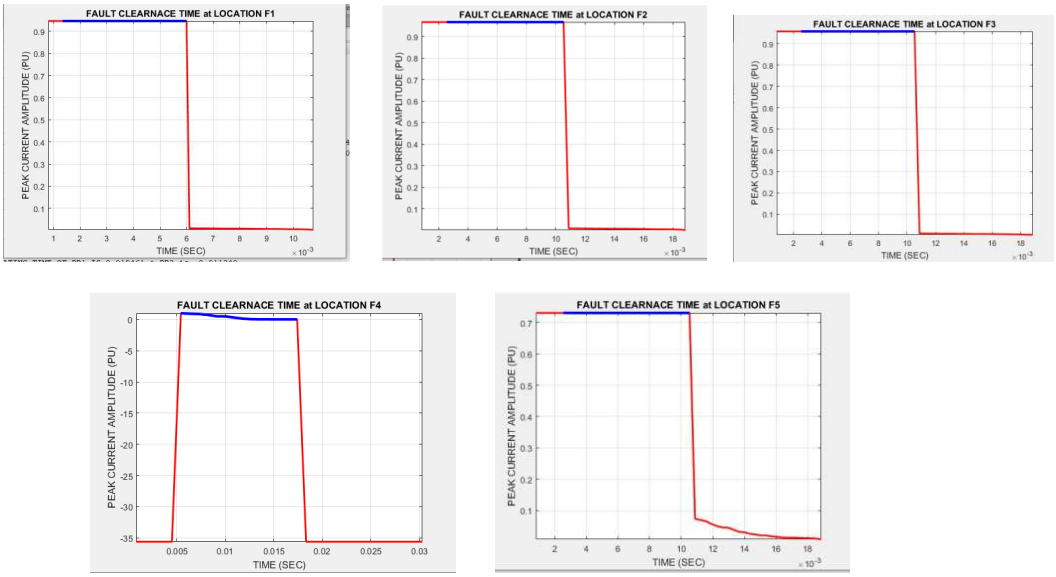

Fig 9. Mitigation of DLG fault at location F1 to F5

Table 3. The Working time of all relays

Fault	Workin Time for all Relays in sec					
	Primary Relay			Secondary relay		
	PR1	PR2	BU1	BU2		
F1	R1 0.050547	R2 0.035281	R1 0.050547	R3 0.019461		
F2	R2 0.035281	R3 0.019461	R1 0.050547	R4 0.043962	R5 0.011340	R6 0.047181
F3	R3 0.019461	R4 0.043962	R2 0.035281	R4 0.043962		
F4	R3 0.019461	R5 0.011340	R2 0.035281	R5 0.011340		
F5	R3 0.019461	R6 0.047181	R2 0.035281	R6 0.047181		

Table 4. Comparative Analysis of Parameters

Parameters(Avg Value)	Traditional method	DWT-DE method	%Reduction
PS	2	1.75	25%
TS	0.358	0.0288	70%
Time of relay	5.45	0.05622	53%
CDS -1	3.285	0.575	27%
CDS -2	0.356	0.2298	12%

4. Conclusion

This Paper proposed DWT-Differential calculation; progressed, advanced technique for issue recognition and moderation. At the first short circuit, the Current preprocessed through DWT which extricate all factual signal further best pair of relay chose with differential advancement calculation. The suggested strategy tried on existing hybrid Microgrid situated at Yawatmal area. It very well may be inferring that whatever issues are looking by Microgrid with customary security is alleviated through the proposed plot. The working time of relay with different parameters gets decreased fundamentally. The dependability and reliability quality of Microgrid improved with more prominent rate. The sensitive and costly power electronic gadgets utilized at the site can shield from harm.

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