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FAULT SECTION ESTIMATION FOR OPTIMIZATION OF DISTIBUTION POWER SYSTEM USING SAIDI AND CARTI FORMULATION APPROACH FOR OPTIMIZATION

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ABSTRACT:- Fault indicator (FI) is used in impedance- based methods for improving fault section estimation in power distribution feeders. The location and number of FIs effects on the reliability indices and can extra charge the distribution companies and consumers. In this paper, the optimal location and number of fault indicator (FI) are determined in Power Distribution Network (PDN) with special economical combined objective function. In this objective function, four imposed costs on distribution companies and consumers are taken into account. For solving this problem, a powerful method i.e. MMOPSO MODIFIED MULTI-OBJECTIVE PARTICLE SWARM OPTIMIZATION TECHNIQUE (MMOPSO) is used.

INTRODUCTION: Based on a presented report, about 80% of interruptions are caused by faults in distribution networks [4]. PDN is susceptible to faults caused by different reasons. These networks are distributed in different regions (urban, residential, and concentrated in urban marginal areas) which are available for people.

1. Weather conditions

2. Equipment failure

These faults cause to decrease power quality, destroyed reliability indices, decrease benefits, and satisfaction of consumers from distribution companies. Therefore, this is favorable for consumers, if location of fault is found quickly and repaired them, consequently time of restoration is reduced. Different methods are presented for fault location in PDN. These methods have two stages. In the first stage, the fault distance is determined and in the second stage, the fault section is estimated.
Fault location methods are classified into two categories:
a) Impedance based methods [2,3]
b) Traveling wave based methods [5]

In the impedance based methods fundamental of voltage and current signals at the beginning of feeder are used.

Implementation of these methods is very simple are cheap, but they have some problems such as sensitivity to Fault resistance and multiple-solution [1, 4]. Traveling-wave methods consider the voltage and current waves, traveling at the speed of light from the fault towards the line terminals [5]. These methods are considered as very accurate, however, also as complex and costly for application, as requiring high sampling frequency [6, 7], Multi response and Detecting travelling wave in faults near to the fault location devices and in zero domain of voltage or current is difficult. With this fault location review, the most methods need to estimate Faulted section. Fault section estimation can be classified to three methods, using current pattern recognition, intelligent methods, different methods which have communications devices. Many indices are presented but are not unique. Some of methods need to communication device and addition equipment's. Consequently, they are expensive and complex. The most of methods need to data bank, which make of it and update of it is very difficult. With these notes, choice of method for locating fault depends on both system topology and available instrumentation for system monitoring. Fault Indicators (FI) allocation can improve impedance based methods. Because of, it can speed up finding correct position of fault section estimation or reduce multi section estimation, consequently restoration time is reduced. Important questions are mentioned in below for FI: How many FIs does each feeder need? And Which place do the designers prefer to install it? As the first FI is presented in [2] but this paper did not present any special method for finding number and position of FIs. In continue different methods are presented for solving it such as GA (Genetic Algorithm), CBGA (Chu-Beasley Genetic Algorithm) and IM (Immune Algorithm). GA method, which is presented and used for solving the OFP problem. It finds the optimal place of FIs. This method extends the presented method in and presents an objective function which is combined of the number of suspected locations and the distance among suspected locations. Also it uses the FI statuses for helping to find faulted section. IM is used for FIs optimal placement which is presented in [9]. It is presented a combined objective functions. The presented objective functions are combination cost of different types of loads (residential, commercial, industrial and key customers).

This paper presents optimal fault indictors allocation for fixed number and variable number of them in PDN with multi objective MMOPSO algorithm. In this paper a new combined objective function is presented. These objective function is formed to four necessary function. In each objective function element, cost of different level and types of loads has been assumed. The special feature of this presented objective function is assuming forced cost on consumers and distribution companies besides of assuming previous presented objective function which is presented in different Refs on this topic. So in continue, both of them are combined and effect of optimal FI allocation is shown and compared with different methods which are presented till now. Therefore, at the end, the presented method is tested on feeder **Roy Billinton testsystem (RBTS4**)

II. PROPOSED METHOD

The security and reliability and service continuity of power distribution system is very important, but it is violating with occurring faults. Fast clearing and isolation of different faults types are critical in maintaining a reliable power system operation and improve service continuity indexes**.** The proposed method presents a new optimal FI allocation method in PDN. In this method, anew combined economic objective function is assumed which must be optimized. Suggestion objective function is combination of three main part of benefit and disadvantage of finance such that show correct behavior of mutual effect between consumer and distribution companies. This objective function is composed four cases as follows:

a. Energy not Supply (ENS) cost
b. Operation cost and restoration cost
c. Unsatisfied consumers cost
d. FI cost (buying & installing)

$$C_1 = C_i \sum_{i=1}^{n} P_i t_i \qquad (1)$$

P_i Amount of load ith
C_i cost of each kWh
n Number of section
t_i Interruption time of load ith

B. OPERATION AND RESTORATION COST

1a) System Average Interruption Duration Index (SAIDI):

As this paper investigates the FI placement via a multi-objective approach, SAIDI and CARTI are considered as the technical objectives. This index represents average interruption duration of customers served during a year. It is determined by dividing the sum of all customer interruption durations by the number of customers served during a year, as follows [1]:

$$\text{SAIDI}=\frac{\text{AVERAGE INTERRUPTION DURATION OF CUSTOMERS}}{\text{SUM OF ALL CUSTOMERS}}$$

1b) Customers' Average Restoration Time Index (CARTI): As the term described in (2) can approximately be found by multiplying SAIDI to customer interruption cost, objectives F1 and F2 seem to have high homogeneity that may harm the multi-objective solution method. Hence, in order to efficiently investigate the effects of the multi-objective approach on FI placement, CARTI is introduced as a new objective function.

$$\text{CARTI}=\frac{\text{TOTAL CUSTOMERS RESTORATION TIME}}{\text{TOTAL NUMBER OF LOAD POINTS}}$$

In comparison with the prevalent system and customer reliability indices, it enables better incorporation of the direct effects of available protection and control devices as well as their accurate operation probabilities on the FI problem:

Restoration time associated with automatic switching*:* If a load point can be restored by successful operation of the existing RCSs, the restoration time depends on automatic switching, otherwise it is equal to the manual switching time.

Restoration time associated with manual switching: The restoration process is accomplished manually while either the automation procedure fails, or automatic restoration facilities are not available. In such case, the manual restoration time affected by the deployed FIs.

Restoration time associated with repairing:

A set of customers which cannot be restored by automatic/manual switching should wait until the faulted zone is repaired; hence, total restoration time of such customers is calculated.

Figure 1 Single-line diagram of RBTS4

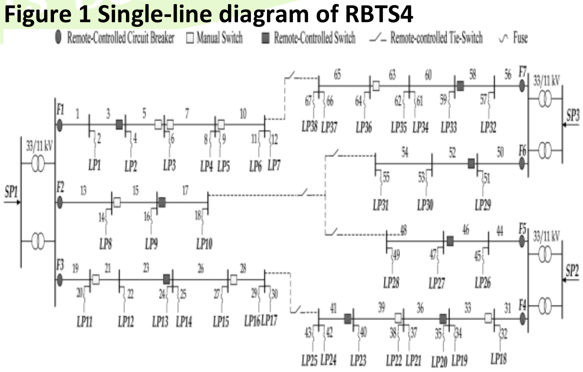

Table 1 Candidate location for FI

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LINE	UPSTREAM(1) /DOWNSTREAM(2)
1	2D
2	1U
3	1U
4	1U
5	1U
6	1U
7	2D
8	1U
9	1U
10	2D

III. SOLUTION APPROACH

A. Multi-Objective Particle Swarm Optimization (MOPSO)

In this paper, the single/multi-objective optimization procedure is implemented by PSO/MOPSO. PSO is a population based stochastic optimization technique developed by Kennedy*et al.* which roughly models.

For the social behavior of swarms for optimization of continuous nonlinear functions . In this algorithm, the particles which represent possible solutions fly through the problem space to find the best solution is executed for the figure 1 bus system.

MOPSO consists of determining all solutions to the MO problem that are optimal in the Pareto sense. In contrast with SO problems where the solution consists of a single element of the search space, the solution to MO problems consists of a set of elements of the search space (MO-multiobjective), (SO-Single Objective).

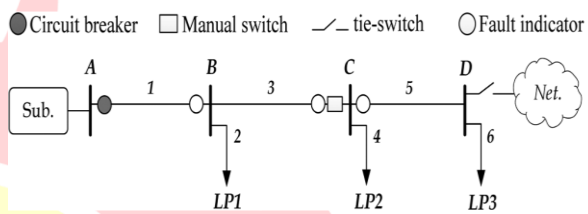
The objective of MO is to determine the best approximation to this Pareto optimal set. For stochastic optimizers in particular, solutions to MO problems are not always identical, and comparing them is often difficult because many criteria must be taken into account. Solving MO problems is itself a multi-objective problem.

The objectives are to:-

(a) Minimize the distance between the approximation set generated by the algorithm and the Pareto front;

(b) Ensure a good distribution of solutions along the approximation set (uniform
if possible);

(c) Maximize the range covered by solutions along each of the objectives.



Feeder type (bus-2)	Feeder length(Km)	Feeder section number
1	.65	2 6 10 14 17 21 25 28 30 34
2	.75	1 4 7 9 12 16 19 22 24 27 29 32 35
3	.80	3 5 8 11 13 15 18 20 23 26 31 33 36

Figure 2. Simple network to illustrate the restoration times.

Table 2 Feeder section

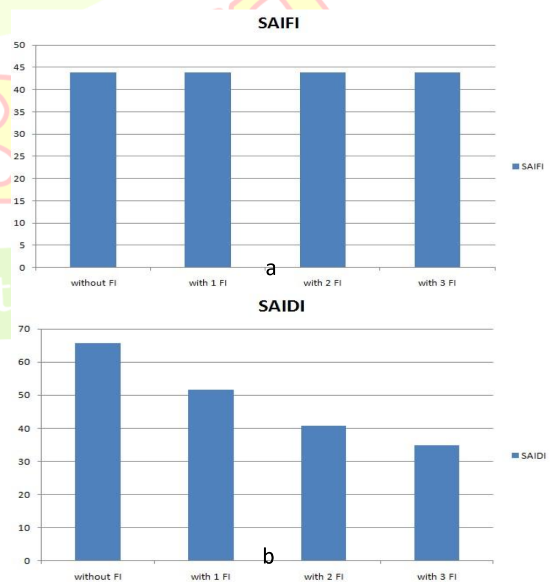


Figure 4. Reliability indices of RBTS4.

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OUT PUT 1 WITH SAIDI and CARDI

Economic Cost=631.922397 KUS$

Number of Fault Indicators=27

Fault indicator Locations

============================

1D 7D 8U 11U 12U 13D 19D 20U 22U 24U 28U

38U 39U 40U 41D 44U 44D 46U 48U 50D 53U 55U 56U 60U 62U 63U 67U

Fault Indicator Cost=29.565034 KUS$

Runtime = 4.180827 s>>

OUT PUT 2 WITHOUT SAIDI and CARDI

Economic Cost=631.928392 KUS$

Number of Fault Indicators=38

Fault indicator Locations

============================

1D 6U 7D 8U 9U 10D 11U 12U 13D 16U 19D 21U 21D 23U 27U 28U 31U 31D 32U 33U

35U 39U 42U 43U 44U 46U 50D 52D 53U 54U 54D 56U 56D 57U 58U 60U 65U 67U

Fault Indicator Cost=41.610048 KUS$

V. CONCLUSIONS

The FI placement problem was investigated through a multi-objective approach solved via an MOPSO based algorithm. The prevalent FI placement problem formulation was extended by incorporating the available protection and control devices with respect to operation uncertainties under contingencies. Furthermore, the CARTI, as a new technical objective, was formulated in the problem. Effects of the existing control and protection devices on the FI problem were studied on different cases. Also, effects of possible distribution topology changes on FI placement problem were investigated. Finally, *The proposed* methodology was implemented to a standard test system (RBTS4) and was studied via several scenarios. The obtained results and discussions reported in the paper show that the proposed approach can be used as an effective framework for optimal FI deployment of a practical network under possible contingencies. Further research might be conducted to consider the effects of redundant FIs, and to find the optimal layout of FIs with respect to the limitations imposed by IT infrastructure. Moreover, the FI placement problem might be studied in presence of DGs considering both online and offline DG operations, as well as uni/bi-directional FIs.

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