Application Of Programmed Fault Locator for Modified Electrical Transmission Line: A Case on National Grid Corporation of The Philippines, Mexico Substation Power Outages

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Abstract: - Wondering what causes a power interruption? Energy consumers may find it hard to understand what causes a power interruption. There are many reasons to consider why a power outage occurs at any time of the day. In the Philippines, organizations of electrical experts have studied approaches and techniques to minimize and prevent these power outages. This includes defining common reasons that cause power outages and correction techniques in order to restore electrical power during power outages. The research takes place at these events and uses analytical studies and methodology to create an outcome that will help organizations in electrical industries with power restorations during power outages.

Key Words: — ***Power Outage, Power Restoration, Transmission Line Fault, Relay Indication, Fault Location.***

I. INTRODUCTION

A power outage happens whenever there are disturbances along an energized power line. Disturbances that contribute to power outages fall on 2 common factors: Planned and Unplanned Outages. Planned Outages are necessary to conduct or perform maintenance activities to assure the good condition of electrical equipment. Unplanned Outages are events that are caused by many factors like severe weather, intrusion of foreign objects such as motor vehicle wreckage, animals, vegetation, and equipment failure. Unplanned outages are uncontrollable because of the factors that cause them. Electrical distribution companies are obliged to restore a power interruption as soon as possible to meet consumer's demand.

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The National Grid Corporation of the Philippines (NGCP) is a privately owned corporation in the Philippines that is in charge of operating, maintaining, and developing the country's state-owned power grid, an interconnected system that transmits power from where it is made to where it is needed. Mexico Substation is one of NGCP's substations located in Mexico, Pampanga. NGCP Mexico Substation is considered a load center because of the high energy demand of its consumers. NGCP Mexico Substation customers include distribution utilities, industrial, manufacturing, and power plants. During unplanned outage, these consumers' operations are affected that results in financial loss due to interrupted productions. Restoration of interrupted lines during an unplanned outage includes finding the exact location where fault occurs, assessing the damages, and conducting correction activities. The restoration process takes time where loss in customer production costs will also depend. As the outage time increases, the loss in production cost also increases.

II. STATEMENT OF THE PROBLEM

During unplanned outages of transmission lines, the substation engineer on the duty relies upon relay protection

which has information of estimated fault location. The substation engineer will inform the transmission line engineer and linemen of the estimated fault location for the restoration of the line. Providing an accurate estimated fault location lessens the time restoration of unplanned transmission line outages. This is where the importance of the accuracy of the estimated fault location takes place.

As the economy grows, the demand for power increases. Transmission line keeps up with this growth through expanding its lines, that is how modified transmission line starts. Though the transmission lines can meet the demand for power, the existing relay protection will eventually lag in fault location. Fault locators of relay protection depend on the impedance of transmission line. If the transmission lines were modified, the fault locators or relay protection will eventually be inaccurate.

To identify the effect of a modified transmission line, this study collected data of accuracy for relay protection and the proposed program for transmission lines Mexico-Sampaloc 69kV Line, Mexico-Calumpit 69kV Line, and Mexico-Apalit 69kv Line. Collected data were based on the actual incidents to provide the actual accuracy of the two elements. The results were analyzed to determine which of the two provides better accuracy.

III. Method And Procedure

Researchers have come up with a method for locating fault disturbances during unplanned outages through historical event logs. Previous outage events are the reference that will help us provide an output file where we can easily locate the fault along the line. Quantitative research using descriptive type is used in this research to determine the efficacy rate of our fault locator. The data collection is based on the historical occurrence of unplanned outages in Mexico Substation. This number of unplanned outages will provide the fault location of each unplanned outage based on relay protection. Through the report called Root Caused Analysis of transmission line personnel, actual fault location can be compared to fault location provided by the relay protection, which is inaccurate with modified transmission line.

The program is based on historical events. All data from 2018 to 2021 were collected, and each data will provide the needed variables for the formulation of the program. Example data is given in the Table 1.

Table.1. Fault Event sample

Transmission Line	Date/Time Out	Date/Time In	Fault Type	Relay Indication Location(km)	Actual Fault Pole Location	Ratio
MEX - SMP	17 02 2018 11:43:00 AM	17 02 2018 4:45:00 PM	1LG C	1.22	19.5	15.98

The data collected consists of transmission lines, date/time of occurrence, fault type, fault location, actual fault pole location, and ratio. Transmission line, date/time of occurrence, and fault type are for listing purposes of the program. The ratio in the data is the quotient of actual fault pole location and fault location. The summary ratio of a certain transmission line with fault type from 2018 to 2021 will be averaged and used for the final output of the program.

Table 1.1. Program output

Transmission Line	Fault Type	Relay Indication Location(km)	Estimated Pole/Structure	
MEX - SMP	1LG C	1.05	23	13 to 33

Table 1.1 shows an example of the final output of the program. This example occurred last Oct. 14, 2020, when the MEX-SMP line had an unplanned outage. Given the MEX-SMP as an example, the total average of the ratio was 21.91. In Table 1.1, 21.91 (average ratio of MEX-SMP with 1LG C fault type) is multiplied in the given relay indication location which resulted in 23. The numbers 18 to 28 are the pole numbers to be inspected by the linemen. As per actual, the fault location was located between pole numbers 22 and 23. If this was based on the spanning of the transmission line, the estimated fault location given by the relay indication will be pole number 14, which is inaccurate. The study will provide data on the accuracy of both relay protection indicator and the program based on historical data in a modified transmission line.

IV. Results And Discussion

The data gathered were the unplanned outages from 2018 to 2021 in Mexico Substation. The Mexico-Sampaloc 69kV Line, Mexico-Calumpit 69kV Line, and Mexico-Apalit 69kV Line were selected in the study. The three transmission lines were selected due to the greatest number of unplanned outages in the selected period and have been modified. Table 2 shows the number of unplanned outages for the three transmission lines. Each unplanned outage is a test in accuracy for both relay indicator and program.

Table.2. List of Unplanned Transmission Line Outages in Mexico Substation

List of Unplanned Transmission Line Outages Year 2018 to 2021	
Transmission Line	**No. of Unplanned Outages**
Mexico-Sampaloc 69kV Line	10
Mexico-Calumpit 69kV Line	10
Mexico-Apalit 69kV Line	12
Total Unplanned Outages	32

Table.3. Accuracy test for Mexico-Sampaloc 69kV Lin

Unplanned Outage No.	Actual Fault Location	Relay	Relay Accuracy In %	Program	Program Accuracy In %
1	19.5	21.5	89.74	27	61.54
2	55.5	37	66.67	54	97.30
3	48	29.5	61.46	34	70.83
4	48	69	56.25	87	18.75
5	64.5	37.5	58.14	44	68.22
6	49.5	36	72.73	44	88.89
7	64.5	37	57.36	45	69.77
8	59	34	57.63	48	81.36
9	59	44.5	75.42	66	88.14
10	63.5	38	59.84	55	86.61

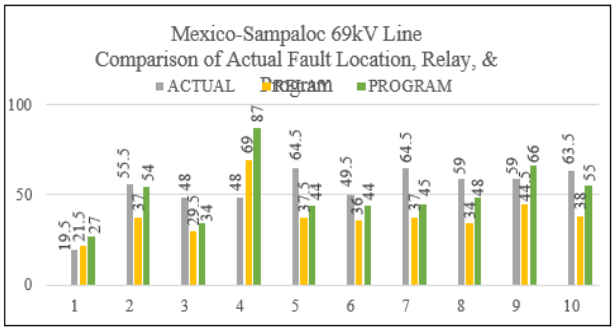

Fig.1. the Mexico-Sampaloc 69kV Line

Figures 1, 2, and 3 shows the Mexico-Sampaloc 69kV Line, Mexico-Calumpit 69kV Line, and Mexico-Apalit 69kV Line comparison of actual fault location, relay indication, and the program. The x-axis is the number of unplanned outages, and the y-axis is the pole number location of the fault. The values at the actual represent the actual pole number where the fault occurs. The values at the Relay represent the estimation for pole number location of the fault based on spanning of the transmission line. And the values in the program represent the estimation for pole number location of the fault based on historical data.

Table 3 shows the accuracy test for relay and the program in Mexico-Sampaloc 69kV Line unplanned outages. Each unplanned outage was a test for both the relay and the program. The computed accuracy of relay and program is the percentage difference from the actual fault location. In 10 accuracy tests of the relay and program, the average accuracy of the relay is 65.52% while the average accuracy of the program is 73.14% in Mexico-Sampaloc 69kV Line.

Table 3.1: Accuracy test for Mexico-Calumpit 69kV Line

Unplanned Outage No.	Actual Fault Location	Relay	Relay Accuracy In %	Program	Program Accuracy In %
1	42.5	36	84.71	43	98.82
2	84.5	22	26.04	95	87.57
3	228	41.5	18.20	199	87.28
4	61	17	27.87	62	98.36
5	49	14	28.57	50	97.96
6	65	18	27.69	67	96.92
7	98.5	24.5	24.87	100	98.48
8	64.5	17	26.36	63	97.67
9	102.5	24	23.41	99	96.59
10	105	24	22.86	99	94.29

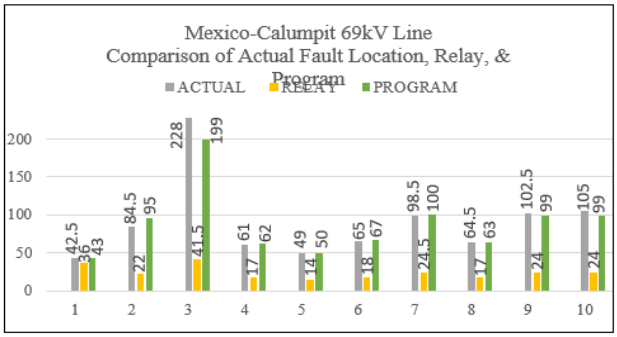

Fig.2. Mexico-Calumpit 69kV Line

Table 3.1 shows the accuracy test for relay and the program in Mexico-Calumpit 69kV Line unplanned outages. In 10 accuracy tests of the relay and program, the average accuracy of the relay is 31.06% while the average accuracy of the program is 95.39% in Mexico-Calumpit 69kV Line.

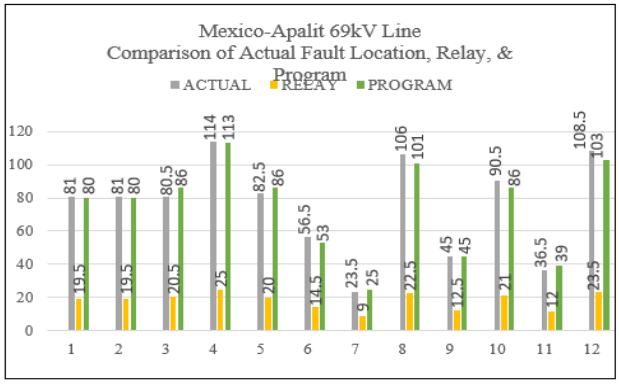

Fig.3. Mexico-Apalit 69kV Line

Table 3.2: Accuracy test for Mexico-Apalit 69kV Line

Unplanned Outage No.	Actual Fault Location	Relay	Relay Accuracy In %	Program	Program Accuracy In %
1	81	19.5	24.07	80	98.77
2	81	19.5	24.07	80	98.77
3	80.5	20.5	25.47	86	93.17
4	114	25	21.93	113	99.12
5	82.5	20	24.24	86	95.76
6	56.5	14.5	25.66	53	93.81
7	23.5	9	38.30	25	93.62
8	106	22.5	21.23	101	95.28
9	45	12.5	27.78	45	100.00
10	90.5	21	23.20	86	95.03
11	36.5	12	32.88	39	93.15
12	108.5	23.5	21.66	103	94.93

Table 3.2 shows the accuracy test for relay and the program in Mexico-Apalit 69kV Line unplanned outages. In 12 accuracy tests of the relay and program, the average accuracy of the relay is 25.87% while the average accuracy of the program is 95.95% in Mexico-Apalit 69kV Line.

For the three test results, the program achieves a higher accuracy rate. Though the first test at Mexico-Sampaloc 69kV Line shows a lower accuracy rate comparing to the other tests, the program has a margin of error that depends on the line. As shown in Table 1.1 for estimated pole/structure, the result value is ± 10 for the margin of error. This margin of error may compensate for the inaccuracy of the Mexico-Sampaloc 69kV Line. And for the Mexico-Calumpit 69kV Line and Mexico-Apalit 69kv Line, the margin of error is reduced since they achieve higher accuracy rates.

V. CONCLUSION

This research aims to determine the effectiveness of an experimental outcome that may be an alternate reference in locating a fault in a transmission line that causes power outages. This study also assessed the application of the program in a modified transmission line. Based on the results gathered, the researchers conclude that the program has a higher accuracy rate than the relay protection indicator in a modified transmission line. Relay protection indicator has a higher accuracy rate in a new transmission line since the impedance of the line can be measured. The relay protection indicator depends on the impedance of the line, therefore when the transmission line is modified, the impedance changes in conjunction with the accuracy of the relay protection indicator. Accuracy of estimated fault location plays a vital role in timely restoration of unplanned outages in a transmission line. Therefore, the program can be a replacement for a fault locator in a modified transmission line.

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