OVERHEAD LINE RELIABILITY INDICES IMPROVEMENT USING SELF-FEEDER AUTOMATION

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ABSTRACT

According to historical data of medium voltage overhead line feeders outages in Medan city, North Sumatra, Indonesia are relatively high, around 3 times monthly due to radial feeder configuration and high numbers of faults in equipments and feeder section, causing great contribution to unavailability of electricity supply to customers. Supply restoration takes lots of time, not only due to procedure reason, but also distribution protection system configuration itself; such as feeder breaker with many load break switches in a feeder. They caused poor reliability indices, especially SAIDI and SAIFI. One of the ways to improve the reliability indices of the overhead lines in fault management is to reconfigure the distribution protection system by using the Self-feeder automation of recloser and load break switches. They work based on sensing and coordinating of voltage, current and time in case any fault in the line, and use no communication facility necessary.

In this paper, the self-feeder automation system is implemented in two feeders forming an open loop scheme. If a fault occurs in one feeder of the group, so the faulty section is isolated, then the remaining healthy section will be supplied from another feeder of the open loop scheme in case of a permanent fault. This system is applied to three locations of the open loop schemes; consist of 3-pairs of 6 tested feeders. Based on data taken for 6 months period, we found a significant improvement on the reliability indices of the tested feeders.

INTRODUCTION

The continuity of electricity supply to customers is one of the performance measures of utility company. Unfortunately, power interruption often experienced by customers caused by faults that mostly occur in medium voltage distribution lines [1]. The medium voltage overhead lines are usually many miles length to cover wide and spread areas. They are susceptible to faults due to lightning, pollution, animal, equipment failures, trees touching, traffic accident, and people activity. The two indicators of reliability indices are SAIDI and SAIFI that measure both of average number and duration of electricity interruption experienced by customer per year. These indices are influenced by two factors, i.e.: inherited factors which depend on design and configuration of the network; and inherent factor which depend on supply area surrounding condition [2]. In order to achieve a better distribution system reliability indices in fault management, there are some strategies, such as [2]:

1. Reduce the number of faults
2. Reduce time of interruption
3. Reduce number of affected customers

Reduce time of interruption may be done by switching actions to isolate the faulty section, and restore the supply for remaining healthy parts. Reduce number of affected customers may be done by reconfigure the networks. The self-feeder automation system can fulfil the two strategies above, especially for both of close and open loop networks with or without communication facility.

In this paper, a field trial on using the self-feeder automation is implemented on 6 overhead line feeders at distribution system in Medan City, PLN North Sumatra Region, Indonesia; configuring 3pairs of open loop scheme. However, implementation of this new system may not show the expected results, especially on the high number trip of feeder breakers because of several handicaps, such as problem on existing feeder relays and setting coordination; but at the initial stage we found a significant improvement on the reliability indices of the tested feeders.

DISTRIBUTION NETWORK FAILURES

Distribution reliability indices of North Sumatra Region and Medan City for period of 2006 to 2010 are shown in Table 1 and Table 2 below with unavailability due to generation shortage neglected [3].

No	Year	SAIDI (h/cust)		SAIFI (int/cust)	
		Total	OHL	Total	OHL
1.	2006	12.7	6.8	16.8	12.9
2.	2007	8.7	3.8	9.0	5.5
3.	2008	7.9	3.4	11.5	7.6
4.	2009	6.0	3.3	8.2	6.1
5.	2010	4.7	2.3	6.8	4.7

Table 1: North Sumatra Region Reliability Indices

No	Year	SAIDI (h/cust)		SAIFI (int/cust)	
		Total	OHL	Total	OHL
1.	2006	11.3	5.6	15.8	13.7
2.	2007	2.0	0.35	2.1	0.9
3.	2008	6.0	1.6	11.0	5.7
4.	2009	5.3	2.3	8.2	4.6
5.	2010	4.9	1.7	7.7	3.4

Table 2: Medan City Reliability Indices

Source: reference [3], edited

Analyses on the reference data show that overhead lines interruption play a dominant value on total indices.
Based on an electric utility of KEPCO Korea report, that SAIDI in period of 2001-2006, around 92.8 % was attributed to distribution facilities, and only 7.2 % was attributed to transmission or generation facilities [4]. Data in both of Table 1 and Table 2 above show similarly.

In order to reduce the poor indices caused by medium overhead lines failures, PLN has been doing a field trial of the self-feeder automation system on 6 tested feeders of Medan City at the end of year 2009. The intention of this field trial is not only to minimize restoration time to healthy sections of the feeder, but also minimize the affected customers.

OVERHEAD LINE PROTECTION SYSTEM

Medium overhead line protection system depends on its neutral point earthing system; whether floating, solidly, resistance or impedance. In Medan City system, the neutral points of transformer 150/20 kV, 60 MVA, Y-Y are earthed solidly at 150 kV side and via 12 Ω resistance grounding at 20 kV side. In this case, we may use overcurrent and ground fault relay for feeder protection.
There are 3 types of overhead line protection apparatus system as follows [5]:

1. I-T System
2. V-T System
3. V-I-T System

In I-T system, protection coordination of the switches, usually recloser and sectionalyzer, uses current (I) and time (T) coordination. The V-T system uses voltage (V) and time (T) coordination. Due to lack of flexibility and other operational reasons of both systems above, so the V-I-T system that uses voltage (V), current (I) and time (T) coordination that may be used satisfactorily. Some benefits of the VIT System i.e.: communication facility is not a must, selective and load encroachment ability.

FIELD TRIAL OF THE SELF-FEEDER AUTOMATION SYSTEM

Configuration of the open loop scheme

In this field trial, we had chosen 6 overhead line feeders configuring 3 pairs open loop scheme with initial plan load current of each section as shown in figure 1 to figure 3 below.

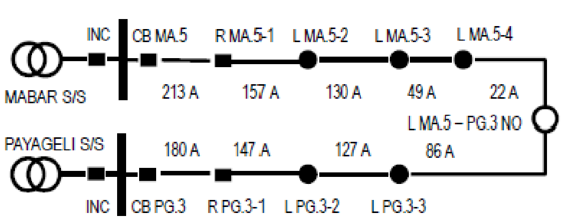

Figure 1: Open loop scheme of tested feeder MA.5 –PG.3

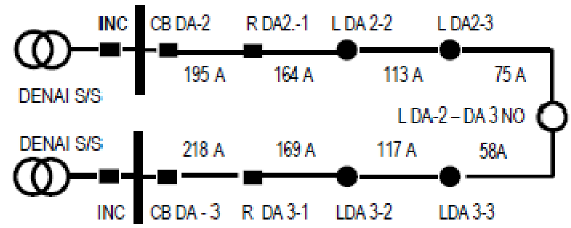

Figure 2: Open loop scheme of tested feeder DA.2 –DA.3

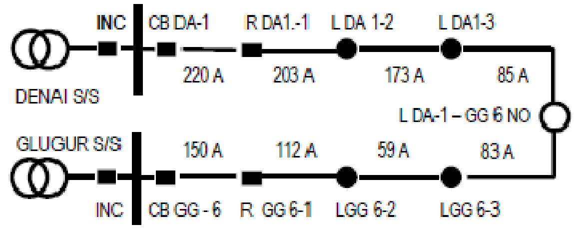

Figure 3: Open loop scheme of tested feeder DA.1 –GG.6

Type, length and current carrying capacity of each feeder are indicated in Table 3 below.

No	Feeder	All aluminium alloy 150mm^2	
		Length (circuit km)	Carrying capacity (A)
1.	MA.5	11.59	385
2.	PG.3	7.98	385
3.	DA.2	6.28	385
4.	DA.3	11.75	385
5.	DA.1	10.24	385
6.	GG.6	5.98	385

Note: A small portion of XLPE cable of outgoing cubicle is neglected

Table 3: Overhead line conductor data

Artificial ground fault field test

Prior to take this test, the load of each section and lateral of each feeder shall be rearrange; and also resetting all protection system of incoming, outgoing, recloser, and load break switches have already been done. The aim of the test is to know the function of the apparatus in case a fault occurs. This artificial fault, by using artificial fault generator (AFG), was made for ground fault with several fault resistances. The fault resistances were taken by making artificial faults on soil, grass and concrete.

The tested open loop scheme MA.5-PG.3 is shown in figure 4. Ground faults testing both on grass and concrete are as following figure 5 (a) and (b).

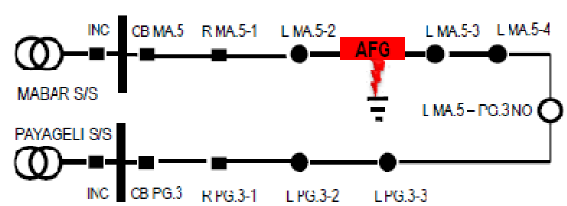

Figure 4: Artificial test on open loop scheme MA.5 –PG.3

(a) (b)

Figure 5: Ground fault testing on: a). grass; b).concrete

The tests data are recorded on recloser memory and the results are represented in Table 4.

No	Current (A)				Voltage (kV)		
	R	S	T	N	R	S	T
1.	154	225	635	479	15.58	14.77	3.61
2.	87	111	608	530	16.39	15.55	5.24
3.	83	83	600	528	16.35	15.71	5.79
4.	75	73	96	22	11.09	11.60	10.77
5.	194	187	211	19	10.84	11.26	10.40
6.	169	168	185	14	10.85	11.31	10.55
7.	150	178	650	563	16.69	15.77	4.06
8.	501	318	740	522	15.29	15.34	3.94
9.	219	218	736	545	16.40	15.65	2.25

Note: underlines figures denote fault currents and voltage

Table 4: Fault event data recorded on recloser MA.5 feeder

It shows that the ground fault tests were done at phase-T. Ground fault tests on soil, concrete and grass are denoted on test numbers 1 to 3; 4 to 6; and 7 to 9 respectively.
It is seen that for high impedance fault, the system has still quiet good result.

Results of field trial

Field trial on 3-pairs of feeders configuring open loop scheme have been performed since the end of December 2009. Starting from this, data collected for a period of 6 months afterwards. Performance of the self-feeder automation system, then, compared with the former over similar duration period.

No	Number of tripping				Number of Closing position of NO Switch
	Feeder	Breaker		Recloser	
		Before	After		
1.	MA.5	30	18	21	1
2.	PG.3	12	19	22	
3.	DA.3	16	3	14	1
4.	DA.2	27	15	11	
5.	DA.1	15	4	5	2
6.	GG.6	18	11	11	
7.	Total	118	70	84	4

Note: Before: period Jul –Dec '09, except DA.1 Nov '09- Feb.'10
After: period Jan-Jun'10, except DA.1 Mar-Jun'10

Table 5: Performance of feeder breaker, recloser, and NO switch

It is clearly shown in Table 5 above, that the number of breaker tripping of each feeder decrease significantly, except the PG.3 feeder; and also reduction level on total number of tripping. High numbers of recloser operation indicate that there were many temporary faults on those overhead lines. The NO switch of each pair of open loop scheme has also moved to its close position that means any healthy section of the faulted feeder is supplied from another companion feeder.

Impact on Reliability Indices Performance

Implementation of this new system may not show the expected results, especially on the high numbers tripping of feeder breaker, but at the early stage this field trial has already given good results in contributing better reliability indices, mainly SAIDI and SAIFI of the tested feeders, as indicated in Table 6 hereunder.

No	Feeder	SAIDI (min/cust)		SAIFI (int/cust)	
		Before	After	Before	After
1.	MA.5	17.20	1.51	0.469	0.017
2.	PG.3	5.26	2.72	0.267	0.078
3.	DA.3	25.77	0.83	0.488	0.007
4.	DA.2	42.67	1.65	0.965	0.014
5.	DA.1	6.49	0.61	0.229	0.031
6.	PG.6	5.26	0.13	0.115	0.010

Note: Before: period Jul –Dec'09, except DA.1 Nov '09- Feb.'10
After: period Jan-Jun'10, except DA.1 Mar-Jun'10

Table 6: Performance of Reliability Indices of the tested feeders

The self-feeder automation system may be used to minimize restoration time, so it will impact on reduction of the affected customers suffering from interruption. Another advantage of this system i.e.: communication facility is not a must.

INTERPRETATION OF RESULTS

The self-feeder automation with open loop scheme is based on both strategies of switching action and reconfiguration of distribution network. This will results in fast switching action to isolate faulted section and restore the remaining healthy part of feeder, hence reduce SAIDI score. If restoration time less than 5 minutes in this part, so it is not consider as an interruption. Hence, it contributes to reduce SAIFI score, as in Table 6 above.

FUTURE WORKS

The 6 tested feeders are a small portion of total 93 feeders in Medan City. The latest reliability Indices performance of the years 2009 and 2010 as indicated in Table 2 are still high. In order to get better reliability indices, we hope the future work will be executed to the other feeders with using communication modem.

CONCLUSIONS

Result of the field trial on 3-pairs of feeders configuring open loop scheme, especially on both number of breaker and recloser tripping of each feeder are still high enough, even there were reduction on total number.

However, the NO Switches change to its Close position proves that manoeuvre the healthy section of faulted feeder to its companion feeder was succeeded. The recloser and switches have also a good performance on ground fault at variable fault resistances.

Finally, there are significant improvements in reducing SAIDI and SAIFI of the tested feeders satisfactorily; even this system has used no communication facility.

Acknowledgments
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