A Novel Hybrid Fault Location Sensor Employable to the Power Transmission Systems

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가공 송전선의 사고 및 낙뢰 검출을 위한 새로운 하이브리드 센서

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Abstract : *In this work, a novel hybrid FL sensor consisting of two Rogowski coils has been designed for the* installation on the ground wire of the transmission tower. The operation range of these coils is as follows: 30kA for the fault current comingfrom the ground fault or short-circuit and for the lightning current up to 150kA over 500kHz. Thus, two important functions could be provided: one is to detect the fault current and the other one is to find the fault location between towers or the location of induced lightning stroke. The on-site investigation at 800kV test yard has been under progress for its on-site application.

Key Words : Fault location(FL) detector; Fault current sensor; Rogowski sensor; lightning stroke detector

1. INTRODUCTION

In these days, the rating voltage and capacity of the power component are now being highly raised in order to meet the rapid increase in electric energy demand. In addition, transmission and distribution networks are easily subject to the faults induced by various causes such as abnormality of weather, service failures, accidents and etc. And it is admitted that the fault probability of the overhead transmission lines is higher than that of the other power components in power system [1]. Thus,it has been practically required to detect the fault location more precisely in order to avoid the long outage time for the customer, and severe economic losses for repairing the damage and restoring the apparatus in trouble[2-5]. And also the fault location (FL) of the transmission line can be done by detecting the fault current induced on the ground wire.

In this work, we have proposed a novel hybrid FL sensor, based on the Rogowski coil[6-9], that could be installed on the ground wire of the transmission tower and also enable to inform two important factors: one is the measurement of the current due to the grounding fault or short circuit fault. The other one is a discrimination of the fault location between towers or the location of lightning stroke by measuring the lightning current since the sensor operates for ~150kA up to over 500 kHz. Moreover, experimental investigations show that the measurable range of fault currents is proved to be up to 30kA and the propagating direction of the faultand the lightning stroke current induced on the overhead ground wire could be identified.

In consequence, it can be pointed out that the proposed novel FL sensor seems likely to be applicable to the real power transmission line.

2. NOVEL SENSOR AND EXPERIMENTS

The principle of Rogowski coil has been known since 1912[6]. A Rogowski coil is a uniformly wound coil of constant cross-sectional area on a nonmagnetic core of shaped into closed loop, that is, an air-cored toroid around the current conductor to be measured. The voltage V induced in the end of Rogowski coil is directly proportional to the rate of change of time-varying current I passing through the loop. And V is theoretically independent of the loop shape or the position of current within the air-cored toroid, and given by the equation (1)[8][9].

$$V = \sqrt{2}\,\omega M I_{RMS}\cos(\omega t + \phi) \qquad (1)$$

In this work, EMD-Rogowski winding machine has been specially developed to fabricate two different types of Rogowski coils (Model RCS25KR) to measure the fault

currents and to detect lightning strokes respectively. The former enables to measure the magnitude and the waveform of the fault currents caused by the ground fault and short-circuit fault and also to identify the direction of the fault point or faulted section. The latter makes possible to distinguish the directionor the damaged section by lightning stroke. And also the output of the FL sensor, with metal housing, as shown in Figure 1, is also provided to make the system insensitive to the locations of the conductor inside the toroid. Moreover, the coils are designed to be immune to the external magnetic fields caused mainly by nearby conductors

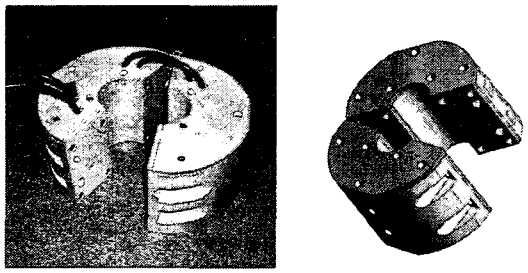

Figure 1 Self designed Rogowski coil of Novel Hybrid FL Sensor (RCS25KR, EMD Lab.)

3. RESULTS AND DISCUSSION

In connection with the fault current, the accuracy of the output of this sensor is observed to be in the range of 1~2% in response to 25kA of short circuit current, for which the output of the coil is appropriately treated[10].

Considering such accuracy, the sensor could restore the waveform of the fault currents taking place at the power system.

Regarding the identification of the stroke location, impulse current (4 kA, 4/10μsec) has been applied and two signals of the coil output from opposite direction are shown in Figure 2 where their symmetry can be well observed.

In order to verify the response of the coil output of the sensor to the higher lightning stroke currents up to tens of kA, impulse generator (Model L series, HIGH VOLT, 800kV, 50kA) has been used and the response to 43kA is shown in Figure 3.

Based on those results in Figure 2 & 3, it could be pointed out that the coil output signals are treated according to our technology in order to distinguish the propagation direction of the lightning stroke by which the polarities of the sensor are well determined.

4. CONCLUSION

Some remarks based on the results could be summarized as follows:

- The prototype sensor enables to measure fault current of tens of kilo amperes with an accuracy of 1~2%. Thelocation of ground fault and short circuit fault could be identified by detecting their traveling directions.
- The propagation direction of the lightning stroke could be distinguished and thus the stroking point could be identified.

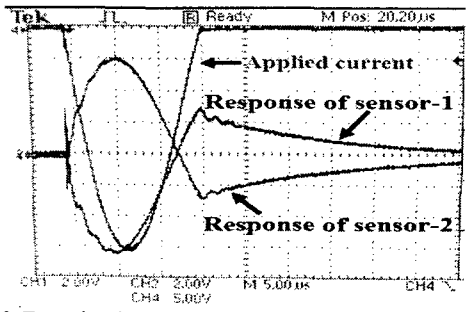

Figure 2 Two signals of the coil output from opposite direction

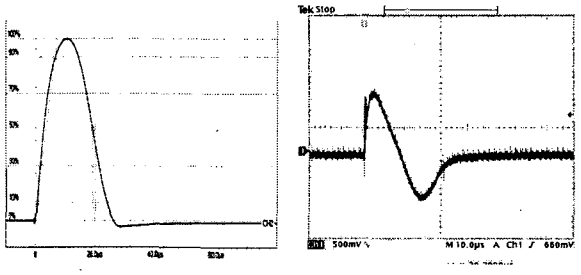

Figure 3 Response waveform of Rogowski coils without integrator (Applied current : 43.6kA, 7.56/19.4 μsec)

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