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SUMMARY

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Study about Coil Matching Method of Contactless Power Supply System for Underwater Vehicle in Seawater

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It is demanded that electric power is supplied to Underwater Vehicle (UV) in seawater for UV user. For this, power supply station in seawater has been developed. The station is a contactless power supplying device that can supply electric power underwater using electromagnetic induction. The station equipped with multiple coils. However, only one pair of coils is used for power supply. Therefore, it is necessary to determine the best coil pair for the power transferring. This operation is called "matching". In this project, a system is discussed that implements coil matching by measuring of degree of coupling. The system was estimated with experiment using the prototype.

Keywords: contactless power transfer, electromagnetic induction, underwater power supply station, multi-coil, coil matching

1. Introduction

The system has been developed to charge UV's battery by installing a power supply station on the ocean floor or in the sea. This power supply station uses contactless power transferring technology based on electromagnetic induction. Multiple and multilayer coils are arranged in the power supply station. Multiple coils are loaded in UV, too. However, it is necessary to find the best coil pair for power transfer since only one pair of coils is used for transferring and receiving power. Therefore, a "matching" method to determine the best coil pair became necessary in this project. For the project, the method was estimated with experiment by using prototype.

2. Matching System Outline

The best coil pair for transferring power is found by matching operation. It can transfer electric power in the highest efficiency. Several methods can used to determine the "best coil pair". For example, there is a method of judging best coil pair from position where UV landed on the power supply station. However, in order to operate this method, the matching system must accurately grasp the landing position of UV on the station, the head direction of UV, and the position of coil installed on the UV. For measurement these data, Optical sensor, acoustic sensor and camera can be used. In a current technology, it is difficult to measure the position with high precision implementing for the coil matching. Also, the station which author assume aims to be able to supply power regardless of function or type of UV. If the station target several types of UV for the power supply, it must grasp in advance the positions of coils mounted on all UVs. Further, the station must be able to distinguish a type of UV that landed on the station. Fulfilling all these requirements is extremely difficult. In other words, the method of finding the best coil pair for the power transferring from position where UV landed on the station cannot be adopted.

This project adopts the method that judge the best coil pair by measuring coupling coefficient. The degree of coupling between power transferring and receiving coils greatly affects the power transferring efficiency. In other hand, the "best coil pair" is determined by comparing a degree of coupling. This degree of coupling is expressed by numerical value called the coupling coefficient. The coupling coefficient is a value calculated by ratio of receiving voltage and transmitting voltage. Therefore, the best coil pair can be determined by setting transferring side voltage constant and measuring the receiving side voltage. Thus, in order to measure the coupling coefficient, it is necessary only to add a measuring

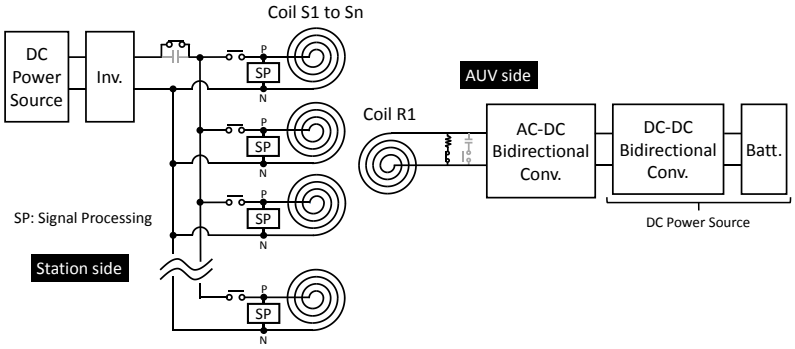

Fig. 1-a Main circuit of prototype.

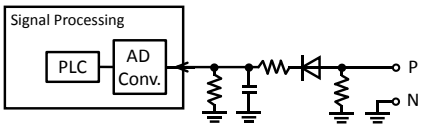

Fig. 1-b Details of SP blocks.

circuit to a main circuit which is used for power transferring and receiving. As a result, the matching system will be simple. The station doesn't need have the information of UV in advance since there is no need to specify the type of UV. Regardless of UV function, only installation of the power receiving system is necessary to perform the matching and the power supply by the same protocol. In this way, the high versatility the authors aim for can be implemented

3. Prototype Outline

The same main circuit is used for the power transferring and the coil matching. However, since necessary function are different, the circuit configuration is changed. Resonant capacitor is connected to the main circuit during the power transferring. Due to this, the circuit can transfer high power in the serial-parallel resonant state. However, the capacitor is disconnected since there is not necessary to transfer high power during matching operation. When the capacitor is disconnected, the circuit is in non-resonant condition, so the transferring power is equal to or less than 1/1000. The voltage transferred in this condition is used as signal. The system measure and compare the coupling coefficient using this signals transferred in this way.

A system that the UV side has one coil and the station side has multiple coils was developed and discussed as prototype (Fig.1-a). Fig.1-b shows the circuit in SP (Signal Processing) block shown in Fig.1-a. In this study, the circuit configuration in SP block only purposes measurement of receiving voltage since only matching is performed. When the UV side coil is more than one, SP block is installed on UV side also. Judging of the best coil is performed on the station side only since there are only one coil on the UV side. For this reason, the UV side sends signal to the station side in order to find the best coil on the station side for the power transferring. When there are multiple coils on the UV side, the system also need to judge the best UV side coil. In this case, both the UV side and the station side send signal each other. In this way, one best coil is found both on the UV side and the station side.

4. Experiment Outline

Fig.2 is photograph of experimental setup to verify the matching method mentioned above. This experimental device simulates both the UV and the station. XY-coordinate are set on the station of this device. The UV side coil can move freely on its coordinates. In the experiment, the UV side coil moved to each coordinates and the coupling coefficient is measured. Basing on this measurement, it is possible to determine whether the system can reliably find the best coil pair for the power transferring by comparing the result of automatic coil selection by the system with data that author achieved in advance. Thus, the validity of the system can be evaluated. When the UV side has only one coil, the matching can be completed with simple operation only. However, if UV side has multiple coils, it is expected that the system and operation protocol will become more complex. Hence, the optimization of the matching system will be planned through this experiment.

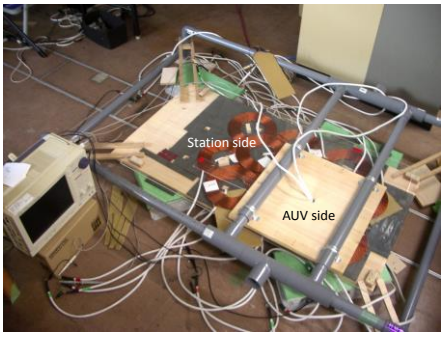

Fig. 2 Prototype of contactless power supply system.