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Multi-Input Long-Distance HTS-Based Wireless Charging System for Undersea Sensor Networks

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Abstract – The future trend of sensor nodes is intellectual, energy-efficient, and with a perpetual lifetime. With ever-increasing requirements in a wide area of detection and high accuracy of measurement, the sensor networks must be built with extensive coverage, and often installed in some places that are tough to be reached. This paper presents a high-temperature superconductor (HTS) based wireless charging system for undersea sensor networks. With proper current control of multiple transmitters and the use of designed HTS coupler, the system controllability is greatly improved compared to traditional wireless power transfer (WPT) systems. Based on the information of impedance characteristics at the primary side, the magnetic field generated by different transmitters can be maximized at the target position. Thus, the maximum output power tracking can be realized with a relatively long transmission distance. Hence, it is particularly attractive to install the proposed system in one or several engineering ships to remotely charge a large area of undersea sensor networks. The system can tremendously reduce the cost for the undersea operation of battery replacement for a large number of sensor nodes.

I Multi-Input Wireless Charging System

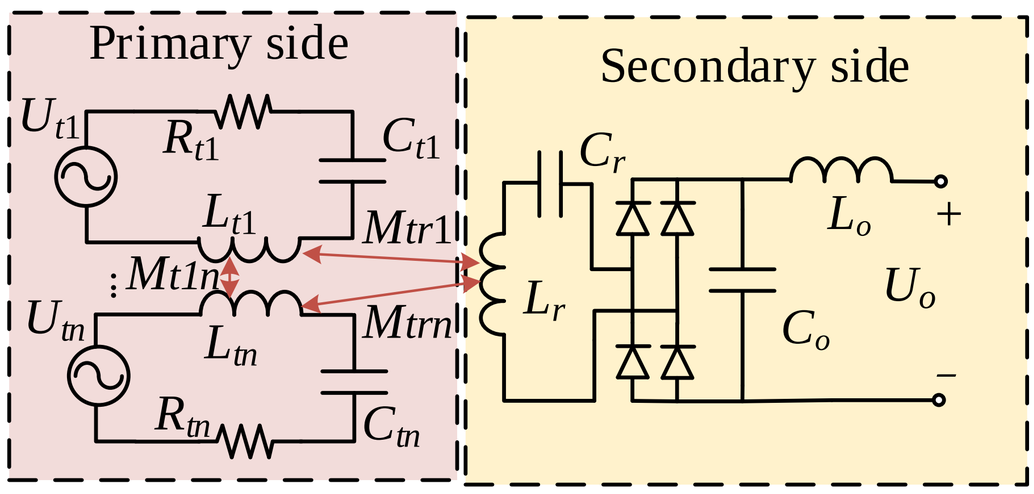
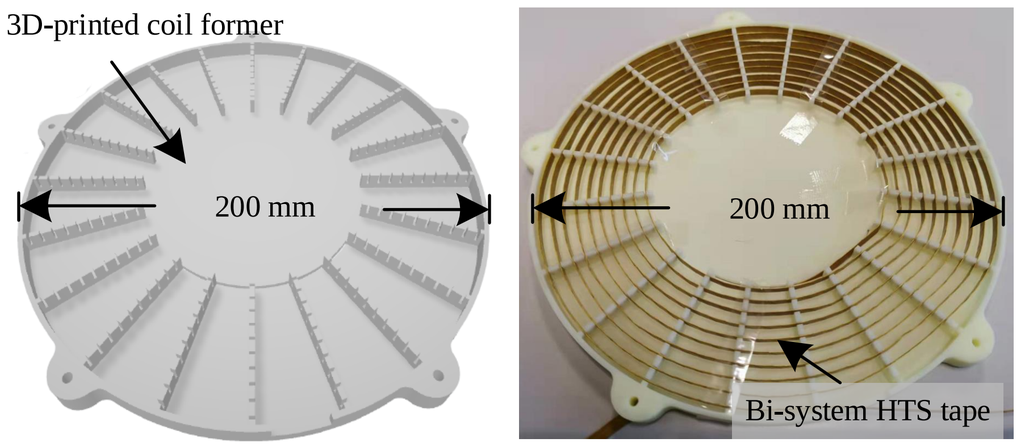


Fig. 1. Circuit topology.



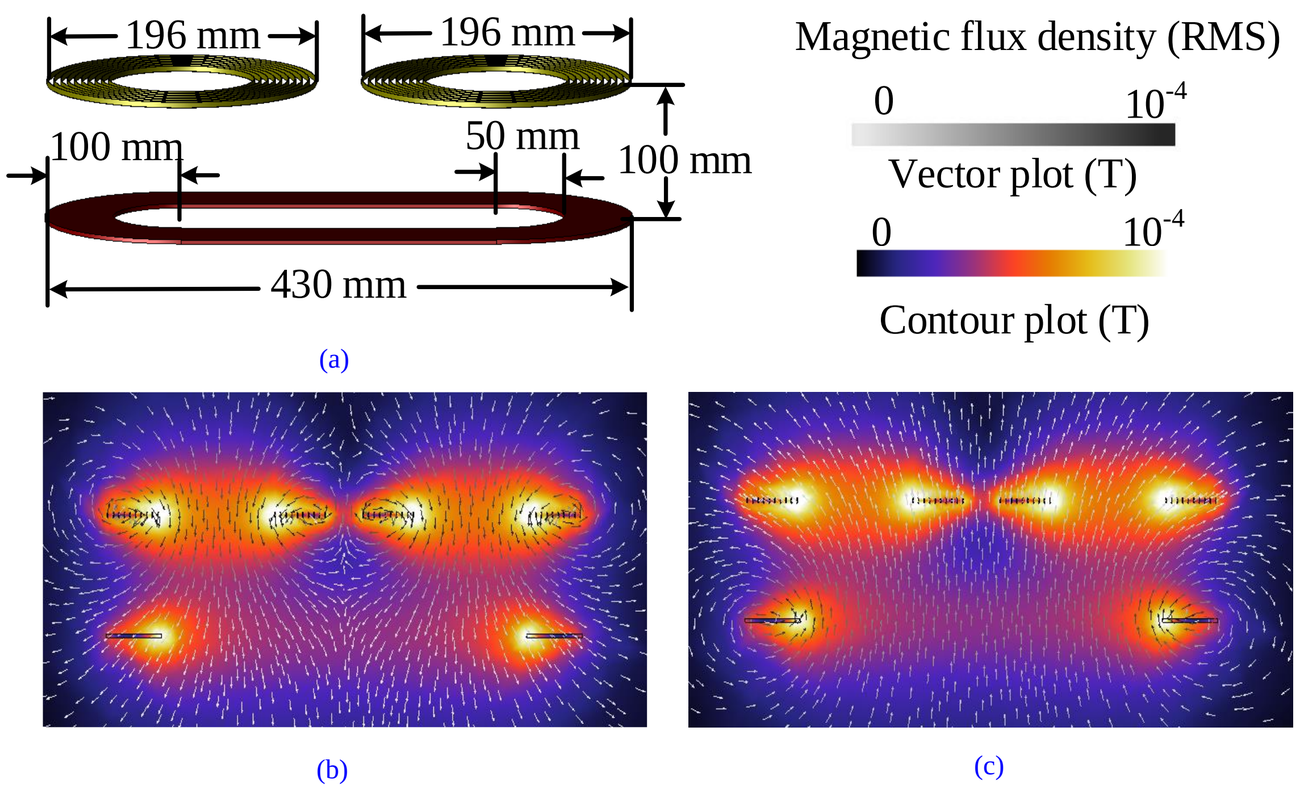
(a) (b)

Fig. 2. Coil design for HTS-based wireless charging system. (a) 3D printed coil former. (b) Practical fabrication.

Table. I
Parameters of HTS transmitter prototype

Item	Value
Material	Bi-system HTS tape
Thickness × width	0.5 × 4 mm
Number of turns	10
Inner radius	53 mm
Interturn gap	4.5 mm
Outer radius	98 mm
Tape length	4.2 m

II Magnetic Profile



(a)

(b) (c)

Fig. 3. Electromagnetic field analysis with identical input currents. (a) System configuration; (b) Magnetic flux density at 0° phase angle; (c) Magnetic flux density at 90° phase angle.

III Conclusions

Based on the energy beamforming technology, this paper proposes a multi-input long-distance HTS-based wireless charging system for undersea sensor networks. The Bi-system HTS tape material is utilized in the coupler coil design to reduce the AC losses and further improve the system efficiency. Firstly, the theoretical analysis of energy beamforming of multiple transmitters has been conducted. Based on the different input impedance characteristics of the transmitters, the optimal current vector can be easily obtained to realize the maximum output power tracking. All the measurements can be conducted from the primary side and no need for extra information feedback from the receiver. Additionally, the system prototype has been built, and the experimental platform is established for practical tests. Both the finite element analysis and experimental results validate the effectiveness of proposed system, as well as its feasibility in practical applications.

Note: More details please refer to the full paper or contact the author via xytian@eee.hku.hk