Linear Motion Type Transfer Robot using the wireless power transfer system

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***Abstract* - Linear-motion transfer robots are wired to receive power via a sleeve commonly known as Cableveyor. The Cableveyor system has two drawbacks: power losses due to their weights and breaks in wire. To solve these challenges, we are working on the development of a wireless transfer robot. This robot has feature to reduce its radiation noise by utilizing the double-peak feature of magnetic resonance.**

***Index Terms* — Wireless power transfer, class-E, Transfer Robot,**

1. Introduction

Linear-motion transfer robots are wired to receive power and signals via a sleeve commonly known as Cableveyor. The Cableveyor system has two drawbacks: (1) Cables and Cableveyor suffer from power losses due to their weights and (2) breaks in wiring require maintenance man-hours.

To solve these challenges, we are working on the development of a wireless transfer robot that combines a wireless power transfer (WPT) system and wireless communications [1]. This paper reports on a prototype WPT linear-motion transfer robot that uses wireless power transfer at a rating of less than 50 W.

2. WPT System for Linear-Motion Transfer Robot

The WPT linear-motion transfer robot may be constructed such that the receiver coil moves over multiple transmitter coils to receive power. This structure requires a system that reduces undesired radiation by feeding power only to the transmitter coil on which the receiver coil is present. Detecting the receiver coil requires sensors or other similar devices, possibly resulting in an increased cost.

As a solution to this problem, this paper proposes a structure that avoids the use of a sensor or other similar device, by selecting a magnetic resonance system for wireless power transfer and utilizing the property that exhibits a double-peak feature, rather than a single-peak feature, in frequency characteristics due to magnetic resonance.

More specifically, use of a resonant frequency (e.g. even-mode frequency) of double-peak feature for power transfer makes the magnetically resonant transmitter coil a low-impedance coil. In contrast, transmitter coils that are not magnetically resonant have a different resonant frequency, turning themselves into high-impedance coils. Thus it becomes possible to feed power selectively to the transmitter coil at which the robot is present (Fig. 1). This sensorless arrangement reduces undesired radiation.

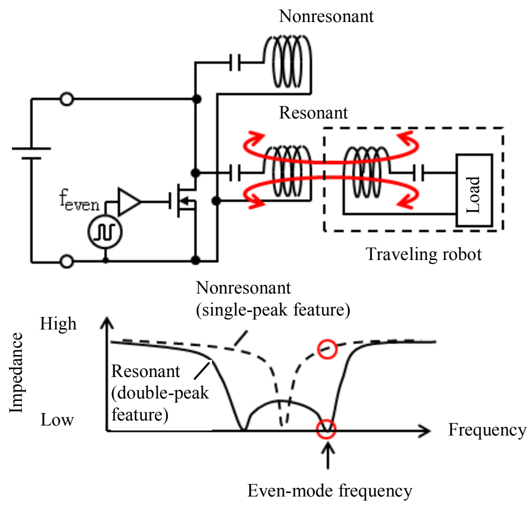

Fig. 1. Power feed system incorporating two transmitter coils

3. System Feasibility Verification (Simulation)

The following discusses a circuit configuration that achieves the aforementioned circuit characteristics. The Class E DC-DC converter circuit configuration used in the present study has already been studied, delivering efficiency of 70.6% and an output of 43.8 W[2]. However, while in the existing study, a Class E inverter and a Class E rectifier were placed symmetrically, the structure discussed in this paper features multiple transmitter coils, making it inappropriate to use the results of the existing study without any adaptation.

As a solution to this challenge, we formed a model circuit comprising a Class E inverter with two transmitter coils (L1 and L2) and a Class E rectifier with receiver coil l1 opposed to transmitter coil L1 to simulate and verify the model's feasibility (Fig. 2).

The simulation results verified: (1) The circuit configuration discussed in this paper works as a Class E DC-DC converter as ascertained by the VDS waveforms of Class E inverter[3] and (2) it is possible to achieve an intended reduction in undesired radiation from transmitter coils, as revealed by comparing the current I1 of transmitter coil L1 with the current I2 (Fig. 3).

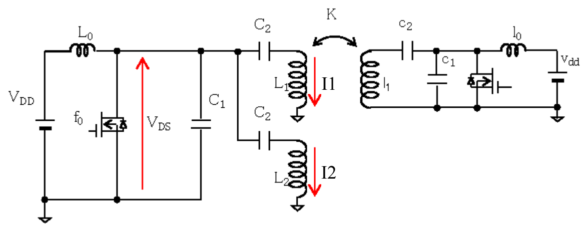

Fig. 2. Simulation model

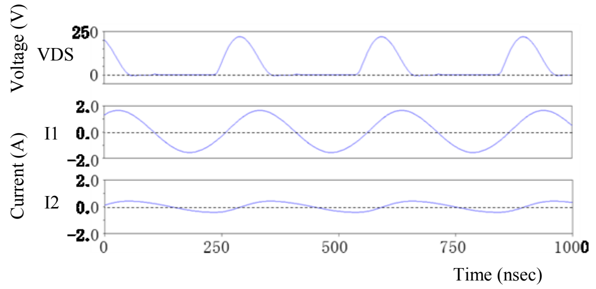

Fig. 3. Simulation results

4. WPT Linear-Motion Transfer Robot

The prototype WPT linear-motion robot was configured, as follows (Fig. 4):

Actuator
x-axis rail (1000 mm) traveling stepping motor
z-axis rail (100 mm) traveling stepping motor
Robot hand
Controllers
Two stepping motor controllers
I/O contacts (16 ch), small robot controller
Bluetooth module
WPT system
Class E inverter, Class E rectifier
Transmitter coils (dimensions: 500 mm x 50 mm, 2 units)
Receiver coil (150 mm x 50 mm)

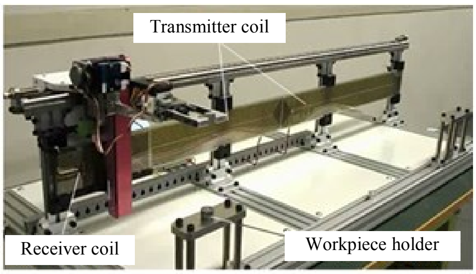

Fig. 4. WPT linear-motion transfer robot

5. Radiation Noise Test

We measured radiation noise emitted by the prototype WPT linear-motion transfer robot at the maximum power rating (36 W) (Fig. 5). Noise (at levels from 100 to 110 dB µV/m) from the transmitter coil opposed to the receiver coil was distributed up to X = 170 cm in parallel with the transmitter coil. In comparison, for the transmitter coil not opposed to the receiver coil, in response to Y = 0 → 100 cm, noise distribution (at levels from 100 to 110 dB µ V/m) changed as follows: X = 170 cm → 55 cm. These results verified the normal operation of the newly devised technique in dealing with undesired radiation.

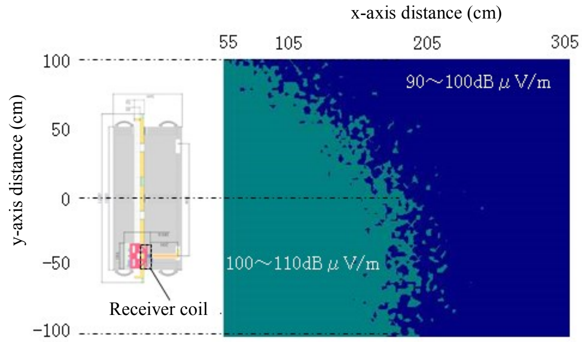

Fig. 5. Radiation noise distribution with WPT in operation (load power: 36 W)

6. Conclusion

This paper demonstrated that in an arrangement in which a receiver coil travels across two transmitter coils, it is possible to reduce the current supplied to the transmitter coil not opposed to the receiver coil and to suppress its radiation noise by utilizing the double-peak feature of magnetic resonance.

The prototype WPT linear-motion transfer robot avoids the use of Cableveyor by wireless transmission of power and signals via a WPT system and Bluetooth.

References

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