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Experiment of Microwave Power Transmission to the Moving Rover

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1. Introduction

From an idea and first experiment of wireless power transmission (WPT) by Nicola Tesla at the beginning of the 20th century[1], many kinds of the WPT experiments via microwave (microwave power transmission ; MPT) have been carried out in the world[2][3], especially for the future hopeful power station in space called SPS (Space Solar Power Satellite/Station). In Japan, USEF(Institute for Unmanned Space Experiment Free Flyer) conducts the SPS research project from FY2000[4].

Recently, we can apply the MPT technologies not only for the SPS but also wireless power transmission on ground, especially for moving target. The USEF conducts the MPT experimental project from FY2004. The target of the project is (1) development of very light power-weight-ratio microwave power transmitter with AIA (active integrated antenna) technologies (below 50g/W target), (2) advancement of power management of rectified microwave power at rectenna, receiver and rectifier of the microwave power, especially against change of connected load, (3) fundamental experiment of coexistence of 100W microwave and 10mW wireless communication waves. Frequency is 5.8GHzCW. For the target of the project, we chose a moving rover with wireless microwave power. We report the experimental results in this paper.

2. System

Figure 1 shows the experimental system. The system block diagram is indicated in Fig.2. The experimental system is composed of the microwave transmitting sub-system, microwave receiving sub-system, and rover and controlling sub-system. The microwave transmitting sub-system was mainly developed in Kyoto University. The microwave receiving sub-system was mainly developed in IHI Aerospace. The rover and controlling sub-system was mainly developed by Jisedaitech L.P..

2.1. Microwave Transmitting Sub-system

The characteristics of the microwave transmitting sub-system are as follows ;

- 32 element AIA with linear polarized rectangular microstrip antenna array and 4W output 3-stage high power amplifiers on bent di-electric base for expand cooling area
- Microwave power source with pre-amplifier and power dividers

ISBN: 978-4-88552-223-9 C3055©IEICE

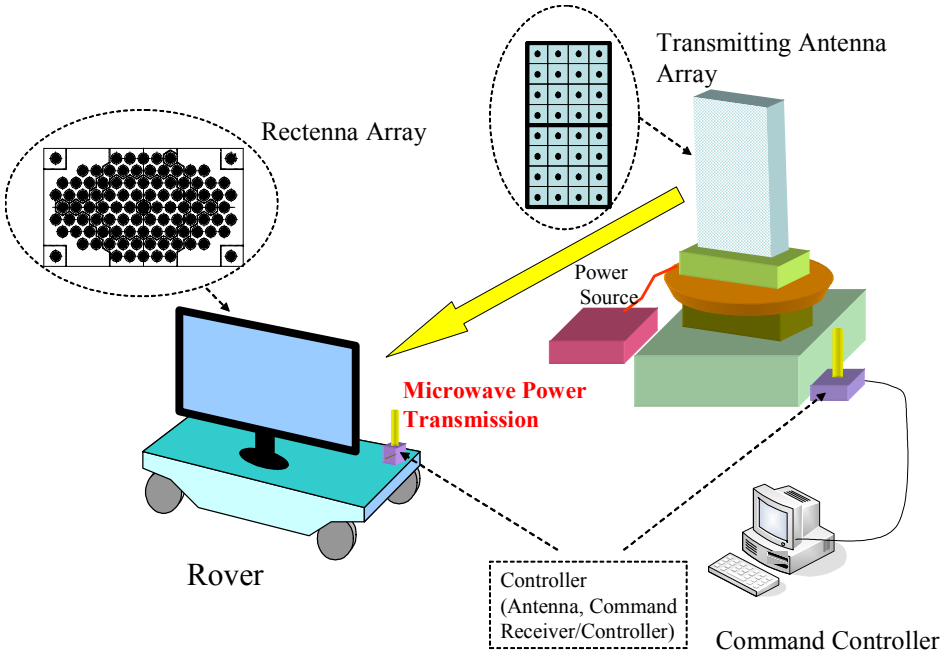

Fig.1 Experimental System of MPT for Moving Rover

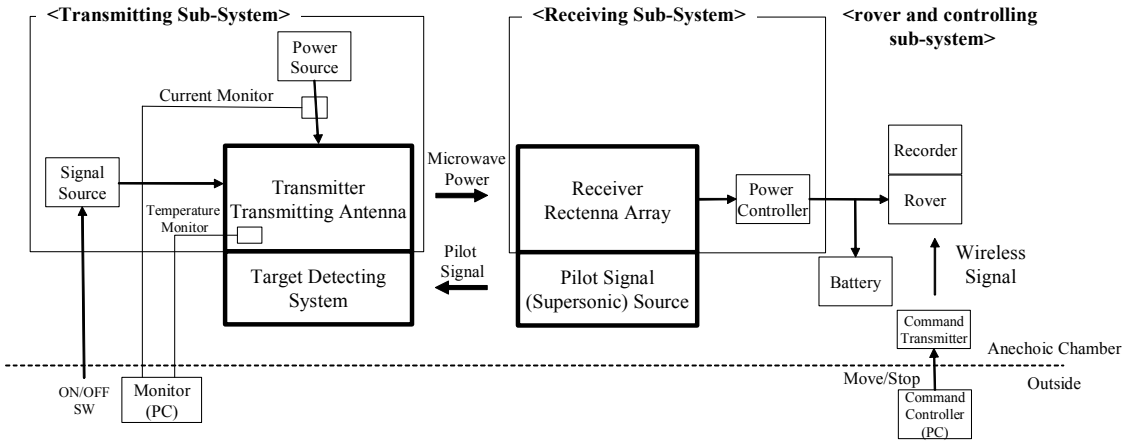

Fig.2 Block Diagram

- Fans for cooling
- DC Power controller for FETs
- DC power source for all elements

AIA is suitable for small and light weight microwave transmitter because the AIA is all integrated antenna and circuits. Figure 3 shows developed microwave transmitting sub-system with 32 AIAs of approximately 120W 5.8GHzCW output. Total weight of the 120W system is approximately 4kg and power-weight-ratio is approximately 33.3g/W. This power-weight-ratio is lightest in the previous microwave power transmitter with semi-conductors. The volume of the sub-system is 0.0544 x 10^{-3} m^3 (0.17 x 0.12 x 0.32 m). Beam pattern is shown in Fig.4.

2.2. Microwave Receiving Sub-system

The microwave receiving sub-system is designed and developed as following specifications ;

- Rectenna arrays on 3 panels on which rectennas are connected in parallel and 3 panels are connected in series
- Stabilized 6V DC output of rectennas through DC/DC converter for higher efficient rectifying of the rectenna
- Lead storage battery for buffer of change of connected load (DC motor)

Figure 5 shows the developed rectenna array and power controller.

Fig. 3 Developed microwave transmitting sub-system with 32 AIAs n bent di-electric base for expand cooling area

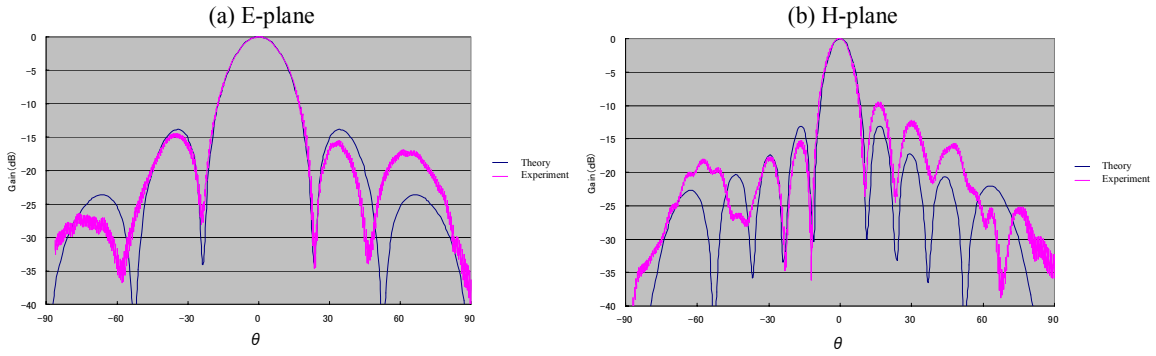

Fig.4 Beam Pattern of 32 AIA array

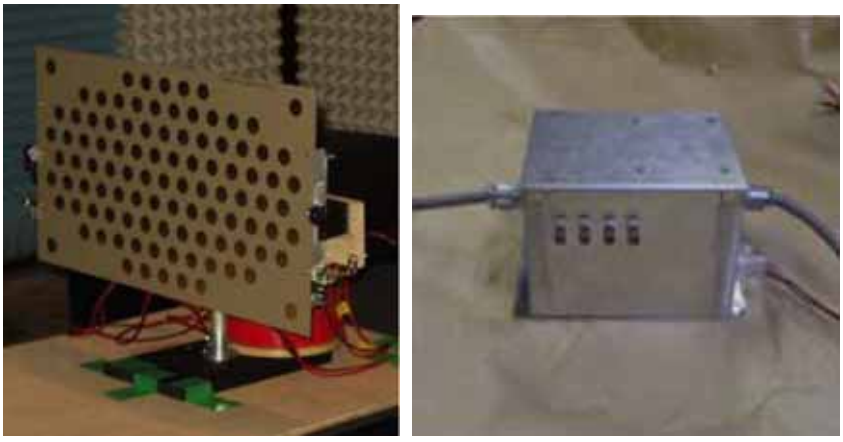

Fig. 5 Developed rectenna array and power controller

2.3. Rover and Controlling Sub-system

This sub-system is composed with rover and target detecting system with supersonic wave and small turn table. Figure 6 shows the rover with recorder, micro computer for controlling, battery, and rectenna array. The weight without rectenna array is approximately 10 kg. It has line trace function and it can move automatically on the fixed line.

The turn table can chase the position of the rover with the supersonic wave from the rover. This system is on the market for home video camera.

2. Experiment

We have succeeded in moving the rover with chasing microwave power. Figure 7 shows the experimental setup. Figure 8 indicates the power history during the power transmission. Total

power of microwave power feed/battery consumption is increased as time goes by and it indicates that transmitted microwave power is larger than the consumption in the moving rover. Therefore, theoretically, the rover can move only with microwave power.

Fig. 6 Rover

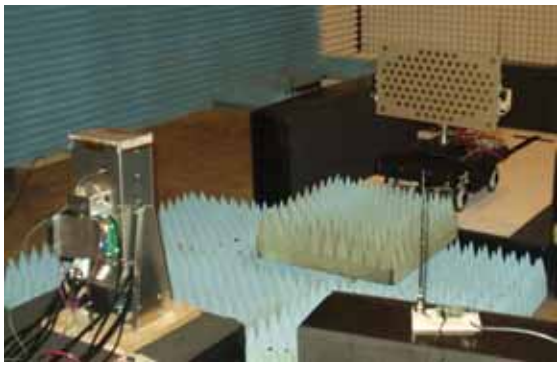

Fig. 7 Experimental Setup

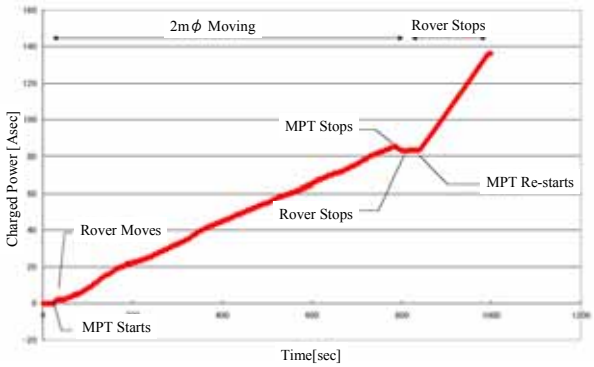

Fig.8 Time Dependence of Total power of microwave power feed/battery consumption

3. Conclusion

We developed experimental system of microwave power transmission to the moving rover. We achieved 33.3g/W of 5.8GHz 120WCW 32 AIAs, (2) advancement of power management of rectenna with DC/DC converter and buffer battery, (3) successfully coexistence of 100W microwave and 10mW wireless communication waves. These results force the MPT technology to next step and finally to SPS.

Acknowledgments

This study was subsidized by the Japan Keirin Association through its Promotion Funds from KEIRIN RACE and was supported by the Mechanical Social Systems Foundation and the Ministry of Economy, Trade and Industry.

Experiment in the present study was carried out with the METLAB system of Research Institute for Sustainable Humanosphere (RISH) at Kyoto University as a collaborative research project conducted by Institute for Unmanned Space Experiment Free Flyer (USEF).

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