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# Study for wireless power transmission of nuclear robot system

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## 1. Introduction

Due to radiation environment, access area and working time in nuclear power plant are limited. If this radiation environment is situated under accident, access to accident area will be strictly restricted. If plant operator is unable to monitor the field condition due to malfunction or damage of monitoring system, movable monitoring system such as robot need to be dispatched into plant inside.

Robot needs energy supply for walking, monitoring and communication. Gasoline engine or electric motor is generally used for driving power of working. Gasoline tank is uncomfortable to carry. Battery capacity does not sustain long time working. Frequent moving back of robot to power charger or refueling tank is inconvenient. Long power cable connection occur winding problem if there are complex structures in walking way. We need some solution for continuous supply of robot energy at the free moving condition of robot.

'Wireless power transmission' is one of the solutions. Some experiment result to transmit wireless power to moving robot is described herein.

## 2. Methods and Results

### *2.1 Wireless power transmission method*

There are magnetic induction, magnetic resonance and radio wave emission methods in wireless power transmission as shown on Fig. 1[1].

'Magnetic induction' transmits wireless power by using magnetic induction between transmission coil and receiving coil. This method can increase transmission distance of wireless power when equip the ferrite core in the transmission and receiving coils.

'Magnetic resonance' transmits wireless power by using resonance between coils. It was known to transmit wireless power as far as 2m distance. Balancing of resonance between transmission and receiving coils is know-how of this method.

'Radio wave emission' transmits wireless power by using radiation. This method transmits wireless power to long distance target. High power micro wave emission has been studied for long time for long distance wireless power transmission between photovoltaic power space station and earth.

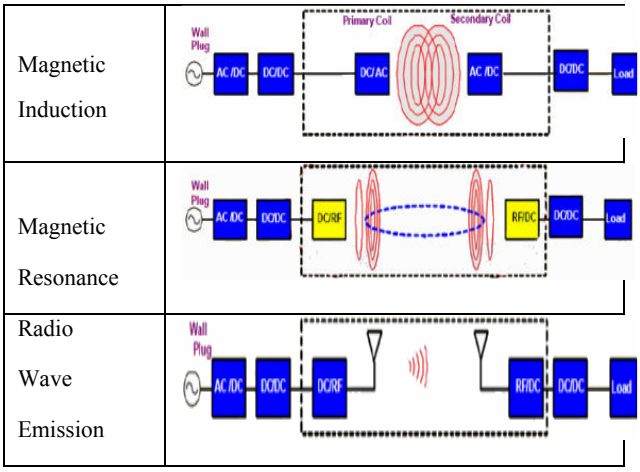


Fig. 1. Wireless power transmission method

### *2.2 Applicable wireless power robot in NPP*

#### 2.2.1 Flying robot

Flying robot is the fastest way for visual monitoring of containment inside. Since weight of flying body is key factor for flying time, small battery is equipped in the flying robot. This small battery serves a few minutes flying. Flying robot has to return to charging station after short time flying. Monitoring can't be performed during this blank time

If the flying robot can charge the battery at the flying condition, continuous monitoring will be possible. Fig. 2 shows a concept of wireless power transmission to flying robot. According to the KAIST research result, this method is verified to have 36.9~9.2% power transmission efficiency at the distance of 3~5m[2].

#### 2.2.2 Working robot

Working robot will be used for hatch opening and turning of valve handle for open or close of piping system. Since working robot consumes high power, charging efficiency is more important than wireless distance. Fig. 3 shows a concept of mat type wireless power supply. Working robot can charge the battery during stay or walking on the mat. Wireless power receiver is equipped on the foot of the working robot. Transmitter and receiver

maintain 0.2cm gap during power transmission. This method has almost 90% charging efficiency compared with that of cable line charging.

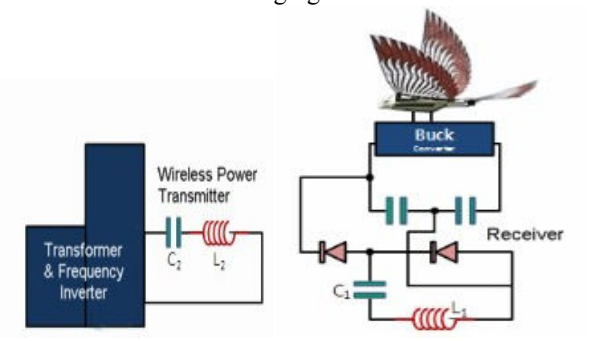


Fig. 2. Concept of wireless power for flying robot

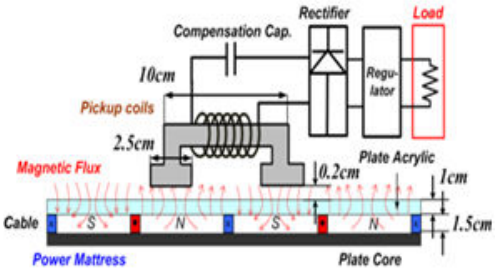


Fig. 3. Concept of wireless power for working robot

*2.3 Test result of wireless power robots*

2.3.1 Flying robot

Transmission part of wireless power consists of horizontal type coil with 5m ferrite core inside. Receiving part consists of 30cm horizontal coil of 210 times winding and core.

'Cybird' flying robot is used for demonstration of wireless power transmission. 7.4V 18W is estimated for minimum operation power of the 'Cybird' wing motor. Fig.4 show dipole type wireless power experiment device

As result of wireless power transmission test, it was verified that 18W power was received when it transmits 100W power at a distance of 4.3m. 46W was received when it transmits 100W at a distance of 2m. 46W power made wing operation of 140times per 1 minute. Efficiency of wireless power was dependent on the distance between transmitter and receiver.

Since dipole type transmitter has no directivity for radio wave, transmission efficiency was very low

2.3.2 Working robot

'Metal fighter' two leg walking robot was used for test of mat type wireless power transmission. Power receiver was installed on the bottom of robot foot. Battery was removed to show that the robot work only by wireless power transmission. Test time was limited to 1 hour since no further test was meaningless. It was verified that 18.6W was received when 20W was sent. Fig. 5 show mat type wireless power experiment device.

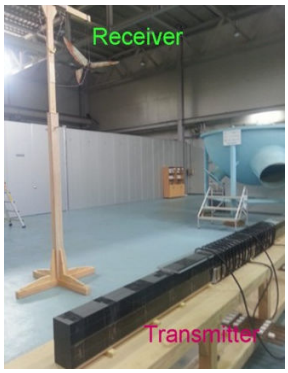


Fig. 4. Dipole transmission

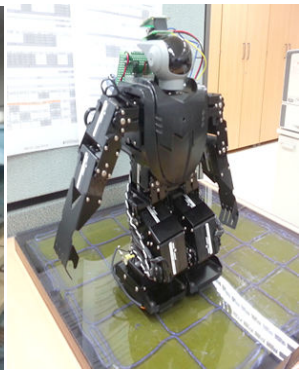

Fig. 5. Mat transmission

## 3. Conclusions

To find possible wireless power transmission method for nuclear robot, wireless power transmission tests were performed. As result of these tests, it was confirmed that wireless power transmission by using dipole and mat type magnetic induction were possible.

As result of flying robot experiment, it was realized that development of light weight core for receiver and wave reflection device for high directional transmitter are necessary for practical use of the dipole type wireless power transmission. Small size core and high directional transmitter will be next target.

Mat type wireless power transmission is regarded as useful for robot power charging station in the inside containment.

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