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**APT SURVEY report on**

**wireless powEr transmission for moving machines**

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**APT Survey Report oN**

**wireless powEr transmission for moving machines**

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1. **Introduction**

Today, wireless power transmission (WPT) technologies are spreading to various applications such as robots, electric carts, electric wheelchairs, electric housewares, drones, IoT, and so on. Recently, as the demand for untact (un + contact) service has increased due to COVID-19, the use of delivery robots and drones is rapidly increasing and the adoption of wireless charging technologies for those is becoming important.

As the development and use of moving machines such as robots and drones are increased, there may be a need for work on wireless charging for the moving machines. As a first step for the work, it would be desirable to know the current status and future plan of the use of WPT on the moving machines in the APT members. A survey is a one way to collect various wireless charging technologies for moving machines under review and development in APT countries and exchange related information e.g. technologies, frequency bands and technical regulations.

Moving machines within the scope of this survey are

- A mechanically, electrically, or electronically operated device for performing a task which provides various services in human life

- Possible applications can include, but are not limited to, housework, life support, light transport, cleaning, entertainment and etc.

- Moving machines can include, but are not limited to, Automated Guided Vehicle(AGV), service robot, transport supporting robot (e-bike, wheel chair and etc.), drone and etc.

At the AWG-28th meeting, an agreement for submitting output document AWG-28/OUT-12 “Questionnaire on Wireless Power Transmission for moving machines” was approved in the plenary meeting.

The WPT for moving machines continues to be in a period of fast development and growth. Broader availability of WPT for moving machines will continue to play an important role and improving the consumer experience.

Given such circumstances, the APT Wireless Group (AWG) approved the Questionnaire on WPT for moving machines in AWG-28 meeting and circulated it to administrators thereafter. The questionnaire is intended to gather the information that if the listed frequency ranges are allowed for moving machines at moment. It’s also to collect service applications used for WPT for moving machines in APT countries

This Survey Report is developed based on the responses to the questionnaire from APT members. It is helpful to understand the regulatory status of WPT for moving machines in the Asia-Pacific region and can be a guide for further development of APT Recommendation(s)/Report(s). The responses are summarized in Chapter 3.

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1. **Terminologies and definitions**

**2.1 Definitions**

|  |  |  |
| --- | --- | --- |
| 1) | Wireless Power Consortium (WPC) | WPC is a group founded in 2008 to establish WPT standards and promote WPT. Major global electronic communication companies as well as mobile telecommunication providers are participating in the group, including Samsung and LG of South Korea. The brand name developed by this group is called “Chee” and denoted by “Qi”. |
| 2) | AirFuel | AirFuel is an interface standard developing organization for wireless electrical power transfer based on the principles of magnetic resonance. The air Fuel system consists of a single power transmitter unit (PTU) and one or more power receiver units (PRUs). The interface standard supports power transfer up to 50 watts, at distances up to 5 centimeters. The power transmission frequency is 6.78 MHz, and up to eight devices can be powered from a single PTU depending on transmitter and receiver geometry and power levels. A Bluetooth Smart link is defined in the Airele system intended for control of power levels, identification of valid loads and protection of non-compliant devices. |
| 3) | Automated Guided Vehicle (AGV) | An AGV system, or automated guided vehicle system, otherwise known as an automatic guided vehicle, autonomous guided vehicle or even automatic guided cart, is a system which follows a predestined path around a facility. |
| 4) | E-Mobility | Electro mobility (or e-Mobility) represents the concept of using electric powertrain technologies, in-vehicle information, and communication technologies and connected infrastructures to enable the electric propulsion of vehicles and fleets. |
| 5) | Society of Automotive Engineers (SAE) | SAE, formerly named the Society of Automotive Engineers, is a globally active professional association and standards developing organization for engineering professionals in various industries. Principal emphasis is placed on global transport industries such as aerospace, automotive, and commercial vehicles. The organization adopted the name SAE to reflect the broader emphasis on mobility. |

**2.2 Abbreviations and acronyms**

|  |  |
| --- | --- |
| AGV | Automated Guided Vehicle |
| ITU | International Telecommunication Union |
| ITU-R | ITU Radiocommunication Sector |
| SAE | Society of Automotive Engineers |
| Wi-Fi | Wireless-Fidelity |
| WPC | Wireless Power Consortium |
| WPT | Wireless Power Transfer/Transmission |

1. **Respondents**

Thanks to the responses from APT Members, the information is consolidated and hyperlinked to the corresponding input documents as provided below:

**Table 3.1 Received Survey responses**

|  |  |  |  |
| --- | --- | --- | --- |
| No. | Input document | Title | Source |
| 1 | [AWG-29/INP-28](https://www.apt.int/sites/default/files/2022/03/AWG-29-INP-28_Japan-Response_to_questionnaire_on_Wireless_Power_Transmission_for_moving_machines.docx) | Response to questionnaire on Wireless Power Transmission for moving machines | Japan |
| 2 | [AWG-29/INP-35](https://www.apt.int/sites/default/files/2022/03/AWG-29-INP-35_Republic_of_Korea-Response_to_questionnaire_on_wireless_power_transmission_for_moving_machines.docx) | Response to questionnaire on Wireless Power Transmission for moving machines | Korea (Republic of) |
| 3 | [AWG-29/INP-46](https://www.apt.int/sites/default/files/2022/03/AWG-29-INP-46_Republic_of_Indonesia-Response_to_questionnaire_on_wireless_power_transmission_for_moving_machines_0.docx) | Response to questionnaire on Wireless Power Transmission for moving machines | Indonesia  (Republic of) |
| 4 | [AWG-29/INP-62(Rev.1)](https://www.apt.int/sites/default/files/2022/03/AWG-29-INP-62Rev.1_China-Response_to_questionnaire_on_wireless_power_transmission_for_moving_machines.docx) | Response to questionnaire on Wireless Power Transmission for moving machines | China (People's Republic of) |
| 5 | [AWG-29/INP-92](https://www.apt.int/sites/default/files/2022/03/AWG-29-INP-92_Cambodia-Response_to_questionnaire_on_Wireless_Power_Transmission_for_moving_machines.docx) | Response to questionnaire on Wireless Power Transmission for moving machines | Cambodia (Kingdom of) |
| 6 | [AWG-30/INP-12](file:///G:\내%20드라이브\진행과제\0_표준%20업무\1_연차별%20표준화%20진행%20상황\2_2021_2025년\2_2022년\AWG%20업무\2022_0905_AWG%2030차%20TMP%20문서%20작성의%20건\수집%20INP\AWG-30-INP-12_Thailand-Response_to_Questionnaire_on_Wireless_Power_Transmission_for_moving_machines_0.docx) | Response to questionnaire on Wireless Power Transmission for moving machines | Thailand (Kingdom of) |

1. **Summary of Questionnaire Responses**

This section summarizes the responses from Japan, Korea, Indonesia, China, Cambodia and Thailand to the Questionnaire.

**4.1 Current situation of moving machines of most commonly used**

This is the response summary for **question#1**.

**Q1:**

Could you please list the three most commonly used Moving Machines in your country in order of priority?

1.1 Factory Automatic Logistics Transfer Machine (AGV)

1.2 Mobility assistance machines in living areas (E-Mobility, autonomous wheelchairs, etc.)

1.3 Automatic cleaning machine

1.4 A machine that guides places such as restaurants

1.5 Multimedia machine (machine dog, etc.)

1.6 Drone

1.7 Goods Delivery Machine

1.8 Fire-fighting assistant machine

1.9 Emergency patient transfer machine

1.10 Others (If the answer selects ‘others’, please describe what it is. )

The below table is a consolidated input based on the answers to the questionnaire.

**Table 4.1.1 Q1 Response Summary**

|  |  |  |  |
| --- | --- | --- | --- |
| **Current situation of most commonly used** | | | |
| Country/Region | 1st | 2nd | 3rd |
| Japan | 1.3 Automatic cleaning machine | 1.1 Factory Automatic Logistics Transfer Machine (AGV) | 1.4 A machine that guides places such as restaurants |
| Korea | 1.3 Automatic cleaning machine | 1.1 Factory Automatic Logistics Transfer Machine (AGV) | 1.2 Mobility assistance machines in living areas (E-Mobility, autonomous wheelchairs, etc.) |
| Indonesia | 1.6 Drone | 1.3 Automatic cleaning machine | - |
| China | 1.7 Goods Delivery Machine | 1.1 Factory Automatic Logistics Transfer Machine (AGV) | 1.3 Automatic cleaning machine |
| Cambodia | 1.1 Factory Automatic Logistics Transfer Machine (AGV) | 1.9 Emergency patient transfer machine | 1.6 Drone |
| Thailand | 1.3 Automatic cleaning machine | 1.4 A machine that guides places such as restaurants | 1.6 Drone |

**4.2 Expectation of near future situation of moving machines of most commonly used**

This is the response summary for **question#2**.

**Q2:**

Could you please list the three moving machines in order of priority that are expected to be used or discussed in the next few years due to their high need for use in your country?

2.1 Factory Automatic Logistics Transfer Machine (AGV)

2.2 Mobility assistance machines in living areas (E-Mobility, autonomous wheelchairs, etc.)

2.3 Automatic cleaning machine

2.4 A machine that guides places such as restaurants

2.5 Multimedia machine (machine dog, etc.)

2.6 Drone

2.7 Goods Delivery Machine

2.8 Fire-fighting assistant machine

2.9 Emergency patient transfer machine

2.10 Others (If the answer selects ‘others’, please describe what it is. )

The below table is a consolidated input based on the answers to the questionnaire.

**Table 4.1.2 Q2 Response Summary**

|  |  |  |  |
| --- | --- | --- | --- |
| **Expectation of near future situation of most commonly used** | | | |
| Country/Region | 1st | 2nd | 3rd |
| Japan | 2.2 Mobility assistance machines in living areas (E-Mobility, autonomous wheelchairs, etc.) | 2.6 Drone | 2.7 Goods Delivery Machine |
| Korea | 2.1 Factory Automatic Logistics Transfer Machine (AGV) | 2.2 Mobility assistance machines in living areas (E-Mobility, autonomous wheelchairs, etc.) | 2.9 Emergency patient transfer machine |
| Indonesia | 2.6 Drone | 2.1 Factory Automatic Logistics Transfer Machine (AGV) | - |
| China | 2.6 Drone | 2.4 A machine that guides places such as restaurants | 2.2 Mobility assistance machines in living areas (E-Mobility, autonomous wheelchairs, etc.) |
| Cambodia | 2.4 A machine that guides places such as restaurants | 2.7 Goods Delivery Machine | 2.3 Automatic cleaning machine |
| Thailand | 2.3 Automatic cleaning machine | 2.4 A machine that guides places such as restaurants | 2.6 Drone |

**4.3 Maximum WPT power for moving machines in a personal home**

This is the response summary for **question#3**.

**Q3:**

Could you please select the maximum transmission power in your country to be used for wireless charging of the Moving Machine in a personal space (home)?

3.1 15 W

3.2 60 W

3.3 200 W

3.4 1 kW

3.5 2.4 kW

3.6 3.3 kW

3.7 6.6 kW

3.8 11 kW

3.9 22 kW

3.10 Others (If the answer selects ‘others’, please describe what it is. )

The below table is a consolidated input based on the answers to the questionnaire.

**Table 4.1.3 Q3 Response Summary**

|  |  |
| --- | --- |
| **Country/Region** | **Answer** |
| Japan | 3.10 Others (Please refer to the specific comments in below) |
| Korea | 3.2 60 W (for Automatic Cleaning Robot) |
| Indonesia | 3.10 Others, Not yet specified |
| China | 3.10 Others, TBD |
| Cambodia | 3.10 Others, Not yet specified |
| Thailand | 3.10 Others , No related established regulation or policy |

**Japan**

In Japan, regulation on maximum transmission power for wireless charging does not depend on an area or space.

In Japan, there is a regulatory system to grant an individual installation permission to the application to use any frequencies for what is called ‘Equipment Utilizing High Frequency Current’, which may include WPT for moving machine. There is no upper limit to maximum transmission power. If the equipment applied to the MIC complies with the technical requirements stipulated in the Ministerial Ordinances of the MIC and if it is certified that the equipment does not cause interferences to other communications, the individual installation permission is granted.

The individual installation permission is exempted if such equipment complies with technical requirements for what is called ‘Type Specification’ for the ‘Equipment Utilizing High Frequency Current’.

The following WPT systems, which have been institutionalized to apply the ‘Type Specification’, may be used for wireless charging of moving machines:

(1) 6MHz band, magnetic field coupling type (maximum transmission power is 100W),

(2) 400kHz band, electric field coupling type (maximum transmission power is 100W).

However, no WPT product under the above category had received the ‘Type Specification’ by 1st February 2022.

**4.4 Maximum WPT power for moving machines in living area**

**Q4:**

Could you please select the maximum transmission power in your country to be used for wireless charging of the Moving Machine used in living area (apartment complex, hospital, hotel, restaurant, airport, etc.)?

4.1 15 W

4.2 60 W

4.3 200 W

4.4 1 kW

4.5 2.4 kW

4.6 3.3 kW

4.7 6.6 kW

4.8 11 kW

4.9 22 kW

4.10 Others (If the answer selects ‘others’, please describe what it is. )

The below table is a consolidated input based on the answers to the questionnaire.

**Table 4.1.4 Q4 Response Summary**

|  |  |
| --- | --- |
| **Country/Region** | **Answer** |
| Japan | 4.10 Others (Please refer to the specific comments in below) |
| Korea | 4.4 1 kW (for Moving Air Conditioner Robot) |
| Indonesia | 4.10 Others, Not yet specified |
| China | 4.10 Others, TBD |
| Cambodia | 4.10 Others, Not yet specified |
| Thailand | 4.10 Others, No related established regulation or policy |

**Japan**

Explanation is same as the Answer to Question 3.

**4.5 Maximum WPT power for moving machines in industrial area**

**Q5:**

Could you please select the maximum transmission power in your country to be used for wireless charging of the Moving Machine used in Industrial area (factory, logistics center, etc.)?

5.1 15 W

5.2 60 W

5.3 200 W

5.4 1 kW

5.5 2.4 kW

5.6 3.3 kW

5.7 6.6 kW

5.8 11 kW

5.9 22 kW

5.10 Others (If the answer selects ‘others’, please describe what it is. )

The below table is a consolidated input based on the answers to the questionnaire.

**Table4.1.5 Q5 Response Summary**

|  |  |
| --- | --- |
| **Country/Region** | **Answer** |
| Japan | 5.10 Others (Please refer to the specific comments in below) |
| Korea | 5.7 6.6 kW (for AGV) |
| Indonesia | 5.10 Others, Not yet specified |
| China | 5.10 Others, TBD |
| Cambodia | 5.10 Others, Not yet specified |
| Thailand | 5.10 Others, No related established regulation or policy |

**Japan**

Explanation is same as the Answer to Question 3.

**4.6 Frequency ranges of WPT for moving machines**

**Q6:**

Could you please select frequency ranges that are discussed or will be used for wireless charging of the Moving Machine in your country?

6.1 19 - 21 kHz

6.2 55 – 57 kHz

6.3 63 - 65 kHz

6.4 79 - 90 kHz

6.5 100 – 205 kHz

6.6 277 – 357 kHz

6.7 6.78 MHz

6.8 902 - 920 MHz

6.9 2.4 – 2.500 GHz

6.10 5.725 – 5.875 GHz

6.11 Others (If the answer selects ‘others’, please describe what it is. )

The below table is a consolidated input based on the answers to the questionnaire.

**Table 4.1.6 Q6 Response Summary**

|  |  |
| --- | --- |
| **Country/Region** | **Answer** |
| Japan | 6.11 Others (Please refer to the specific comments in below) |
| Korea | 6.4 79 - 90 kHz (because of SAE J2954)  6.5 100 – 205 kHz (because of WPC Qi Standard) |
| Indonesia | 6.11 Others (Please refer to the specific comments in below) |
| China | 6.11 Others (Please refer to the specific comments in below) |
| Cambodia | 6.2 55 – 57 kHz  6.5 100 – 205 kHz  6.6 277 – 357 kHz  6.7 6.78 MHz |
| Thailand | 6.11 Others (No related established regulation or policy) |

**Japan**

Institutionalized systems

* 425-524 kHz : 100W or less (electric field coupling system)
* 6.765MHz - 6.795MHz : 100W or less (magnetic field coupling system)

Systems for which institutionalization is under consideration

* 100kHz - 148.5kHz : 300W or less (magnetic field coupling system)
* 6.765MHz - 6.795MHz: 4kW or less (electric field coupling system)

**Indonesia**

As possible candidate forwireless charging of the Moving Machines are 100-148.5 kHz and 6 765 – 6 795 kHz

**China**

* 19-21 kHz
* 79-90 kHz
* 100-148.5 kHz
* 6765-6795 kHz
* 13553-13567kHz

**4.7 Wireless Communication method of WPT for moving machines**

**Q7:**

Could you please select the wireless communication methods for the discussion to be used when wireless charging and controlling the Moving Machine in your country?

7.1 NFC (Near Field Communication)

7.2 Zigbee

7.3 Bluetooth

7.4 Wi-Fi

7.5 UWB

7.6 LoRaWan

7.7 Z-wave

7.8 Others (If the answer selects ‘others’, please describe what it is.)

The below table is a consolidated input based on the answers to the questionnaire.

**Table 4.1.7 Q7 Response Summary**

|  |  |
| --- | --- |
| **Country/Region** | **Answer** |
| Japan | 7.8 Others (Please refer to the specific comments in below) |
| Korea | 7.4 Wi-Fi  7.3 Bluetooth |
| Indonesia | 7.8 Others, Not yet specified |
| China | 7.3 Bluetooth  7.1 NFC (Near Field Communication) |
| Cambodia | 7.1 NFC (Near Field Communication)  7.3 Bluetooth  7.2 Zigbee  7.4 Wi-Fi  7.6 LoRaWan  7.7 Z-wave |
| Thailand | 7.8 Others, All of the methods could be used if they conform to the existing radiocommunication laws |

**Japan**

Please refer to the table in the Answer of Question 8.

**4.8 Description of company or product of WPT for moving machines**

**Q8:**

Could you please briefly describe the company or product that sells or plans to sell products related to wireless charging and control of Moving Machines in your country?

**Japan**

See the following Table.

**Table : Examples of products for WPT for Moving Machines in Japan**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Implementing entity | Application | Development/  Commercialization phase | WPT System\* | Frequency | Transmission power | Communication methods |
| TOSHIBA  CORPORATION | AGV used indoors in factories, warehouses, etc. | commercialized | M | 9kHz band (Note 1) | 3kW | Infrared communication |
| Furukawa Electric Co., Ltd. | AGV used in factories | Under research and development | M and E | 85kHz band, 13.56MHz band, 27.12MHz band | 100W～3.3kW | Bluetooth, Wi-Fi, ZigBee |
| TAISEI CORPORATION | electric kickboard | Under research and development  （demonstration experiment stage） | E | 13.56MHz | Max. 200W | None (manual operation) |
| DENSO COOPERATION | AGV for factories / logistics / delivery, etc. | Under research and development  Some systems have obtained individual installation permissions as ‘Equipment Utilizing High Frequency Current’ and are under system evaluation.  Commercialization is scheduled after relevant institutionalization. | M and E | 85kHz band (M),  6.7MHz band (E) | Max. 2kW | Wi-Fi |
| Daifuku Co., Ltd. | transportation between semiconductor manufacturing processes, transportation of LCD panels, transportation in automobile factories | commercialized | M | lower than 10kHz (Note 1) | Max. 40kW | none |
| AGV and AMR in factories | commercialized | M | lower than 10kHz (Note 1),  85kHz | 6kW (less than 10kHz),  1.5kW(85kHz) | Extremely low power radio stipulated in a Ministerial Ordinance of MIC, Japan |

\* M : magnetic field coupling system WPT,

E : electric field coupling system WPT

Note 1:

In Japan, Article 100 of the Radio Act provides that any person who wishes to install the equipment which utilizes electric current at a frequency of 10 kHz or higher must obtain permission from the Minister of Internal Affairs and Communications. On the other hand, sales of WPT equipment which utilizes electric current at a frequency lower than 10 kHz are possible without any procedure with regard to the Radio Act.

However, Article 101 of the Radio Act provides that in the cases where the radio wave or high frequency current incidentally transmitted by any equipment other than radio equipment, except the equipment with permission of the Article 100, causes successive and serious obstruction to the functions of radio equipment, the Minister of Internal Affairs and Communications may order the person who holds or occupies the equipment to take necessary measures to eliminate the obstruction. Therefore, harmful interference on radio communications is minimized.

**Korea**

1. A Korean company called “EVAR” is planning to sell an AGV-type electric vehicle automatic charging robot from 2022. This robot will perform indoor/outdoor autonomous driving supported by wireless charging.

2. Korean e-commerce company named "Coupang" has introduced an autonomous transfer robot to its logistics center for factory logistics delivery since 2019. "Coupang" classifies wireless charging technology as the most urgent and most feasible technology for 24-hour autonomous operation.

3. A Korean company called "WiPowerOne" has been developing a wireless charging system for drones since 2015. In addition, they are developing and selling a 500 W class wireless charging system for charging drones.

**Indonesia**

There are still no company that sells or plans to sell wireless charging and control of Moving Machines.

**China**

This question is under investigated

**Cambodia**

1. Emergency patient transfer machine

2. Automatic cleaning machine

**Thailand**

Not relevant.

**4.9 Description of regulations or laws of WPT for moving machines**

**Q9:**

If there are any regulations or laws that require special attention when wireless charging and controlling the Moving Machine in your country, could you please briefly describe the sentences?

**Japan**

Close-coupled WPT equipment may be used for wireless charging of Moving Machines. If it utilizes electric current at a frequency of 10 kHz or higher, it is categorized as ‘Equipment Utilizing High Frequency Current’ and it requires individual installation permission pursuant to the provisions of Article 100 of the Radio Act. However, equipment which obtained ‘Type Specification’ stipulated in Article 46 Paragraph 2 of the Ministerial Ordinance for Enforcement of the Radio Act is exempted from the individual installation permission pursuant to Article 45 of the same Ordinance.

As to Beam WPT equipment, which might be used for wireless charging of Moving Machines, institutionalization is ongoing in Japan.

**Korea**

The Republic of Korea classifies the wireless power transmission system/equipment as ISM equipment. ISM equipment including wireless power system/equipment using more than 50W output power is required a license.

EMC certification is required for wireless power transmission equipment/device using less than 50W output power.

**Indonesia**

MCI decree 13/2018 regarding frequency allocation, MCI decree 1/2019 regarding class license frequency, Director General Decree 161/2019 regarding technical requirement of SRD Devices.

**China**

At present, the regulation is under study.

**Cambodia**

At present, the regulation is under consideration.

**Thailand**

There is no specific regulation.

1. **Administration Information and Profile**

**Table 5 Summary of Administration Information and Profile**

|  |  |
| --- | --- |
| **Country/Region** | **Administration Information and Profile** |
| Japan | Name of organization : The Ministry of Internal Affairs and Communications (MIC), Japan  Name of contact person : MATSUMIYA, Shima (Ms)  Email Address : gijutsukanri@ml.soumu.go.jp |
| Korea (Republic of.) | Name of organization : Korea Radio Promotion Association(RAPA)  Name of contact person : CHANHYUNG CHUNG  Email Address : backbum@rapa.or.kr |
| Indonesia (Republic of.) | Name of organization : Ministry of Communication and Informatics  Name of contact person : 1. Cendrawasih Ardhi Putri , 2. Muh Arief Nugroho  Email Address : cend001@kominfo.go.id, miha115@kominfo.go.id |
| China (Republic of.) | Name of organization : Ministry of Industry and Information Technology of the People’ Republic of China  Name of contact person : Li qingyang  Email Address : liqingyang@miit.gov.cn |
| Cambodia (Republic of.) | Name of organization : Telecommunication Regulator of Cambodia  Name of contact person : Mr. Vuthy LAY  Email Address : vuthylay@trc.gov.kh  Contact Number: +855976241038 |
| Thailand | Name of organization : Office of the NBTC  Name of contact person : Mr. Sukrit Chaiharn  Email Address : sukrit.c@nbtc.go.th |

1. **Conclusion**

This Report presents the survey results on WPT for moving machines from APT countries based on the responses to AWG-28/OUT-12 “Questionnaire on Wireless Power Transmission for moving machines”.

From the consolidated results in Chapter 4.1 ~ 4.2, WPT systems/device for moving machines are already commercialized in APT countries. Current and future commonly used application of WPT for moving machine were Factory Automatic Logistics Transfer Machine (AGV), Mobility assistance machines in living areas (E-Mobility, autonomous wheelchairs, etc.) and Automatic cleaning machine were answered.

Maximum amount of WPT power for moving machines in a personal home, living area and industrial area are summarized from chapter 4.3 to chapter 4.5. Since regulations or laws for WPT for moving machines have not yet been finalized in most countries, it has been confirmed that no decisions have been made on the amount of power possible in some areas.

In chapter 4.6, candidate frequency was not determined as a specific frequency because laws/regulations had not yet been established. However, some countries responded that they were considering the ITU-R recommended frequency bands (100kHz - 148.5kHz) and (6.765MHz - 6.795MHz) used by WPC and AirFuel, the existing wireless power transmission DeFacto standardization organizations. And they answered that they are also considering candidate frequencies for wireless charging of electric vehicles.

In chapter 4.7, there was a question about communication methods that can be considered in the current situation, and one communication method does not seem to be dominant yet.

Finally, product and company information of each country related to WPT for moving machine was collected in chapter 4.8 and related regulatory/legal situations were collected in Chapter 3.5. This kind of information is expected to be helpful for each APT country.

Through this Survey Report, we were able to survey many information about WPT for Moving Machine. In the next step, it would be good to consider investigating wireless charging for Moving machines, as many countries have answered.

**Appendix**

The questions below are questionnaire part of Wireless Power Transmission for moving machines:

**Questionnaire Part**

**Question 1:** Could you please list the three most commonly used Moving Robots in your country in order of priority?

① Factory Automatic Logistics Transfer Robot (AGV)

② Mobility assistance robots in living areas (E-Mobility, autonomous wheelchairs, etc.)

③ Automatic cleaning robot

④ A robot that guides places such as restaurants

⑤ Multimedia robot (robot dog, etc.)

⑥ Drone

⑦ Goods Delivery Robot

⑧ Fire-fighting assistant robot

⑨ Emergency patient transfer robot

⑩ Others (If the answer selects ‘others’, please describe what it is. )

**Question 2:** Could you please list the three moving robots in order of priority that are expected to be used or discussed in the next few years due to their high need for use in your country?

① Factory Automatic Logistics Transfer Robot (AGV)

② Mobility assistance robots in living areas (E-Mobility, autonomous wheelchairs, etc.)

③ Automatic cleaning robot

④ A robot that guides places such as restaurants

⑤ Multimedia robot (robot dog, etc.)

⑥ Drone

⑦ Goods Delivery Robot

⑧ Fire-fighting assistant robot

⑨ Emergency patient transfer robot

⑩ Others (If the answer selects ‘others’, please describe what it is. )

**Question 3:** Could you please select the maximum transmission power in your country to be used for wireless charging of the Moving Robot in a personal space (home)?

① 15 W

② 60 W

③ 200 W

④ 1 kW

⑤ 2.4 kW

⑥ 3.3 kW

⑦ 6.6 kW

⑧ 11 kW

⑨ 22 kW

⑩ Others (If the answer selects ‘others’, please describe what it is. )

**Question 4:** Could you please select the maximum transmission power in your country to be used for wireless charging of the Moving Robot used in living areas (apartment complex, hospital, hotel, restaurant, airport, etc.)?

① 15 W

② 60 W

③ 200 W

④ 1 kW

⑤ 2.4 kW

⑥ 3.3 kW

⑦ 6.6 kW

⑧ 11 kW

⑨ 22 kW

⑩ Others (If the answer selects ‘others’, please describe what it is. )

**Question 5:** Could you please select the maximum transmission power in your country to be used for wireless charging of the Moving Robot used in Industrial area (factory, logistics center, etc.)?

① 15 W

② 60 W

③ 200 W

④ 1 kW

⑤ 2.4 kW

⑥ 3.3 kW

⑦ 6.6 kW

⑧ 11 kW

⑨ 22 kW

⑩ Others (If the answer selects ‘others’, please describe what it is. )

**Question 6:** Could you please select frequency ranges that are discussed or will be used for wireless charging of the Moving Robot in your country?

① 19 - 21 kHz

② 55 – 57 kHz

③ 63 - 65 kHz

④ 79 - 90 kHz

⑤ 100 – 205 kHz

⑥ 277 – 357 kHz

⑦ 6.78 MHz

⑧ Others (If the answer selects ‘others’, please describe what it is. )

**Question 7:** Could you please select the wireless communication methods for the discussion to be used when wireless charging and controlling the Moving Robot in your country?

① NFC (Near Field Communication)

② Zigbee

③ Bluetooth

④ Wi-Fi

⑤ UWB

⑥ LoRaWan

⑦ Z-wave

⑧ Others (If the answer selects ‘others’, please describe what it is.)

**Question 8:** Could you please briefly describe the company or product that sells or plans to sell products related to wireless charging and control of Moving Robots in your country?

**Question 9:** If there are any regulations or laws that require special attention when wireless charging and controlling the Moving Robot in your country, could you please briefly describe the sentences?

**REFERENCES**

[1] APT AWG-28, Questionnaire on WPT for Moving Machines