The Wireless Feeding Flexible Printed Circuit Which is Available for the Curved Surface Mount

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The miniaturization of electronics appliances has been restricted with conventional antennas that are made of magnet wire coils and have poor flexibility. To address this challenge, we replaced magnet wire coils with flexible printed circuits (FPCs) by utilizing our original 3-dimensional wiring technology for the first time in the industry. This improved flexibility of the antennas and enabled size reduction. Our new product enhances the functionality of electronics appliances by offering cordless charging capability or water- and dust-proof properties.
Having these advantages, this product is expected to be used in a variety of fields where the equipment need to be smaller and lighter such as wearable devices, health-care and industrial equipment.

Keywords: wireless power transmission, wearable, flexible printed circuit (FPC), curved surface mounting, microminiature

1. Introduction

Sumitomo Electric has recently developed and begun to ship samples of a thin microminiature wireless power transmission module that, without connecting a power cord, supplies power to wearable user devices and other electronic equipment (hereinafter, "wireless power module"). This paper reports on this wireless power module.

2. Wireless Power Module Overview

The newly developed wireless power module uses an electromagnetic induction system that provides contactless power transmission. Its transmitting end supplies electric energy through space, which generates a magnetic flux on the receiving end to pass an electric current.

Conventional inductive wireless power modules consists of a control board and an antenna. The antenna uses an inflexible wound coil, which is a design constraint in achieving miniaturization. Meanwhile, conventional wearable equipment with external power terminals is problematic in terms of water- and dust-proof design. Thus emerged the idea to reduce the size and thickness of the wireless power device, eliminating the need for terminals, and thus offer a power module that can be installed in wearable equipment.

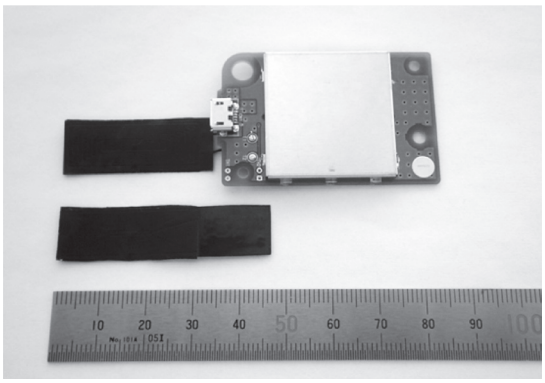

Photo 1. Wireless power module (Transmitter [back] and receiver modules)

3. Features

The wireless power module has the following features.

(1) Microminiature and thin antenna

The control section has decreased in size due to the use of a WPC v.1.1-compliant integrated control IC. In the antenna section, the antenna circuits of the transmitter and receiver modules have been optimized to reduce power transmission losses. **Figure 3** shows the output characteristics of the receiver antenna circuit with the newly developed transmitter and receiver being opposed to each other. The input threshold of the receiver control IC is exceeded within a band up to twice the transmission frequency (100 kHz), proving the module's stable power transmission capability. **Figure 4** shows inductance versus frequency of the newly developed receiver module antenna. The frequency characteristics of the antenna up to 14 MHz, as shown in **Fig. 4**, enabled by Sumitomo Electric's proprietary circuit structure, reveal that the antenna can be used in a magnetic field resonance*2 power transmission system. Thus a wireless power antenna design has been successfully developed using a flexible printed circuit (FPC) with dimensions of 30 (W) by 10 (H) mm.

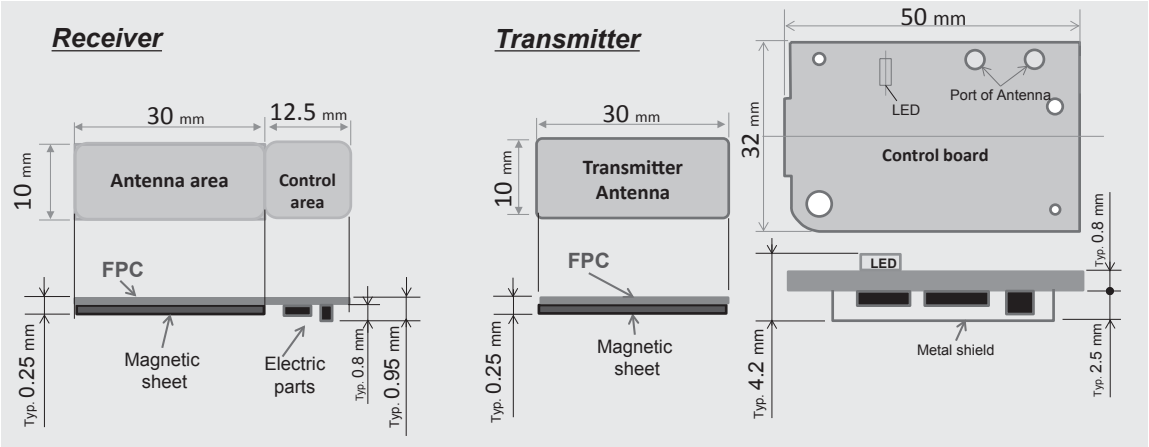

Fig. 1. Wireless power module outline

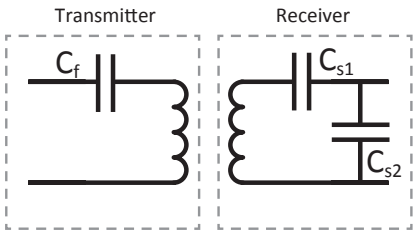

Fig. 2. Wireless power module antenna circuits

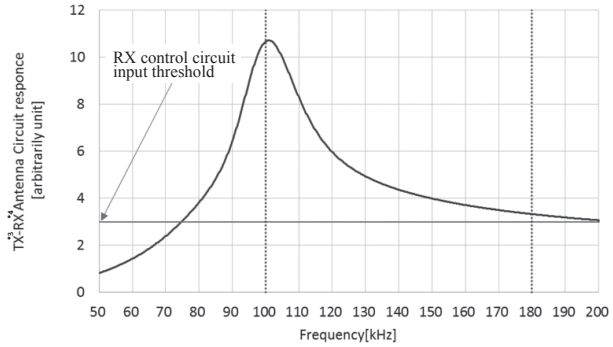

Fig. 3. Antenna circuit output characteristics with opposed transmitter and receiver

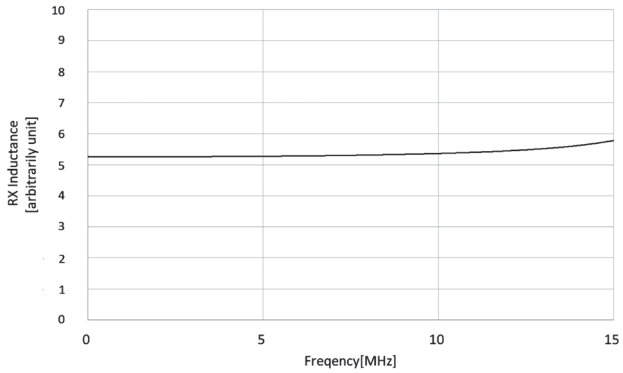

Fig. 4. Inductance vs. frequency of receiver module antenna

(2) Design flexibility

Both transmitter and receiver antennas are made of FPC. This is intended to make optimal use of the features of FPC, notably its flexibility, to enable the antenna to be placed in various enclosures. This antenna can be installed even in a U-shaped or bent section, which is not possible with a power module incorporating a wound coil.

The wireless power module improves the degree of freedom in product design and facilitates making products smaller and thinner. The newly developed product is believed to enable higher performance and aesthetic design for electronic equipment and also improve functionality, such as water tightness and a cordless body.

Photo 2. Antenna section incorporating Sumitomo Electric's FPC

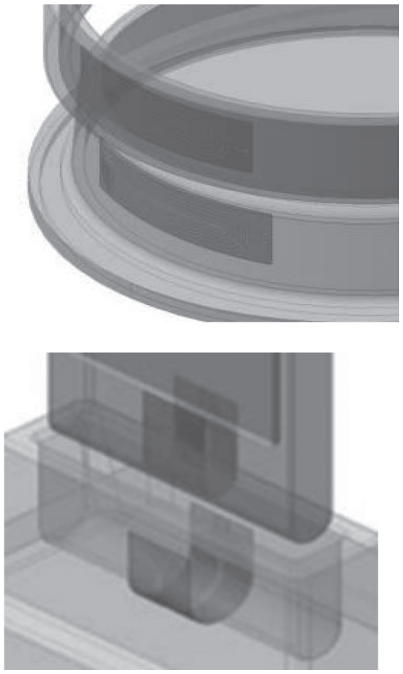

Fig. 5. Example placement requiring flexibility for fitting into enclosure

(3) Power transmission control function

An electromagnetic induction system could decrease in transmission efficiency and generate heat if a displacement occurs or a foreign body interferes with the system. In this regard, Sumitomo Electric's wireless power module uses WPC v.1.1-compliant control ICs in both the transmitter and receiver and has a power transmission control function using a temperature monitor. These capabilities enable the module to stop power transmission when the temperature rises.

(4) Module provided as a combination of transmitter and receiver

Sumitomo Electric covers from design to manufacturing of the transmitter/receiver module. When downsizing a product, it is especially necessary that the design takes into consideration the balance between transmission and reception. Sumitomo Electric provides a module with optimized antenna circuits under the condition of opposed transmitter and receiver.

4. Characteristics

The load current versus output of the receiver module (**Fig. 6**) proves that the module outputs 5 V stably over a load current range from 0 to 0.2 A. The transmitter and receiver, both of which use FPC, have proven themselves capable of achieving a transmission efficiency of 58% or higher by optimizing the size and the antenna circuitry design.

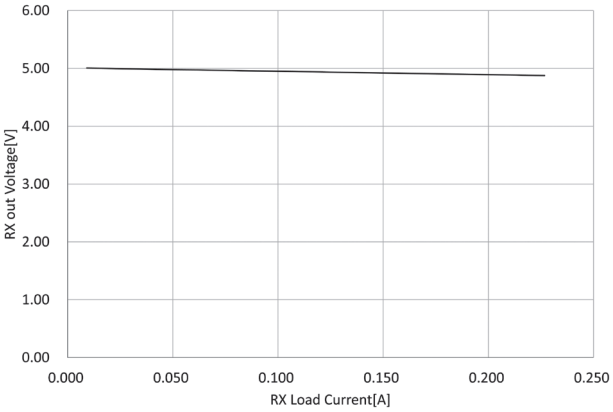

Fig. 6. Load current vs. output voltage

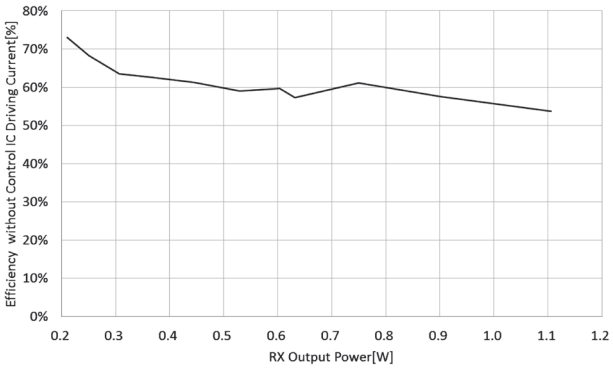

Fig. 7. Power transmission efficiency (control IC drive current not included)

5. Conclusion

The wireless power module consists of control circuits and antenna circuits. Conventionally, the antenna element has been made of a wound coil without flexibility that posed limitations on designing downsized products. Making optimal use of the Company's simulation techniques and proprietary circuitry, Sumitomo Electric has successfully commercialized a power module in which FPC is used instead of a wound power transmission coil. This improves flexibility of the antennas and enables size reduction. The newly developed product is believed to enable higher performance and greater aesthetic design capabilities for electronic equipment and to also improve functionality, such as water tightness and a cordless body. Envisioned application areas of this product are those that require additional size and weight reduction, including wearable user devices that should desirably be water- and dust-proof, health care equipment that need to be cordless, and industrial equipment.

Table 1. Specifications for wireless power module

	Parameter		Specification
Transmitter end	Input voltage		5 VDC
	Input current		400 mA max. (reference value applicable to the dimensions shown below)
	Dimensions	Antenna	30.0 (W) × 10 (H) × 0.25 (T) mm (projections not included)
		Control section	50 (W) × 32 (H) × 0.80 (T) mm (projections not included)
Receiver end	Output voltage		5 VDC
	Output current		170 mA max. (reference value applicable to the dimensions shown below)
	Dimensions	Antenna	30 (W) × 10 (H) × 0.25 (T) mm (projections not included)
		Control section	12.5 (W) × 10 (H) × 0.25 (T) mm (projections not included)

Technical Terms

∗1 R: radius of bend (unit: mm)

∗2 Magnetic field resonance system: A wireless power transmission system. Magnetic field resonance is a phenomenon where the magnetic field oscillation generated by a current passing through a coil on the transmitting end is transferred to the resonance circuit on the receiving end that resonates at the same frequency. The magnetic field resonance system is the focus of attention since it enables power transmission over a wider distance than possible with an electromagnetic induction system.

∗3 TX: transmitter module

∗4 RX: receiver module

References

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(2) http://www.sei-sect.co.jp/products/wireless_charge.html

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