Design and Testing of Deployable Antennas for Wireless Charging of Low Power Sensors

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With the advancement in the automation technology and robotics, robots started to effectively replace human involvement in several areas; some examples are automated warehouses, inspection robots, and social robots for assisted living. Such robots can perform several tasks including but not limited to charging itself and via wireless energy transfer maintaining low power sensors such as sensors embedded inside walls and wireless sensor tags for monitoring structural health, water flow, motion, and humidity. Far-field wireless RF energy transfer is a candidate technique for such applications; since, unlike inductive power transfer, microwave far-field energy transfer allows long distance power beaming and less effected from the orientation of receiver and transmitter blocks. Reported studies on microwave far-field energy mostly focus on scavenging of the ambient energy for low-power densities; therefore, many different receiver antenna designs are proposed in the literature. When designing a mid-range RF wireless power transfer (WPT) system, additional parameters such as free space loss, transmitter antenna gain, and the input power of the transmitter should also be considered. A high gain transmitting antenna is needed to transfer the required power levels; however, the space on a robot for a transmitting antenna is limited and the antenna should be compact to not to obstruct the mobility of the robot. Such space constraint makes the antenna design challenging as the gain of the antenna is directly related with the antenna size.

To this end, a deployable Yagi-Uda antenna and a deployable rubber horn antenna are designed to operate at 2.45 GHz and 5.8 GHz unlicensed ISM bands, respectively. Deployable mechanisms of the antennas overcame the space limitation on the robot. To realize the deployable mechanism, Yagi-Uda antenna is folded with plastic hinges and the flare of the horn is compressed. Both of the antennas have a gain of 15 dBi and accompanying with the policies of Federal Communications Commission, the input power of the antennas are 27 dBm and 30 dBm for Yagi-Uda and horn antennas, respectively. Assuming that the power level at the sensor will be 10 mW total power level at the receiver antenna is calculated as 16.7 mW. It is also worth noting that RF to DC power conversion efficiency of traditional rectifiers, designed for energy scavenging, can rise up to 60% with the increased power density at the receiver antenna. Thus, in this work RF to DC power conversion efficiency is considered as 60%. The range of the Yagi-Uda was 5.5 meters. Antenna simulations with S-parameter responses and gain patters as well as range tests with receiver antennas will be shown during the presentation.