Wearable Magnetoinductive Waveguide for Wireless Body Area Network and On-body Wireless Power Transfer

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Wearable technology is growing at a rapid pace with applications ranging from healthcare (e.g., detection and monitoring of physiological signals, motion capture, rehabilitation) to consumer electronics, gaming, virtual reality, and more. Wearable sensors located on different parts of the human body can be connected via wireless means to a hub (typically a smart phone) to form a wireless body area network (WBAN). Data collected from the sensors can then be post-processed to draw useful inferences and real-time feedback can ultimately be provided to users via the hub. Alternatively, such network may enable Internet connectivity, empowering data transmission to other relevant locations (e.g. hospitals). That is, WBANs are indispensable and form the backbone of wearable technology.

To form WBANs, Radio-Frequency technologies are most commonly used (e.g., Bluetooth, Zigbee) that utilize electromagnetic waves as a means of communication. However, they suffer from very high and variable loss, and are vulnerable to interference. As an alternative, human body communications utilize biological tissues as a channel and rely on electric field as means of communication. These are quite secure, but suffer from considerable loss and are obtrusive due to the use of electrodes. Magnetic induction based WBANs utilize the magnetic field as means of communication and, hence, provide relatively low loss. Nevertheless, loss increases significantly as the distance between transmitter and receiver is increased. Notably, these technologies can also be used to wirelessly power the wearable sensors, but with similar limitations as above. We remark that wireless powering of WBANs, as opposed to “gold standard” battery approaches, enhances seamlessness and takes the sensors a step closer to being truly wearable.

In light of the above, we present wearable magnetoinductive waveguides (MIWs) which are formed via series of electrically small resonant loops (ESRLs). In the past, we demonstrated the feasibility of MIWs for WBAN communication (V. Mishra and A. Kiourti, "Wearable Planar Magnetoinductive Waveguide: A Low-Loss Approach to WBANs," *IEEE Transactions on Antennas and Propagation*, vol. 69, no. 11, pp. 7278-7289, Nov. 2021), and here we expand upon their use for powering as well. Our approach utilizes magnetoinductive waves that are composed of confined magnetic fields, hence enabling extremely low loss and negligible interference. Results on tissue-emulating limbs show up to 50-60 dB improvement in transmission loss as compared to state-of-the-art technologies. Notably, ESRLs can be implemented using e-threads and seamlessly integrated in garments. That is, the proposed wearable design can be used to form wearable WBANs and concurrently enable seamless wireless power transfer to the sensors.