Simultaneous Wireless Power and Data Transfer for Sensor System

Demonstrating Technological Capabilities for Industrial Applications in Challenging Environments

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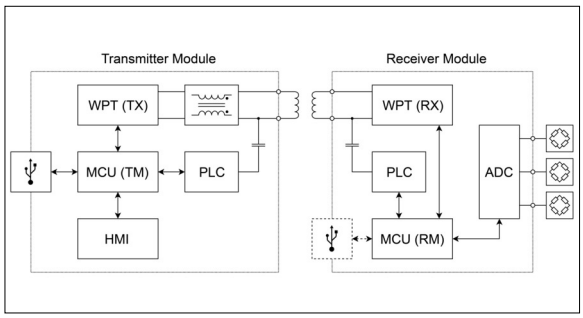
Introduction: Integrating sensors into subtractive manufacturing machinery is essential for monitoring and controlling the machining process. Force sensors are commonly used, but machines lack sensors on rotating axes, like machine chucks. Cable-based solutions are impractical, and slip rings are unsuitable due to exposure to coolants and debris. Previous methods using batteries and radio transmission have significant drawbacks, such as low operating time and communication reliability. The project focuses on developing a proof of concept for wireless power and data transfer to sensors on spinning axes.

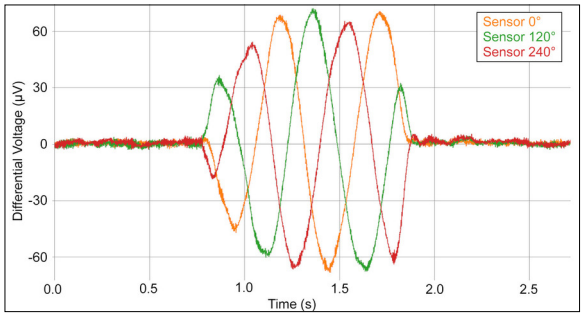
Approach: The objective is to design and implement a demonstration unit capable of delivering 1 W of wireless power to a rotating unit and transmitting data from three force sensors to the host device. Research on wireless power and data transfer technologies led to the evaluation of state-of-the-art chipsets. The Qi charging standard was selected for power transfer due to its widespread adoption and integrated solutions. For data transmission, Power-Line Communication (PLC) was chosen, as it can be capacitively coupled into the transmission system. Two coils were manufactured to effectively transfer both power and data between the two units. Custom PCBs were developed, with the rotating unit designed to have a compact form factor of 22 x 32 mm. Three strain gauge sensors mounted on an aluminum pole are used to measure the forces applied to the chuck. The sensors are sampled at 1 kHz with a 24-bit resolution. The data is then transmitted using a custom protocol based on Reed-Solomon error correction. Next, the sensor values are sent to the host device via USB, where they can be visualized in real-time. Additionally, a mechanical setup was constructed to mount the machine chuck on a rotating shaft, enabling it to be freely rotated by hand.

Result: The project successfully demonstrates the possibility of combining WPT and PLC technologies. With the custom coils achieving a coupling factor of 87% for power transfer, all requirements were met, resulting in a fully functional system that creates a foundation for future development.

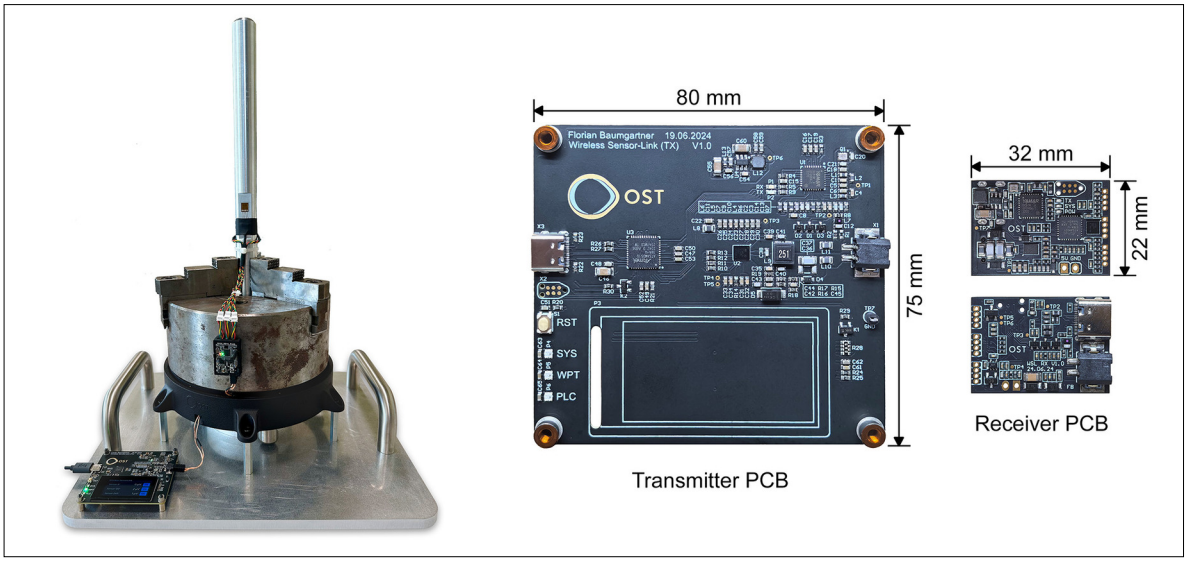
Hardware Block Diagram
Own presentment



Measurement Results of 3-Axis Force Sensors
Own presentment



Final Demonstration Unit & Printed Circuit Boards (PCBs)
Own presentment



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Subject Area
Electrical Engineering

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