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WIRELESS, SMARTPHONE CONTROLLED POTENTIOSTAT INTEGRATED WITH LAB-ON-DISC PLATFORM

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ABSTRACT

A smartphone controlled wireless data transmitting and inductive powering Power Lab-on-disc (PLoD) platform is developed based on 2.4 GHz Bluetooth and 205 kHz Qi techniques, respectively. A potentiostat is integrated on the PLoD platform, and amperometric measurements are performed. The wireless potentiostat can provide -3~3 V with 14-bit resolution for amperometry in a range of -300~300 µA with a readout noise floor of 1.2 µA (p-p) in a static condition. A 0~3000 rpm spinning test shows that a phosphate buffer saline (400 mV potential) baseline noise is proportional to spinning acceleration and deceleration.

KEYWORDS: Wireless, Smartphone, Potentiostat, Bluetooth, Qi, Android, Arduino

INTRODUCTION

It is beneficial to integrate miniature microfluidics-based instruments on centrifugal microfluidic platforms or so called lab-on-disc (LoD) systems. Combining Arduino based microcontroller, inductive wireless power and Bluetooth data transmission, wireless rotating platform has even more potential applications. Since the inductive wireless power has been standardized as "Qi" for powering mobile devices, it is easy to find the Qi power transmitter and receiving coils in shops.

We developed a smartphone controlled Power Lab-on-disc (PLoD) platform prototype based on 2.4 GHz Bluetooth and 205 kHz Qi techniques, respectively. A block diagram of the PLoD is shown in Figure 1. The platform integrates a microcontroller, a Bluetooth transmitter, a 14-bit resolution digital to analog converter (DAC) and a 14-bit resolution analog to digital converter (ADC), single channel potentiostat circuit and a power regulator.

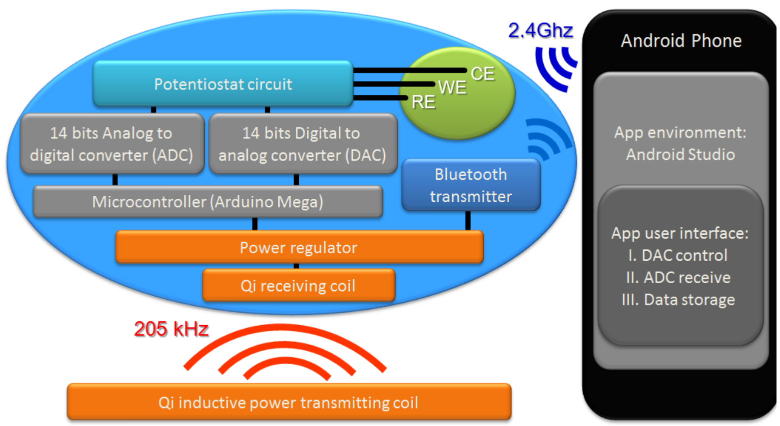

Figure 1: Block diagram of the wireless potentiostat integrated into PLoD platform.

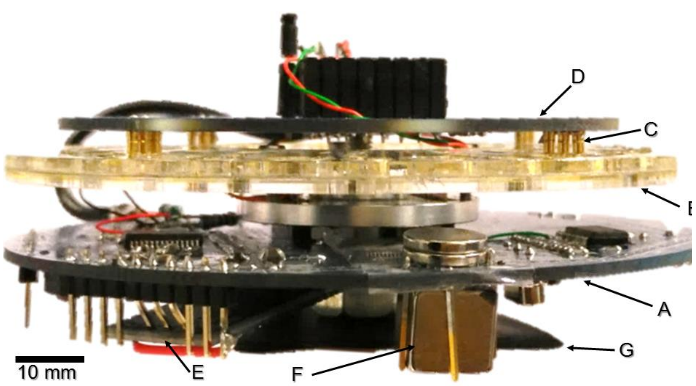

Figure 2: Photo of the wireless potentiostat integrated with the PLoD platform. A: Main circuit disc. B: Microfluidic disc. C: Gold electrodes contacted with spring loaded pins. D: Top circuit board. E: Bluetooth transmission module. F: Counter-weight. G: Qi receiving coil.

Figure 2 shows a photo of the PLoD platform prototype which has a diameter and height of 100 mm and 53 mm, respectively. A microfluidic disc with 24 sets of potentiostat electrodes was placed between a top and a main circuit discs. Gold coated spring contact electrodes on the top circuit disc provided mechanical clamping and electrical contact to the microfluidic disc. A Qi coil was fixed at the bottom of the platform for receiving power from a Qi transmitting coil (not shown). The platform was carefully balanced by a counterweight to achieve high spinning speed and low vibration.

EXPERIMENTAL

The Qi inductive power provides 5V and can transmit 5~10 Watt within 5 mm distance. However, the Qi power is very noisy and contains 205 kHz and 800mV noise spikes. A specialized filter is crucial for filtering the high-frequency noise, the filtered noise level is reduced to 80mV. The ADC and DAC are controlled by digital I/O pins of the microcontroller for higher resolution analog input and output. The potentiostat circuit can provide -3~3 V for amperometry and measure current in a range of -300~300 µA with a readout noise floor of 1.2 µA (p-p) in static condition.

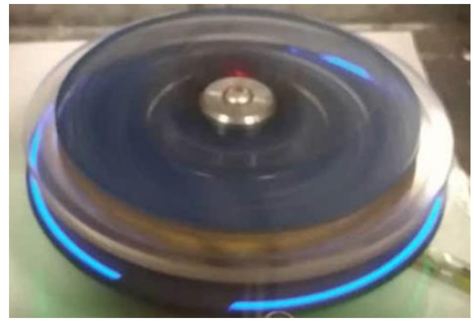

Figure 3: The platform spun at 3000 rpm.

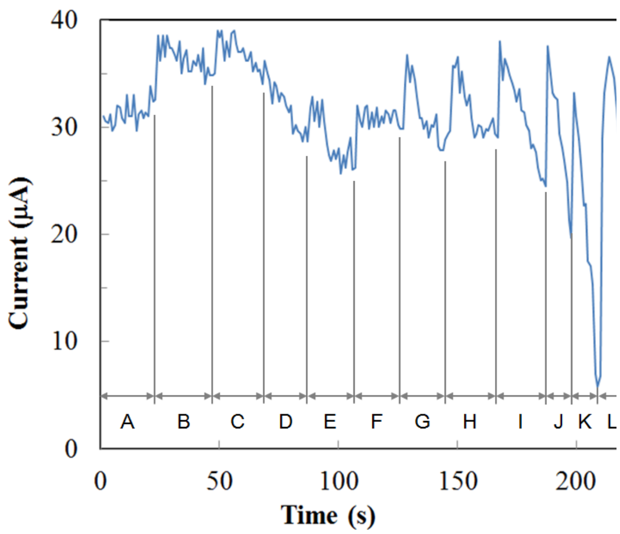

Figure 4: Baseline noise vs. spinning seed. A: 0 rpm. B: 300 rpm. C: 600 rpm. D: 900 rpm. E: 1200 rpm. F: 1500 rpm. G: 1800 rpm. H: 2100 rpm. I: 2400 rpm. J: 2700 rpm. K: 3000 rpm. L: 0 rpm.

RESULTS AND DISCUSSION

The PLoD can spin stably up to 3000 rpm, as shown in Figure 3. A 0~3000 rpm spinning test with a phosphate buffer saline (PBS) baseline noise (400 mV potential) is proportional to spinning acceleration and deceleration. The wireless potentiostat PBS baseline noise versus the spinning speed is shown in Figure 4. The noise peaked at the spinning acceleration and deceleration. When the platform was spinning at a constant speed, the noise dropped to a range of 3 µA (p-p). We believe the noise is proportional to the vibration while spinning as well.

CONCLUSION

The goal of this work is to develop high resolution and multi-channel PLoD for various transducers combined with centrifugal microfluidics as a portable analysis platform for bioprocess, diagnostics, food safety and environmental monitoring.

ACKNOWLEDGEMENTS

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