

Real-time Cerebral Perfusion Monitoring via Microwave Technology

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Cerebral perfusion is a critical biomarker for neurological function and health, with abnormalities being indicative of various conditions such as stroke, traumatic brain injury, and epilepsy [1]. Existing clinical imaging techniques, including Computed Tomography Perfusion (CTP) [2], Magnetic Resonance Perfusion Imaging (MRPI) [3], and Transcranial Doppler Ultrasound (TDUS), exhibit limitations such as bulkiness, reliance on contrast agents or radioactive tracers, poor time resolution, and restricted portability. These constraints underscore the need for non-invasive, real-time, and portable monitoring solutions.

This study presents a novel microwave system for cerebral perfusion monitoring, leveraging the dielectric property variations in brain tissues induced by periodic blood flow changes. A compact ultra-wideband antenna, measuring $17\text{ mm} \times 17\text{ mm} \times 2.54\text{ mm}$, with a relative bandwidth of 103%, was developed for this purpose. Integrated with a portable Vector Network Analyzer (VNA), the system was validated through experiments on Sprague-Dawley rats under normal and arterial blockage conditions, where measurable changes in perfusion signals were observed. Human trials conducted on healthy volunteers further demonstrated the system's capability to detect periodic cerebral perfusion rhythms correlated with cardiac cycles.

This research provides the first demonstration of cerebral perfusion signal measurement using microwaves, highlighting its potential for real-time bedside monitoring. The system offers key advantages, including portability, cost-effectiveness, and the absence of ionizing radiation. Future work will focus on extending the system's functionality through advanced imaging algorithms and expanding its validation to clinical settings with diverse patient populations.

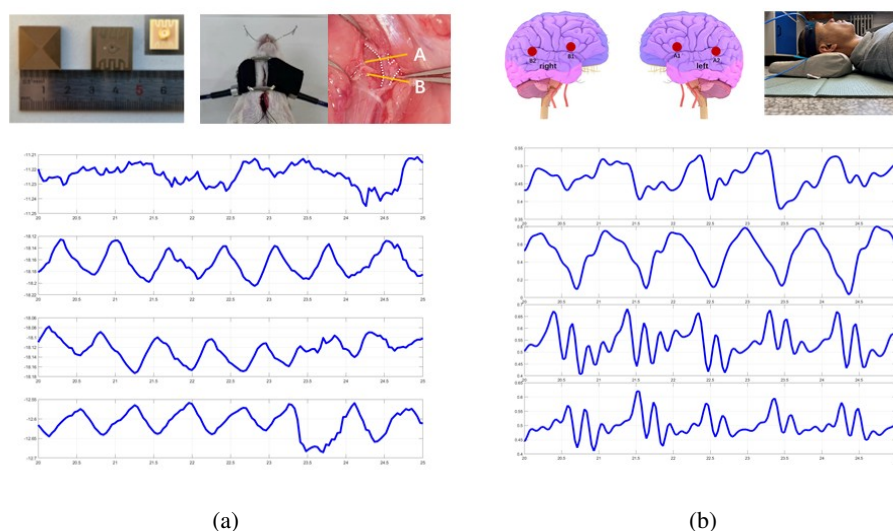


Figure 1: Measured cerebral perfusion signals: (a) on laboratory rats; (b) on a volunteer.

References

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