Performance comparison of four bio-impedance spectroscopy systems

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Abstract. In order to measure impedance spectra of biological tissues in wideband accurately, a high performance measurement system is required. Using a constant current source and a differential voltmeter with tetrapolar electrodes is the most popular method for measuring impedance spectrum. However, its performance is degraded due to the limited output impedance of constant current source at high frequency. Also, we need to have a differential voltmeter with high input impedance and high performance for common-mode signal rejection because we must use electrodes to measure biological tissues. In this study, we designed 3 different bio-impedance spectroscopy systems (BIS), and compared their performances with that of a commercial impedance analyzer (SI1260A, AMETEK Inc. UK). In the first BIS system, we adopted the common method which used a current source with generalized impedance converter to maximize the output impedance at operating frequencies and a voltmeter with the phase sensitive demodulation. Even if the phase sensitive demodulation method can produce better performance with removing noise, it was bulky and high cost for computing power. We modified the first BIS system for the second BIS system by using a constant voltage source instead of using a current source. Two independent voltmeter measured the voltage across the chosen internal resistor to monitor the injected current and the voltage across the sample impedance. The third BIS system was applied the voltage source and the magnitude-ratio and phase-difference detection method proposed by Yang *et al* in place of the phase sensitive demodulation. The evaluation was carried out on resistors and saline phantoms over the frequency range of 50 Hz to 2 MHz. The results showed that the second BIS system using voltage source gave better performace than other BIS systems over all testing frequencies. The measurement error for the first BIS system was increased above 500 kHz, steeply. The commercial impedance analyzer was the best performance with a resistor load. However, its performance was degraded when the load was changed to a saline phantom. We may design the better BIS system when considering the experimental results and their analyses.

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