Simulation and experimental results from 3-D vector flow estimations for a 62 x 62 2-D row–column (RC) array with integrated apodization are presented. A method for implementing a 3-D transverse oscillation (TO) velocity estimator on a 3-MHz RC array is developed and validated. First, a parametric simulation study is conducted, where flow direction, ensemble length, number of pulse cycles, steering angles, transmit/receive apodization, and TO apodization profiles and spacing are varied, to find the optimal parameter configuration. The performance of the estimator is evaluated with respect to relative mean bias $\bar{B}$ and mean standard deviation $\sigma$. Second, the optimal parameter configuration is implemented on the prototype RC probe connected to the experimental ultrasound scanner SARUS. Results from measurements conducted in a flow-rig system containing a constant laminar flow and a straight-vessel phantom with a pulsating flow are presented. Both an M-mode and a steered transmit sequence are applied. The 3-D vector flow is estimated in the flow rig for four representative flow directions. In the setup with 90° beam-to-flow angle, the relative mean bias across the entire velocity profile is (−4.7, −0.9, 0.4)% with a relative standard deviation of (8.7, 5.1, 0.8)% for $(v_x, v_y, v_z)$. The estimated peak velocity is $48.5 \pm 3$ cm/s giving a −3% bias. The out-of-plane velocity component perpendicular to the cross section is used to estimate volumetric flow rates in the flow rig at a 90° beam-to-flow angle. The estimated mean flow rate in this setup is $91.2 \pm 3.1$ L/h corresponding to a bias of −11.1%. In a pulsating flow setup, flow rate measured during five cycles is $2.3 \pm 0.1$ mL/stroke giving a negative 9.7% bias. It is concluded that accurate 3-D vector flow estimation can be obtained using a 2-D RC-addressed array.

**General information**
Publication status: Published
Organisations: Department of Electrical Engineering, Biomedical Engineering, Department of Micro- and Nanotechnology, MEMS-AppliedSensors, BK Medical ApS
Contributors: Holbek, S., Christiansen, T. L., Stuart, M. B., Beers, C., Thomsen, E. V., Jensen, J. A.
Pages: 1799-1814
Publication date: 2016
Peer-reviewed: Yes

**Publication information**
Journal: IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control
Volume: 63
Issue number: 11
ISSN (Print): 0885-3010
Ratings:
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.73 SJR 0.986 SNIP 1.385
Web of Science (2016): Impact factor 2.743
Web of Science (2016): Indexed yes
Original language: English
Keywords: 3-D vector flow imaging, Blood flow, Medical ultrasound, Row-column addressed arrays, Transverse oscillation
Electronic versions:
Holbek_et_al_2016.pdf
DOIs:
10.1109/TUFFC.2016.2582536
Source: PublicationPreSubmission
Source ID: 127060745
Research output: Contribution to journal › Journal article – Annual report year: 2016 › Research › peer-review