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Conditioning a current source using OCCII-GIC for EIT systems

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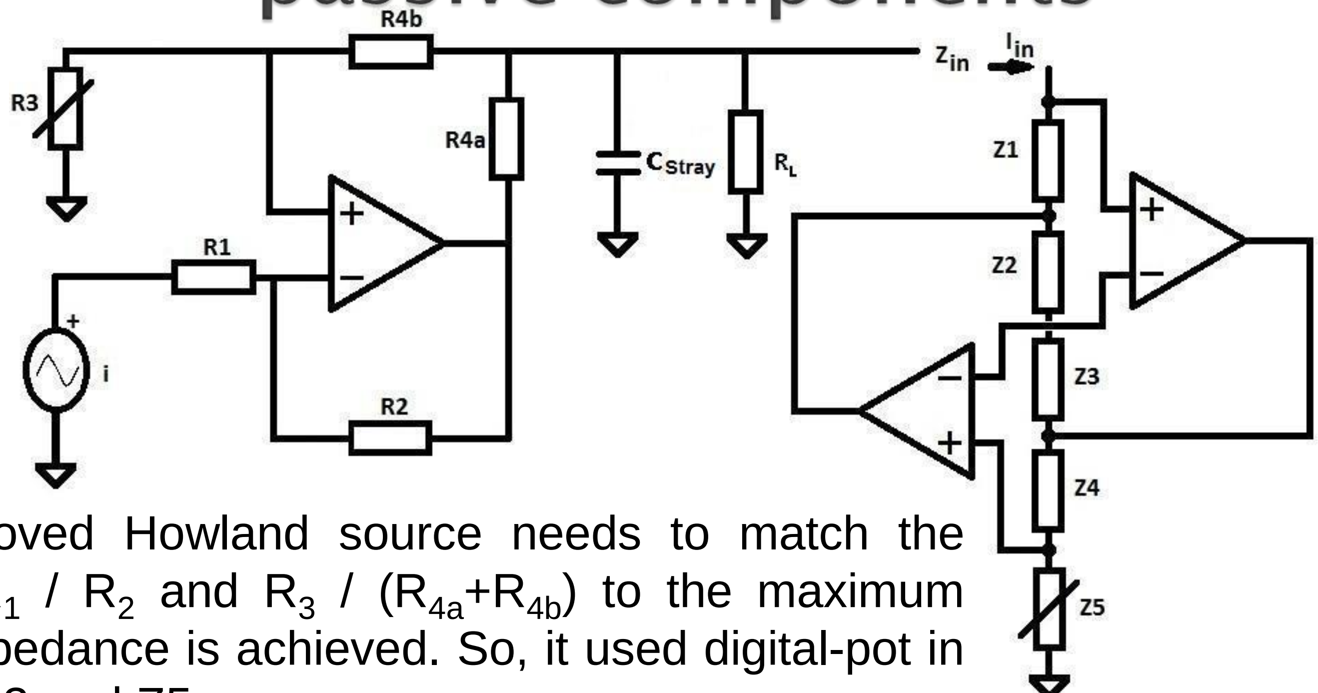
Introduction of the Sussex EIT

- 3D breast cancer detection system using EIT
- The Sussex EIT system is based on a four-electrode method
- The excitation current: 0.2mA to 2mA$_{pk-pk}$
- The voltage meter: 14-bit ADCs with input range of 5V$_{pk-pk}$
- Operation frequency: around 10 frequency points from 10kHz to few megahertz
- Planar electrode plate
- Single source share by drive and receive multiplexers

improved Howland Current source and general GIC with two op amp and five passive components



The improved Howland source needs to match the ratio of R_1 / R_2 and R_3 / $(R_{4a}+R_{4b})$ to the maximum output impedance is achieved. So, it used digital-pot in place of R3 and Z5.

Fig.1 A schematic of an general GIC combined with an improved Howland current source circuit (Ross 2003 and Oh, T.I 2007)

The second generation of Current Conveyor (CCII+)

In an ideal implementation of CCII+, the voltage at X node (V_X) does equal that at Y node (V_Y) and the current at Y node equal that at TZ node. However, the characteristic functions in actual format are given by, $V_X=\beta V_X$, $I_Y=0$ and $I_{TZ}=\pm\alpha I_X$, where β and α are tracking error of voltage and current. The OCCII increases the accuracy compared to a CCII (Sedra A, 1970). The additional op amp is connected in a negative feedback loop in the CCII to form the OCCII circuit (right fig), reduces the transfer function error in conveying the current.

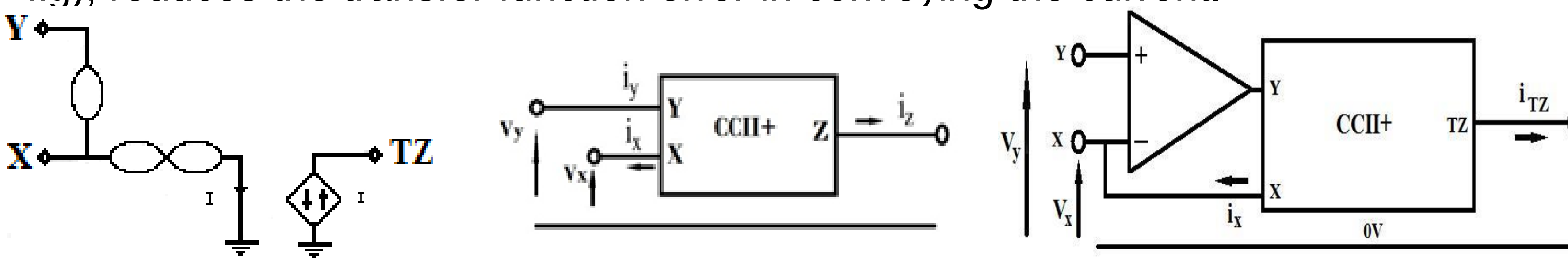


Fig. 2 Current model of CCII (left fig.) and simplified current follower in CCII (middle fig.) and combination of op amp and CCII as a OCCII (right fig.)

The OCCII-GIC using to cancel stray capacitance by producing an inductance (1)

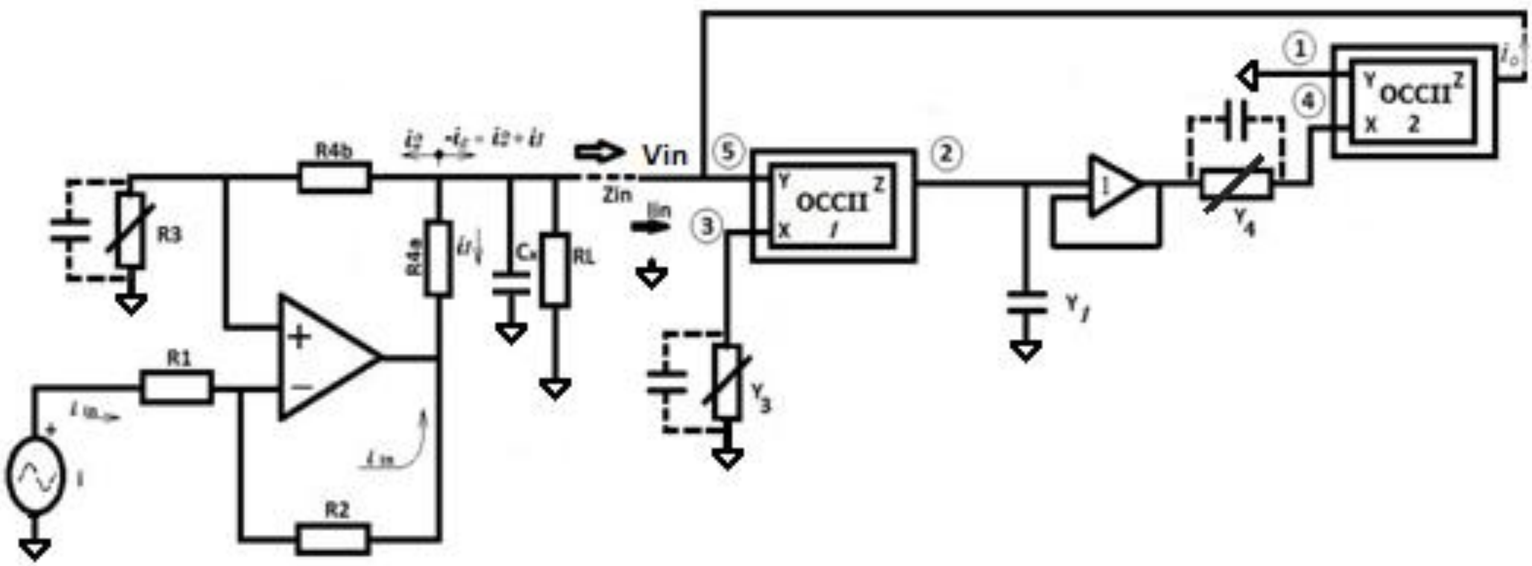


Fig.3 A schematic of an OCCII-GIC combined with an improved Howland current source circuit by using digital-pot. (Cicekoglu,1998)

The OCCII-GIC using to cancel stray capacitance by producing an inductance (2)

The system cancels different capacitances at different frequencies using coarse and fine digital-pots, Y_3 and Y_4, respectively. The OCCII uses three OPA656 operational amplifiers, input capacitance 2.8pF, and two AD844S ICs, output capacitance 4.5pF. The capacitances (from data sheet) of the 100step X9C102 digital-pot used is 10pF at both ends and 25pF at the wiper.

Simulation results

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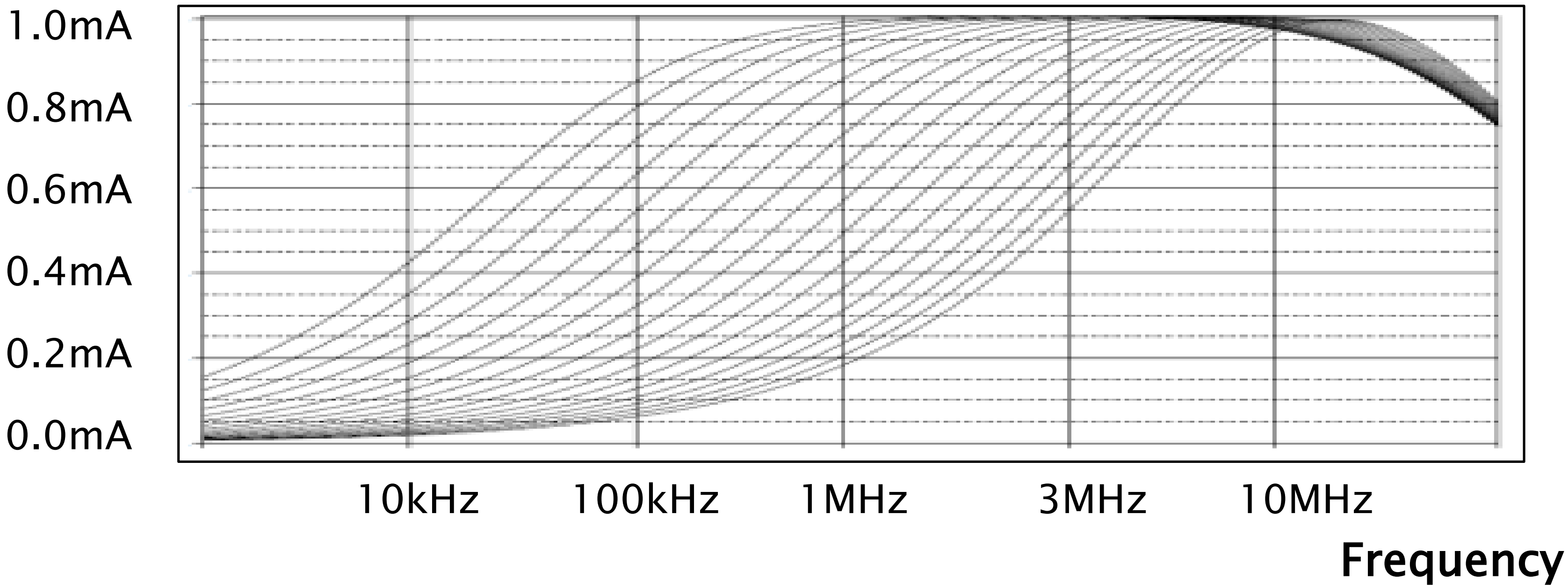

Fig. 4 The simulation graph shows a multi-frequency AC sweep output of the OCCII-GIC and improved Howland current source. Digital-pot Y4 (100Ω to 5kΩ, increment in 10 logarithmic step per decade) for different loads from 1kΩ to 5kΩ.

Simulation results

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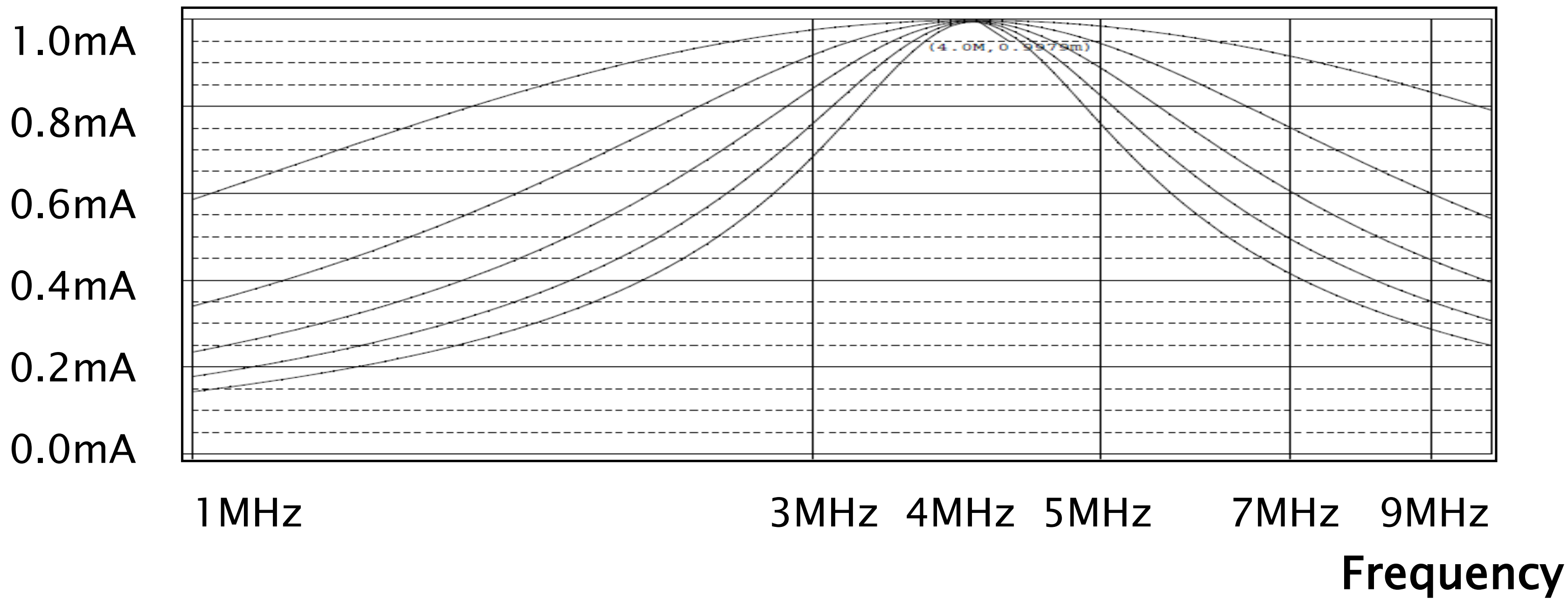

Fig. 5 The simulation graph shows the AC sweep output of the OCCII-GIC and improved Howland current source. Digital-pot Y4 (100Ω to 5kΩ, increment in 10 logarithmic step per decade) at a frequency of 4MHz with different loads from 1kΩ to 5kΩ.

References

1. ROSS, A.S., SAULNIER, G., NEWELL, J. and ISAACSON, D., *Physiological Measurement*, 24(2), pp. 509, 2003.
2. OH, T.I., LEE, K.H., KIM, S.M., KOO, H., WOO, E.J. and HOLDER D *Physiological Measurement*, 28(10), pp. 1175, 2007.
3. Sedra A, Smith K, IEEE Trans., vol. CT-17, pp 132-134, 1970.
4. Cicekoglu, M.O, *International Journal of Electronics*, 85(4), pp. 455-462, 1998.
5. A Zarafshani, N Huber, N Béqo, B Tunstall, G Sze, C Chatwin and Wei Wang (2010) “A Flexible Low-Cost, High-Precision, Single Interface Electrical Impedance Tomography System for Breast Cancer Detection Using FPGA”, Journal of Physics (IOP): Conference Series, EIT, USA
6. T R Qureshi, C R Chatwin, N Huber, A Zarafshani, B Tunstall and Wei Wang (2010) “ Comparison of Howland and General Impedance Converter (GIC) circuit based current sources for bio-impedance measurements”, Journal of Physics (IOP): Conference Series, EIT, USA
7. Nevis Béqo, Gerald Sze, Benjamin Tunstall, Guofeng Qiao, Ali Zarafshani and Wei Wang (2010) “A flexible and configurable hardware for the Combined EIM and Ultrasound device”, Journal of Physics (IOP): Conference Series, EIT, USA
8. Zhang, Xiaolin, Wang, Wei, Sze, Gerald, Barber, David and Chatwin, Chris (2014) *An image reconstruction algorithm for 3D electrical impedance mammography.* IEEE Transactions on Medical Imaging, 33 (12). pp. 2223-2241. ISSN 0278-0062
9. Zarafshani, Ali, Huber, Nicolas, Béqo, Nevis, Tunstall, Benjamin, Sze, Gerald, Chatwin, Chris and Wang, Wei (2010) *A flexible low-cost, high-precision, single interface electrical impedance tomography system for breast cancer detection using FPGA.* Journal of Physics: Conference Series, 224 (1). 012169. ISSN 1742-6588
10. Qiao, G, Duan, W, Chatwin, C, Sinclair, A and Wang, W (2010) *Electrical properties of breast cancer cells from impedance measurement of cell suspensions.* Journal of Physics: Conference Series, 224 (1). ISSN 1742-6588

References

11. Qiao, Guofeng, Wang, Wei, Duan, Wei, Zheng, Fan, Sinclair, A J and Chatwin, C R (2012) *Bioimpedance analysis for the characterization of breast cancer cells in suspension.* IEEE Transactions on Biomedical Engineering, 59 (8). pp. 2321-2329. ISSN 0018-9294
12. Qureshi, Tabassum-Ur-Razaq, Chatwin, Chris, Zhou, Zhou, Li, Nan and Wang, Wei (2012) *Investigation of voltage source designs for Electrical Impedance Mammography Systems.* In: 34th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC 2012), 28/8/2012 to 1/9/2012, San Diego, California, USA .
13. LS Jamal-Aldin, RCD Young, CR Chatwin (1997) Application of nonlinearity to wavelet-transformed images to improve correlation filter performance, Applied optics 36 (35), 9212-9224
14. B Ganeshan, KA Miles, RCD Young, CR Chatwin (2008) Three-dimensional selective-scale texture analysis of computed tomography pulmonary angiograms, Investigative radiology 43 (6), 382-394
15. B. Nevis, “An investigation into combining electrical impedance mammography with 3D ultrasound for breast cancer detection,” Doctoral thesis, Engineering and Design, University of Sussex, 2013.
16. G. Sze, “Detection of breast cancer with electrical impedance mammography,” Doctoral thesis, Engineering and Design, University of Sussex, 2012