



Plagiarism Checker X Originality Report

Similarity Found: 6%

Date: Monday, February 06, 2023

Statistics: 130 words Plagiarized / 2126 Total words

Remarks: Low Plagiarism Detected - Your Document needs Optional Improvement.

IPTEK, Journal of Engineering, Vol. 5, No. 1, 2019(eISSN: 2337-8530) 5 The Influence of Multi-Frequency Current Injection in Image Reconstruction for Two-Dimensional High-Speed Electrical Impedance Tomography (EIT) Aris Widodo 1 , Agus Rubiyanto 1 , Endarko 1 Abstract ? The image reconstruction for two-dimensional high-speed Electrical Impedance Tomography (EIT) has been successfully studied with multi-frequency current injection.

The aim of this study is to get the best image reconstruction under the influence of multi-frequency current injection of this EIT system. In this method, we used current injection at 1 mA with varies of frequency in the range 10 to 50 kHz injected at the practical phantoms with 16 electrodes. Polyvinyl chloride (PVC) cylinder was put in the practical phantom as the anomaly. Then, The boundary voltage of the practical phantom was measured by the voltage measurement circuit. After that, it processed in the computer with Gauss-Newton Algorithm to get image reconstruction.

The result showed that the best image reconstruction was achieved at 10 kHz of frequency current injection. The best image reconstruction had more accuracy of shape, position and electrical properties of an anomaly in boundary phantom than another image reconstruction result . Keywords ? High-Speed, Electrical Impedance Tomography (EIT), Multi-Frequency, Image Reconstruction, Phantom I.

INTRODUCTION Electrical Impedance Tomography is an imaging technique using an electrical signal that injected in a medium such as human body and industrial part to get the image inside of the boundary medium by mapping conductivity distribution [1]. It has been used in Industrial, Geophysical and Medical Application. In The medical application such as for monitoring respiration system, preliminary cancer detection or

another medical imaging purpose [2]. The advantages of EIT de vice are not harmful because it doesn't use radioactive material like CT scan, not expensive, portable and easy to build for DIY practice [3].

EIT uses constant current 1mA with a frequency between 10 kHz to 1MHz and it is injected into boundary medium by Electrode Pairs [1]. The output result is voltage feedback from boundary measurement using electrode pairs too that show conductivity response of the boundary medium [4]. The Conductivity is reconstructed using some algorithm to obtain a conductivity distribution image. In a recent study, many improvements of EIT has applied to get better performance such speed for monitoring purpose and resolution for the anatomical purpose [5].

The influence of current frequency tends to affect the capability of current can pass through the medium. In study of cola cole load, it said that low frequency had a lower capability to pass the medium than high frequency [6]. 1 Aris Widodo , Agus Rubiyanto , and Endarko are with Department of Physics , Institut Teknologi Sepuluh Nopember, Surabaya, 60111, Indonesia. E-mail: aris.prof22@gmail.com . So, in this research, we studied about the influence of current frequency **in image reconstruction for two - dimensional high-speed Electrical Impedance Tomography (EIT)** to get the appropriate frequency of the current source and improve the result of reconstruction image . II. M ETHOD In this Research, the m ulti-frequency constant current 1mA signal that varied between **10 to 50 kHz** had injected by High -speed EIT to boundary circle phantom that contained an anomaly as shown in Figure 1.

The anomaly was a cylinder Pipe of Polyvinyl Chloride (PVC) and it was placed inside the phantom. The boundary phantom was using 16 of electrode pairs as the path of the current to pass into medium and measure voltage feedback. The practical phantom size had 9 mm diameter and it used 0.5 × 0.5 cm 2 copper (Cu) electrode. This measurement method used neighboring method for current injection process and it's speed was 1ms/data. The total data of neighboring method was 256 for one measurement process to get an image result. Then, measurement voltage had acquired automatically by D AQ device as part of this EIT [7].In this research, we used embedded system EIT, it means that unit control was using microcontroller and Single Board Computer (SBC).The multiplexer became a switch and it transmitted the current to the phantom and also as reciever that it collectted the boundary voltage's data.

Each variation of frequency gave one set of boundary voltage measured data and it shown as measurement point vs voltage graph as a forward problem then reconstructed by Electrical Impedance Tomograp hy and Diffuse Optical Tomography Reconstruction Software (EIDORS) using E 6 **IPTEK, Journal of Engineering** , Vol. 5, No. 1 , 201 9 (eISSN:

2337 - 8530) Gauss -newton algorithm to reconstruct image [8], [9]. The final step was comparing each reconstructed image from all frequency variation to see the effect of frequency on quality of the reconstructed image and real image were included . III.

R ESULTS AND D ISCUSSION After measuring the boundary voltage of practical phantom. The boundary voltage was processed by unit control. Each voltage of number measurement was presented by boundary voltage distribution graph. The complete boundary voltage data was contained homogenous and inhomogenous voltage data. Homogenous condition was happened when the phantom was empty. If the phantom was contained an anomaly like PVC, it would happen an inhomogenous condition. The result of homogenous and inhomogenous voltage condition would show a difference between them and it can be seen as shown in Figure 2. The form of boundary voltage distribution graph has special behavior.

When the voltage measurement point is near current injection point, it has high voltage and it is decreasing if measurement point moves away from current injection point. From figure 1 shows the voltage shifting at peak point 4 th and 5 th , it happens because t here is an anomaly on the phantom near electrodes 4 th and 5 th . the shifting voltage goes to upward. It means as the Kirchoff's law on electricity said voltage is linear to resistance if current is kept constant. F rom correlation above, it can be analyzed when the PVC's anomaly was located inside of phantom and it was high resistivity.

The voltage was increasing. So, the inhomogeneous line in that peak point is going upward shifting but this was the preliminary detection of anomaly's position and it does n't show the distribution of conductivity. So, the next step is image reconstruction to see the anomaly's conductivity distribution inside the practical phantom. The voltage shifting also happen in variation of current frequency but it describes another physical phenomena in EIT like Cola-cole does. In Cola -cole load analysis, it was said that when frequency of current is high.

The current can pass through the medium with high resistivity. From this research, that cola -cole load principle will be proved with real application on practical phantom and also the influence of frequency to the image reconstruction result will be analyzed too. As mention on method, the frequency of current was 1mA, 10kHz to 50kHz and it was injected to the practical phantom. It gives the result voltage distribution graph.

But now it only show on specific peak point with all frequency variation result data as shown in Figure 3. From Figure 3, the shifting voltage for each frequency is appeared. Higher frequency makes the the boundary voltage is decreasing. It happened because

the **current can easily pass through** an anomaly for higher frequency. When current can easily pass, it can be easily said that the resistance is decreasing. But it is not completely true. It happens because of the principle of Impedance. In impedance theory, when Alternating Current (AC) passes through a circuit or medium that has resistance, capacitance, and inductance characteristics. The impedance will be the result of those characteristics.

The capacitance characteristic has more sensitivity with frequency changing because of the reactance principle. When high frequency of current passes through a capacitor, the current will be passed easily and the impedance result from the capacitor is decreasing. So, the impedance can't impede the current so the voltage is decreasing as the frequency increments. From Figure 3, the theory about the influence of current frequency is proven. But it needs more evidence that shows the influence of frequency. So the next step is comparing the image reconstruction result of each frequency to add more evidence that the influence of frequency really does. After all, the boundary voltage of each frequency variation was measured.

Then, it would be compared with each other to see the best result of image reconstruction. The comparison of each reconstructed image from each frequency variation shows a color distribution that blue color as a more resistive medium. In this case, the anomaly is a cylinder pipe (PVC) that is located in the specified location to see the accuracy of EIT and identify the electrical properties of materials as shown in Figure 4. At 10 kHz frequency, it gives a better reconstructed image than another does. Higher frequency gives lower intensity and size of conductivity distribution from image reconstruction.

It happens because of **the characteristic of frequency** effect when it passes through the medium as theory above. When higher frequency, **current can easily pass through** an anomaly and at the location of anomaly has increased the conductivity, so the blue color will decrease the intensity and shift to the positive value of color bar. However, the ability of EIT to detect PVC as resistive materials has been accomplished as shown in Figure 4. From Figure 4, the noise is shown by another color that is opposite the anomaly. In this case, it is red color.

It happened because there is corrosion at the electrode 1st and 2nd and also noise can happen if the contacting area of medium doesn't set perfectly and current signal has noise too. So, in this research, every measurement step is checked and set perfectly to minimize that noise. IV. CONCLUSION In this research, we studied the influence of frequency in image reconstruction result of high- **speed Electrical Impedance Tomography** (EIT). The result of this research is The use of 1 mA, 10 kHz sinusoidal

constant current for image reconstruction in the two-dimensional high-speed Electrical Impedance Tomography demonstrated the best performance compared to others because the image reconstruction intensity color matches with the real image coverage area. The EIT system can recognise the anomaly object placed inside in the system.

For future work, it is planned to find the best result image reconstruction of this current frequency variation when it is injected to human tissue. *IPTEK, Journal of Engineering*, Vol. 5, No. 1, 2019 (eISSN: 2337-8530) 7 Figure 1. EIT device diagram with high-speed measurement process. Figure 2. Boundary Voltage distribution at 10kHz. Figure 3. Boundary voltage for all frequency at specified peak. Figure 4. Comparison between (A) real image, reconstructed image at (B) 10kHz, (C) 20kHz, (D) 30kHz, (E) 40kHz and (F) 50kHz constant current 1mA injection. 8 *IPTEK, Journal of Engineering*, Vol. 5, No. 1, 2019 (eISSN: 2337 - 8530) REFERENCES [1] M. Khalighi, B.

V. Vahdat, M. Mortazavi, and M. Mikaeili, "Design and implementation of precise hardware for Electrical Impedance Tomography (EIT)," *Trans. Electr. Eng.*, vol. 38, no. E1, pp. 1–20, 2014. [2] P. O. Gaggero and P. Thomann, "Miniaturization and distinguishability limits of electrical impedance tomography for biomedical application," Université de Neuchâtel, 2011. [3] A. B. S. Umbu and E. Endarko, "The design of voltage controlled current source (VCCS) for single frequency electrical impedance tomography (EIT)," in 2017 International Seminar on Sensors, Instrumentation, Measurement and Metrology (ISSIMM), 2017, pp. 30–36. [4] T.

Rymarczyk and K. Szulc, "Reconstruction of conductivity distribution in electrical impedance tomography by topological derivative," in 2017 18th International Symposium on Electromagnetic Fields in Mechatronics, Electrical and Electronic Engineering (ISEF) Book of Abstracts, 2017, pp. 1–2. [5] Y. Zhang and C. Harrison, "Tomo: wearable, low-cost, electrical impedance tomography for hand gesture recognition," in *Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology - UIST '15*, 2015, pp. 167–173.

[6] A. J. Puspitasari and E. Endarko, "Study of precision constant current sources with resistor load and a Cole-Cole load for multi-frequency in electrical impedance tomography," in 2016 International Seminar on Sensors, Instrumentation, Measurement and Metrology (ISSIMM), 2016, pp. 12–17. [7] J. Malmivuo and R. Plonsey, *Bioelectromagnetism: principles and applications of bioelectric and biomagnetic fields*. New York: Oxford University Press, 1995. [8] V. Sarode, P. M. Chimurkar, and A.

N. Cheeran, "Electrical impedance tomography using EIDORS in a closed phantom," *Int. J. Comput. Appl.*, 2012. [9] M. Farha and E. Endarko, "Combined algorithm of total

variation and Gauss -newton for image reconstruction in two -dimensional Electrical Impedance Tomography (EIT),” in 2017 International Seminar on Sensors, Instrumentation, Measurement and Metrology (ISSIMM), 2017, pp. 37 –41.

INTERNET SOURCES:

1% -

[http://portalgaruda.fti.unissula.ac.id/index.php?ref=browse&mod=viewjournal&journal=4984&issue=%20Vol%201,%20No%201%20\(2014\)](http://portalgaruda.fti.unissula.ac.id/index.php?ref=browse&mod=viewjournal&journal=4984&issue=%20Vol%201,%20No%201%20(2014))

1% - <https://garuda.kemdikbud.go.id/documents/detail/2172299>

<1% - <https://ieeexplore.ieee.org/document/8327855>

<1% -

<https://www.its.ac.id/fisika/wp-content/uploads/sites/19/2021/05/20.-Endarko.pdf>

<1% - <https://www.onesearch.id/Record/IOS1119.article-5019/Details>

<1% -

<https://pdfs.semanticscholar.org/eece/df94f4fa47bd72999a8a4192b59c6d24f67a.pdf>

<1% -

https://www.answers.com/physics/Are_materials_that_electric_current_can_easily_pass_through

<1% -

<https://www.quora.com/When-sound-waves-travel-from-one-medium-to-another-does-frequency-remains-same>

<1% -

<https://www.chegg.com/homework-help/questions-and-answers/main-features-simple-diffusion--molecules-pass-membrane-areas-higher-lower-concentration-h-q86084445>

<1% - <https://www.nature.com/articles/s41598-021-98793-0>

<1% -

https://repository.unsri.ac.id/16722/1/DEVELOPMENT_AND_STUDY_ON_TRANSFORMER.pdf

1% - <https://journal.unesa.ac.id/index.php/jpfa/article/view/8481>

<1% - <https://ieeexplore.ieee.org/document/9690489/>

1% - https://link.springer.com/chapter/10.1007/978-3-030-89098-8_3