ICTEC'22
International Conference on Telecommunication, Electronic and Computer Engineering

Proceedings of

4th International Conference on Telecommunication, Electronic and Computer Engineering 2022

Hybrid Conference

1st & 2nd November 2022

Edited by:
Ahmad Sadhiqin Mohd Isira
Wira Hidayat Mohd Saad
Mohd Shahril Izuan Mohd Zin
Mawarni Mohd Yunus
Khairun Nisa Khamil

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

CENTRE FOR TELECOMMUNICATION RESEARCH & INNOVATION

Proceedings of 4th International Conference on Telecommunication, Electronic and Computer Engineering (ICTEC'22)

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Penerbit UTeM Press
Universiti Teknikal Malaysia Melaka
2023

eISBN: 978-967-2792-74-1

FIRST PUBLISHED 2023

Member of the Malaysian Scholarly Publishing Council (MAPIM)
Member of the Malaysian Book Publishers Association (MABOPA)

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Published and Printed in Malaysia by:
Penerbit UTeM Press
Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
Tel: +606 270 1241 Faks: +606 270 1038

Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available from the National Library of Malaysia

eISBN 978-967-2792-74-1

EDITORIAL PREFACE

This e-proceedings contains a collection of 59 exceptional papers chosen from the 4th International Conference on Telecommunication, Electronic and Computer Engineering (ICTEC'22), which was held on 1st & 2nd November 2022. Organized by the Faculty of Electronic and Computer Engineering (FKEKK) at Universiti Teknikal Malaysia Melaka (UTeM), in conjunction with the Centre for Telecommunication Research and Innovation (CeTRI), this conference has formed a collaboration with five other universities: Universitas Andalas, AMITY University, Universitas Sriwijaya, Vellore Institute of Technology, and King Mongkut's Institute of Technology in Ladkrabang.

ICTEC'22 brought together researchers, academics, and professionals from all over the world to share their new discoveries and findings in the fields of telecommunication, electronics, and computer engineering. The technical committee received an overwhelming response to the conference, with submissions from all over the world. Our hope is that this conference will strengthen academic and research collaborations between institutions both locally and internationally, inspiring and propelling engineering research and fostering beneficial collaborations between organizations.

All papers submitted underwent a rigorous peer-review process, with revisions made according to the reviewers' comments. Ultimately, 59 papers were selected for publication in this open access e-proceedings, which can be viewed or downloaded at https://ictec.utem.edu.my/proceedings/2022.

As editors-in-chief, we would like to extend our heartfelt appreciation to the reviewers who worked tirelessly to review the submitted papers for this proceedings. We would also like to express our gratitude to all the authors for their prompt revision of their papers in accordance with the proceeding requirements. Our hope is that this e-proceedings will serve as a valuable reference for researchers, and that the event will sustain the research culture in universities and industries by bringing together educators, researchers, and practitioners to share their findings.

Thank you!

Dr. Ahmad Sadhiqin bin Mohd Isira
Associate Prof. Dr. Wira Hidayat bin Mohd Saad

Editors-in-Chief
Proceedings of 4th International Conference on Telecommunication, Electronic and Computer Engineering (ICTEC'22)

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AIMS & SCOPE

The International Conference on Telecommunication, Electronics, and Computer Engineering 2022 (ICTEC'22) is the fourth conference organized by the Centre for Telecommunication Research and Innovation (CeTRI) and the Faculty of Electronic and Computer Engineering (FKEKK) at Universiti Teknikal Malaysia Melaka (UTeM). In collaboration with Universitas Andalas, AMITY University, Universitas Sriwijaya, Vellore Institute of Technology and King Mongkut's Institute Technology of Ladkrabang, ICTEC 2022 aims to provide a platform for researchers, academics, and industry professionals from around the world to share their latest research findings and discoveries in the fields of Telecommunication Engineering, Electronics Engineering, Computer Engineering, and Industrial Revolution (IR) 4.0.

The conference welcomes submissions of original extended abstracts that conform to the 4 conference themes: Telecommunication Engineering, Electronics Engineering, Computer Engineering and Industrial Revolution 4.0 (IR 4.0). Topics of interest include, but are not limited to, wireless communication systems, optical communication systems, signal processing, control systems, computer networks, software engineering, artificial intelligence, machine learning, robotics, IoT, cloud computing, big data analytics, cybersecurity, smart manufacturing, smart cities, autonomous systems, and human-machine collaboration.

ICTEC 2022 offers an opportunity for participants to exchange ideas, network with peers, and establish new collaborations. The conference also provides a platform for researchers to showcase their work and contribute to the advancement of knowledge in the fields of Telecommunication, Electronic, and Computer Engineering.

EDITORIAL POLICIES

PEER REVIEW PROCESS

- Our peer review and editorial processes are conducted through an online conference management system, Microsoft's Conference Management Toolkit (CMT).
- All submitted papers undergo rigorous blind peer-review by at least two experts in the relevant scientific field.
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- Reviewers who accept an invitation to review are given fourteen days to complete their review via CMT, with extensions available upon request.
- We typically provide a maximum of two rounds of revision per manuscript. The ultimate responsibility for editorial decisions lies with the Editor-in-Chief, and all decisions are final.
- Possible decisions include acceptance, acceptance with amendments, and rejection, and all acceptances are subject to legal requirements regarding libel, copyright infringement, and plagiarism.

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- Authors must confirm that their manuscripts are their original work and submit them in proper English and format, in accordance with the Author Guidelines.
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- All authors listed should have made significant contributions to the research.
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- Authors must report any errors they find in their published paper to the Editors.
- Authors should acknowledge all significant funders and competing interests related to their research.
- All other sources of support for publication should be clearly identified in the manuscript, usually in an acknowledgment.

RESPONSIBILITY OF REVIEWERS

- Manuscripts will be blind-reviewed by at least two experts to reach the first decision. Reviewers are asked to declare any conflicts of interest and must keep all information confidential.
- Reviewers are expected to focus on the scientific quality and overall style of the manuscript, conforming to the best practices of clear and concise academic writing. If Reviewers recognize that a manuscript requires linguistic edits, they should inform the Authors or Editors in their report.
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- Reviewers are expected to provide polite and constructive reports. Insulting or uninformative comments will be rescinded.
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- Editors are responsible for ensuring the scientific quality of the published papers, focusing on their importance, originality, clarity, and relevance to the publication's scope.
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- Editors must ensure the quality and integrity of the academic record and conform to internationally accepted ethical guidelines.
- Editors should preserve the anonymity of Reviewers unless they later decide to disclose their identities.
- If Editors suspect misconduct, they must take action and attempt to obtain a resolution to the problem.
- Editors should not reject papers based on suspicions but only on proof of misconduct, and must not allow conflicts of interest between Authors, Reviewers, and Board Members.

By following these policies, we aim to ensure the highest standards of quality, transparency, and ethical conduct in our publications. We encourage Authors, Reviewers, and Editors to familiarize themselves with these policies and to adhere to them at all times.

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A Review of the Basic Principle of Interferometry Lightning Detection System and Construction of Buffer Circuit for Measuring Lightning Vertical Electric Field

Wiwin A. Oktaviani[1,2], Muh. Abu Bakar Sidik[3*], Mohd. Riduan Ahmad[4], Muh. Irfan Jambak[3]
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ABSTRACT: This paper describes a VHF Interferometry system that can detect the direction or location of lightning strikes by measuring the phase difference in the frequency spectrum of a pair of antennas. The system uses a parallel plate antenna with a buffer circuit to measure the electromagnetic field, and the main component of the buffer circuit is an IC and impedance circuit. The system's accuracy depends on the quality and cleanliness of the analyzed signal. The paper also discusses various signal-denoising techniques such as linear fit, cross-correlation, and wavelet transform. The authors suggest that for the development of interferometry techniques to be successful, there should also be improvements in signal denoising techniques, increased data storage capacity, and reliable storage media.

Keywords: *Interferometry; Lightning Detection System; Buffer Circuit*

1. INTRODUCTION

Lightning is a natural phenomenon where lightning involves the movement of charge vertically due to the release of positive or negative charges and produces electromagnetic emissions with the frequency range of VLF to VHF [1]. The energy emitted by lightning's electromagnetic emission is so powerful that it can destroy items. Thus, to avoid or limit the impact of damage caused by lightning strikes, a method of detecting the lightning position and the direction from which the potential for lightning would hit is required. `Electromagnetic emission is a parameter used to determine the direction of lightning strikes, known as lightning location systems.

One of the techniques used in lightning location systems is interferometry. This technique is the most promising method of determining the location of the strike since it does not require many antennas and sensors and is not susceptible to the noise that usually arises along with the signal to be recorded [2]. One of the current discussions in the VHF Interferometry lightning location system is the accuracy rate of the interferometry technique. In particular, this paper will examine a research question, such as what is the most factor that affects the accuracy of the VHF Interferometry Lightning Location System.

2. INTERFEROMETRY AND ELECTRIC FIELD MEASUREMENT SYSTEM

Interferometry is used to study lightning discharges by measuring the time difference between two antennas. Hayenga, in 1979 developed the VHF radio interferometry method to identify the various processes that occur during discharge [3] using a frequency of 34 MHz [4]. Numerous researchers have improved the technique since then.

The basic principle of interferometry is to estimate phase differences in the frequency spectrums of a pair of antennas [5], and the phase difference determines the direction of the electromagnetic field emission source [6]. Two antennas separated by a distance detect electromagnetic fields emitted by distant sources. The output signal from the two antennas will have a phase difference, denoted as $\phi=2d \sin \cos/ \lambda$. The method has a fringe ambiguity of 2π in the phase measurement with a baseline $d > /2$, which can be overcome by positioning two pairs of antennas with perpendicular baselines of $\lambda/2$ and 4λ [7]. This position allows the azimuth and elevation of the sources to be determined, and the lightning source can be located using two sets of identically separated antennae.

Interferometry systems typically use two frequencies: narrowband and broadband. Interferometry with broadband frequencies operates in a frequency range where electromagnetic emissions from lightning can be observed, and it can record high-resolution electromagnetic emissions, making it preferable to use than narrowband frequencies. The VHF broadband interferometer can describe the physical process during lightning flashes in greater detail [2].

However, large frequency ranges require a substantial amount of digital storage capacity. To address this, researchers have developed techniques such as sequential triggering, where memory storage is divided into segments that record one electrical broadband pulse for one microsecond [6]. Morimoto et al. developed a digital-based VHF-broadband interferometry system that produces accurate results [8].

In a lightning measuring system, noise or unwanted signals might impact some areas of the signal's frequency spectrum. A denoising technique is required to eliminate as much noise as possible while keeping the significant aspects of the studied signal. The linear fit approach is used in Shao and Krehbiel's interferometry system to

detect the direction of electromagnetic emission sources by integrating the results of measuring phase differences between antenna pairs in an array [9]. Mardiana and Kawasaki employed the cross-correlation approach to computing the phase difference of two fast-moving electromagnetic signals in their broadband [6]. The cross-correlation technique may combine with other techniques to improve accuracy. The wavelet transform is a multiresolution signal processing approach. It is better suited for non-stationary spectra observed in nature rather than the Fourier Transform.

A lightning detection system uses a parallel plate antenna with a buffer circuit as a sensor. Buffer circuits separate the high-impedance antennas, provide enough power to drive the signal from the antenna to the oscilloscope via the coaxial cable, and filter the frequency spectrum of the lightning flash signal without amplifying it. Galvan and Fernando pioneered the use of buffers to measure electrical elements [10], and other researchers have adopted this method. The IC must be a high-speed buffer, which enables accurate measurement of the amplitude and rise time of the lightning electric field, with unity gain characteristics and producing a high output current.

The accuracy rate of lightning location detection systems is affected by the "installation error" level, which can be corrected through calibration [11]. The efficiency of detection methods varies depending on the observed frequency band. The systems should carefully filter noise signals at the pre-processing stage to ensure that relevant lightning information is not omitted, improving lightning detection performance.

3. DISCUSSION

The interferometry technique for lightning detection has several advantages over other techniques. It can be operated with only one station, does not require many antennas, yet provides accurate observations. The accuracy of the technique is influenced mainly by the quality of the received signal, making the pre-processing stage and signal-denoising process crucial.

To overcome memory storage limitations, digital signal processing technology, sequential triggering techniques, and database management systems such as MySql can be used. This method allows for real-time recording and display of lightning signal observation data. However, it is important to maintain signal cleanliness to generate valid data.

The parallel plate antenna equipped with a buffer circuit is a good choice for sensing lightning signals due to its construction being oriented perpendicular to the vertical electric field vector. Potential developments for this antenna include making it more compact and mobile for easier installation and transportation.

4. CONCLUSION

Interferometry is a technology that can deliver accurate detection results for a lightning location without needing many antennas or a large space. However, to improve the accuracy and expand storage capacity, developing signal processing techniques and storage media technology is necessary. With these advancements, real-time monitoring and detection of lightning will be possible.

ACKNOWLEDGEMENT

The authors are grateful to the Engineering Faculty Universitas Sriwijaya for facilitating the research project and Atmospheric Science and Disaster Management Research Group (ThorRG), Universiti Teknikal Malaysia Melaka (UTeM).

REFERENCES

[1] K. L. Cummins and M. J. Murphy, "An Overview of Lightning Locating Systems: History, Techniques, and Data Uses, With an In-Depth Look at the U.S. NLDN," *IEEE Trans. Electromagn. Compat.*, vol. 51, no. 3, pp. 499–518, Aug. 2009.

[2] A. Alammari et al., "Lightning Mapping: Techniques, Challenges, and Opportunities," *IEEE Access*, vol. 8, pp. 190064–190082, 2020,

[3] C. Hayenga, "Positions and movement of VHF lightning sources determined with microsecond resolution by interferometry," May 1979.

[4] J. W. Warwick, C. O. Hayenga, and J. W. Brosnahan, "Interferometric directions of lightning sources at 34 MHz," *J. Geophys. Res. Oceans*, vol. 84, no. C5, pp. 2457–2468, 1979.

[5] J.-Y. Lojou, M. J. Murphy, R. L. Holle, and N. W. S. Demetriades, "Nowcasting of Thunderstorms Using VHF Measurements," in *Lightning: Principles, Instruments and Applications: Review of Modern Lightning Research*, H. D. Betz, U. Schumann, and P. Laroche, Eds. Dordrecht: Springer Netherlands, 2009, pp. 253–270.

[6] R. Mardiana, T. Ushio, Y. Ota, M. Murakami, Z. Kawasaki, and K. Matsuura, "Broadband radio interferometer utilizing a sequential triggering technique for locating fast-moving electromagnetic sources emitted from lightning," *Proceedings of the 16th IEEE Instrumentation and Measurement Technology Conference*, May 1999, vol. 3, pp. 1761–1766 vol.3.

[7] C. O. Hayenga and J. W. Warwick, "Two-dimensional interferometric positions of VHF lightning sources," *J. Geophys. Res.*, vol. 86, no. C8, p. 7451, 1981.

[8] T. Morimoto, A. Hirata, Z. Kawasaki, T. Ushio, A. Matsumoto, and L. Ho, "An Operational VHF Broadband Digital Interferometer for Lightning Monitoring," *IEEJ Trans. Fundam. Mater.*, vol. 124, pp. 1232–1238, Jan. 2004.

[9] X. M. Shao and P. R. Krehbiel, "The spatial and temporal development of intracloud lightning," *J. Geophys. Res. Atmospheres*, vol. 101, no. D21, pp. 26641–26668, 1996.

[10] A. Galván and M. Fernando, "Operative characteristics of a parallel-plate antenna to measure vertical electric fields from lightning flashes," 2000.

[11] Y. Nakamura, T. Morimoto, T. Ushio, and Z.-I. Kawasaki, "An Error Estimate of the VHF Broadband Digital Interferometer," *IEEJ Trans. Fundam. Mater.*, vol. 129, no. 8, pp. 525–530, 2009.

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4th International Conference on Telecommunication, Electronic and Computer Engineering 2022

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e ISBN 978-967-2792-74-1

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