

Author's Guidelines for the Transactions of the Institute of Electric Engineers of Japan

(This guidelines revised and came into force on January 2012)

[1] Rules for Submission

1. Categories and Scopes of the IEEJ Transactions

Transactions of the Institute of Electric Engineers of Japan (IEEJ) are important source of information delivered to the society members directly. The authors are advised to read the guidelines before submission as all submissions to the IEEJ Transactions are processed according to these guidelines. The IEEJ publishes several Transactions and each of them has each category and scope. Attached Table 1 indicates the IEEJ Transactions their categories and scopes.

2. Types of Submission and Requirements

There are four types of submission for the IEEJ Transactions: Paper, Technical Note, Letter and Discussion, (however, there are two types of submission for IEEJ Transactions on Electrical and Electronic Engineering, hereinafter referred to as "TEEE": Paper and Letter.) Followings are their requirements that are expected to have.

2.1 Requirements of Paper

Papers published in the IEEJ Transactions should have the contents that contribute to the scientific research or technology in the electrical engineering, and should satisfy at least one of the following requirements (1) through (3), and the two essential requirements (4) and (5), below.

- (1) The paper is objectively judged to have creativity. (Creativity)
- (2) The paper is objectively judged to have originality. (Originality)
- (3) The paper is useful to the development of the scientific research or the technology. (Usefulness)
- (4) The paper contains no obvious error.
- (5) The paper should not be published in the other publications prior to submission to IEEJ. The publications refer to the books and journals printed in Japan or elsewhere, and the in-house publication of the government, public institutions and the universities. However, in the following cases, the author may still submit the paper as a new paper.
 - (a) Paper that had been previously published in the meetings or symposia or any such similar meetings, sponsored or co-sponsored by the IEEJ prior to submission in the IEEJ Transactions. This paper should also be non-problematic in the copyright law.
 - (b) Paper that expands the Letter previously published as recent news in the IEEJ Transactions.

2.2 Requirements of Technical Note

Technical Notes to be published in the IEEJ Transactions must not be published in the other publications prior to submission to the IEEJ, and must meet one of the following criteria.

- (1) Systematic analysis of the existing theories.
- (2) Test results, test criteria, numerical tables and technical practice with universal interest.
- (3) Comprehensive report of scientific or technical topic that is worth specific attention at the time.
- (4) Other topics that are deemed to have scientific or technical contributions.

Authors may submit the contents, as a Technical Note, which had been previously published in the meetings or symposia or any such similar meetings, sponsored or co-sponsored by the IEEJ prior to submission in the IEEJ Transactions. This Technical Note should also be non-problematic in the copyright law.

2.3 Requirements of Letter

Letters to be published in the IEEJ Transactions must not be published in the other publications prior to submission to the IEEJ, and must meet one of the following criteria.

- (1) Recent News on a creative new research or technical developments.
- (2) Recent News on an original scientific study or technology.

Authors may submit the contents, as a Letter, which had been previously published in the meetings or symposia or any such similar meetings, sponsored or co-sponsored by the IEEJ prior to submission in the IEEJ Transactions. This Letter should also be non-problematic in the copyright law.

2.4 Requirements of Discussion

Discussion of Paper, Technical Note and Letter and the responses from the author constitute Discussion. Authors should directly state the point of argument with only a short preamble and discover the truth. Discussion should state only what is relevant to the original article and should not touch upon items disrelated to the paper.

3. Qualifications of the Authors

Submissions from both members and non-members of the IEEJ are welcome. However, the applicable publishing fees for the manuscript authored by only non-members of the IEEJ are different from those submitted by authors including an IEEJ member. (Refer to [4] 1.)

4. Copyright

- (1) Copyright, which specified in Rules on Copyright of the IEEJ, of all Papers, Technical Notes, Letters and Discussions, appearing in the IEEJ Transactions shall belong to the IEEJ. Thus, the authors who will submit Papers, Technical Notes, Letters and Discussions have to transfer a copyright, which is all of the rights stipulated in the provisions from Article 21 to Article 28 in the Copyright Law of Japan, to the IEEJ at initial submission. The IEEJ considers that all the authors have read and understood the description of Copyright in the Author's Guidelines for the Transactions of the IEEJ, and transfer the copyright to the IEEJ in agreement with all the items upon the completion of submission through the IEEJ Paper Management System on the Web. Please contact the IEEJ Editorial & Publishing Section about how to transfer the copyright which unable to submit thorough the IEEJ Paper Management System on the Web. (e.g. Discussion.). However, the following rights will remain with the authors after the copyright transfer.
 - (a) All rights other than the copyright, such as patent rights.
 - (b) The author's rights to use the work as part of compiling a biography of his/her work.
 - (c) The author's rights to reproduce copies of the work for non-commercial use. (e.g. for educational material.)
 - (d) Other uses of the work that will not infringe upon the Copyright Law of Japan.
- (2) Authors must not submit or publish the Paper, Technical Note, Letter and Discussion containing the same contents to multiple publications. When the Paper, Technical Note, Letter and Discussion are rejected for publication, the copyright transfer to the IEEJ becomes invalid from the moment the decision is made to reject.
- (3) Authors should be noted the following items in copyright transferring.
 - (a) Authors should take full cautions in quoting articles from another work to avoid any infringement of copyright. A written permission to reproduce must be obtained without cost when copyright permission is required.
 - (b) All the persons who have made substantial contributions to the work shall appear as authors.
 - (c) An agreement for publication shall be obtained in cases where it is necessary from a person having appropriate authority in any organization to which authors belongs.

[2] Manuscript Preparation

1. General Remarks

The IEEJ Transactions are public forum for communicating expeditiously and extensively to the members, the results of new research, development and applications that contribute to the scientific research and technology in the electric engineering. When writing a manuscript, the authors should keep in mind the following points to communicate effectively the information valuable and interesting to the members and to ensure that the paper is published in the Transactions promptly.

- (1) Ensure that the significance of the subject to be published and the results are understandable to the readers who are the specialists in the field as well as the non-specialists. Special attention should be taken when writing the abstract and the introduction.
- (2) Express clearly, omitting the subjects irrelevant to the theme. Check elaborately for any spelling errors or typographical errors. The IEEJ recommends the manuscript to be read by a reliable third person.
- (3) Contents of the paper should be presented in a logical order and there should not be any leap of logic in the explanation. Propriety of the hypothesis or the conditions which form the premise of the paper should be considered carefully and the universality should be illuminated.
- (4) Summarise the current status of study in the related field, and explicitly define the position of the content to be published.
- (5) Express clearly the creative, original or useful aspects of the content to be published. For example, illuminate the points how theory, experimental methods or the results differ from the existing theories, methods or results.

2. Language Limitations

Manuscripts must be written in Japanese or English, provided however when the Program Committee approves, this will not be the case. In the case of submitting to TEEE and IEEJ Journal of Industry Applications, manuscripts have to be written in English only.

3. Page Limitations (See Table 2)

3.1 Paper and Technical Note

Paper and Technical Note should be 6 pages or less. However, author may use up to the maximum of 14 pages, this is to say that the author is allowed to use 8 additional pages if necessary. When an author submits two articles that are deemed to be of single topic, but divided into two submissions due to the page limitations, the author will be requested to rewrite and combine the two articles.

3.2 Letter

Letter should not exceed 2 pages.

3.3 Discussion

Discussion should not exceed 1 page.

3.4 Extended Summary

Extended Summary should not exceed 1 page. However, there is no need to submit Extended Summary for Letter, Discussion and Paper submitted to TEEE. Extended Summary is excluded from the Page Limitations described in 3.1.

4. Manuscript Format

Manuscript format for Paper, Technical Note, Letter which will be submitted to the IEEJ Transactions (hereinafter referred to as “Paper and Article”) is designated in this chapter. Please

contact the IEEJ Editorial & Publishing Section about the format of Discussion.

4.1 Manuscript Preparation

In principle, all manuscript should be prepared using LaTeX style file or MS-Word Template for the IEEJ Transactions provided by the IEEJ. The IEEJ LaTeX Style File and MS-Word Template are available for downloading from the following IEEJ website. It is possible to submit your manuscript without using the IEEJ LaTeX Style File or MS-Word Template. However, in this instance, applicable publishing fees are different from those of manuscript using the IEEJ LaTeX Style File or MS-Word Template. (Refer to [4] 1.)

URL address for the IEEJ LaTeX Style File and MS-Word Template:

<http://www2.iee.or.jp/ver2/honbu/90-eng/14-magazine/index030.html>

Please ensure the described below when preparing the manuscript using the IEEJ LaTeX Style File or MS-Word Template.

- (a) Figures and photographs should be electronically included in the manuscript.
- (b) The IEEJ LaTeX Style file and MS-Word Template distributed should not be modified.

4.2 Manuscript Structure

Manuscript should consist of the following contents in the order as specified below. Please format a manuscript in reference to Appendix 1.

- (1) Title
- (2) Name of the author and the IEEJ membership category of each author
- (3) Abstract (Paper and Technical Note: 150 to 200 words, Letter: 100 words.)
- (4) Keywords
- (5) Author affiliation and contact information
- (6) Text
- (7) Acknowledgment (Only in case of necessity.)
- (8) Reference
- (9) Appendix (Only in case of necessity.)
- (10) Author's biography of each author (This may be omitted in case of Letter.)
- (11) Author's photograph of each author (This may be omitted in case of Letter.)

4.3 Keywords

Select and supply six or less keywords that represent the theme of paper and article. Words should be selected following the criteria below.

- (a) Select words or phrases with specific meanings.
- (b) Use nouns.
- (c) Abbreviations should be limited to those used and understood extensively in Japan and elsewhere. (New words coined by the author should not be used.)
- (d) Compound words should be limited to commonly used terms.

4.4 Writing the Main Text

Text should be organized in the following order.

- Chapter: 1. Heading
- Section: 1.1 Sub-heading

4.5 References

- (1) References should include not only the author's own papers but the works of paper and article

written by others, and ensure that appropriate and sufficient list of bibliography is provided. Authors cannot attach any reference material that are related to content of the paper and article at submission.

- (2) All references should be numbered and listed at the end of the main text, and the numbers should be noted in the main text with a parenthesized number in superscript, where the reference is made in the main text.
- (3) Committee reports and in-house reports not available to public should not be included in the references.
- (4) Paper and article under submission should not be quoted.
- (5) Reference should be stated in the following manner.
Name of the author(s): “Title”, Name of Publication, Volume, Number, Page (Year and Month of Publication) Include all the author’s names in full. Try to avoid abbreviating the title.

4.6 Figures, Photographs and Tables

- (1) Figures, photographs and tables should be prepared according to Appendix 3.
- (2) Captions for figures and photographs should be placed directly below the figures or photographs. (It is unacceptable without caption as only “Fig. 1.”) Table captions should be placed directly above the table. (It is unacceptable without legend as only “Table 1.”)
- (3) All legend in figure, photographs and tables must be in English.
- (4) Figures, photographs and tables should be serially numbered.
- (5) The size and position of figures, photographs and tables inserted should be clearly legible to the readers and position them at the tops and bottoms of columns. Avoid placing them in the middle of columns.
- (6) When a figure does not fill the full column width, do not use the remaining space for text.

4.7 Author’s Biography and Photograph

Use the last seven lines of the text for author biography. In principle, place a facial photo (28 mm (height) by 22 mm (width)) flush left under the name of the author. Following the membership category, write the short introduction. (See page 2 of Appendix 1)

Author may omit author’s biography and facial photograph in the case of Letter.

4.8 Extended Summary

Extended Summary should be prepared so that it provides by itself an understandable outline of the original paper and article, and it is also possible to include the figures, photographs and tables. It is allowed to have content comparable to abstract, but not applicable for Paper and Technical Note on IEEJ Transactions D and IEEJ Journal of Industry Applications. Extended Summary format should be according to Appendix 2. Authors have the option of containing E-mail address in the Extended Summary.

The IEEJ LaTeX Style File and MS-Word Template for Extended Summary are available for downloading from the IEEJ website at:

<http://www2.iee.or.jp/ver2/honbu/90-eng/14-magazine/index030.html>

[3] Submission and Review Process

1. Submission Process

Submission, receipt, review, resubmission, evaluation and submission of final manuscript of paper and article should be made online at the IEEJ Paper Management System on the Web. Author need to access the following URL to take procedure. For details, refer to the Author’s Guidelines on the IEEJ Paper Management System Login screen.

URL address for submissions:

<http://www2.iee.or.jp/ver2/honbu/90-eng/14-magazine/index030.html>

2. Submission

Paper and article are to be submitted electronically via the IEEJ Paper Management System. Authors should be followed the onscreen instructions on the IEEJ Paper Management System on the Web to register the necessary information and submit a manuscript and an Extended Summary in PDF format. (See Table 2.)

For submission of Discussion, please inquire the IEEJ Editorial & Publishing Section.

3. Receipt, Review, Resubmission and Evaluation

- (1) The paper and article submitted are confirmed the registration information by the IEEJ Editorial & Publishing Section, and the author will receive an acknowledgment receipt with a paper ID. However when a paper or an article deviates significantly from the instructions described in these guidelines, the said paper or the article will not be accepted. And, any replacement of the papers and articles would be rejected once they submitted. Any change and addition of the authors would be also rejected once they submitted.
- (2) The paper and article submitted will be reviewed in accordance with the “Rules for Paper Screening” by one or two or more reviewers. Based on the comments of the reviewers, the editor in chief evaluates the paper and article, and reports the results to the chairperson of the Editorial Affairs Committee. The chairperson of the Editorial Affairs Committee, based on this evaluation report, decides acceptance or rejection as categorized below, and then notify the author accordingly. The Extended Summary will be read from a viewpoint of whether or not it has been prepared in such a manner that the outline of the paper is understandable. However, it will not be used for evaluation in things like deciding on whether to accept or reject the paper.

Evaluation A : Publish as it is. (Accept)

Evaluation B: Publish with minor revision. (Accept with change)

Evaluation C: Refer back to the authors for clarifications before decision on acceptance.
(Reevaluation after Referral)

Evaluation D: Not to be published. (Reject)

- (3) Author who received inquiries from reviewers should revise a manuscript and draw up a response paper to the inquiries, and must submit a revised manuscript, a revised Extended Summary, and a response paper via the IEEJ Paper Management System on the Web within 90 days after receipt inquiries for revision or clarification. (See Table 3.) Paper and article may be deemed withdrawn when authors fail to submit a revised manuscript and has not responded to inquiries within 90 days after being returned for modification. Submission of the revised manuscript after the completion of withdrawal procedures is considered as a new submission, and receipt, review, and evaluation will be treated in the same way as initial submission.
- (4) Notification of acceptance will be sent to the author if the submitted manuscript is accepted for publication in the IEEJ Transactions.
- (5) Notification of rejection will be sent with reasons for the rejection if the manuscript decided to be rejected. If unable to accept the reason for reject, authors can protest in writing up to two times.
- (6) Paper screening procedure follows the steps described above and the IEEJ Editorial Affairs Committee shall not be held responsible for any liabilities incurred.
- (7) Paper and article submitted to the IEEJ must not be submitted to other journals.

4. Procedures Following Acceptance

4.1 Submission of Final Manuscript

Author upon receiving the notification of acceptance must register the necessary information and submit the final manuscript following the instructions on the IEEJ Paper Management System on the Web. The following final manuscript data should be stored into a compressed folder and uploaded on

the IEEJ Paper Management System.

- (1) A set of manuscript data files (LaTeX, MS-Word and other files)
- (2) Extended Summary data file
- (3) Photograph file for author's introduction (JPG, EPS and other files)
- (4) Example for paper and article (PDF file)
- (5) Example for Extended Summary (PDF file)

Letter and Paper submitted to TEEE require no files on Extended Summary.

4.2 Proofreading by the author

As a general rule, the author will be asked to proof-read the final copy only once.

[4] Publishing Fees

1. Publishing Fees

After paper and article have been accepted for publication in the IEEJ Transactions and IEEJ Journal of Industry Applications, the author will be requested to pay the publishing fees.

The publishing fees depend on whether the manuscript is prepared using the IEEJ LaTeX Style File or MS-Word Template. For manuscripts prepared using the IEEJ LaTeX Style File or MS-Word Template, the publishing fees are indicated in the Table 4-1. For manuscripts prepared without using the IEEJ LaTeX Style File or MS-Word Template, the publishing fees are indicated in the Table 4-2. And, please note that the publishing fees also depend on whether an IEEJ member is included as authors in the manuscript.

To be considered the "Manuscript submitted by authors including a member of the IEEJ", at least one author must become a member of the IEEJ by the time the Notification of Acceptance is sent to the author. However paper and article by only non-Japanese authors from outside Japan even if a member of the IEEJ is not included as authors at the time of notice of acceptance, the applicable publishing fees are the "Manuscripts submitted by authors including a member of the IEEJ".

2. Color Charges (TEEE print version only)

Presenting color figures, photographs and tables in TEEE print version can be done at the author's request and all charges for color are subject to charged to the author.

3. Reprints

- (1) The IEEJ provides the electronic (pdf) version of the paper and article published in the IEEJ Transactions and IEEJ Journal of Industry Applications to authors.
- (2) Authors who want to purchase the reprints are available at the IEEJ Electronic Library after the IEEJ Transactions A to E and IEEJ Journal of Industry Applications are published.
- (3) Authors who want to purchase the reprints of the paper and article published in TEEE, can apply and purchase the reprints directly at John Wiley & Sons.

4. Penalties for Failure to Pay for Publishing Fees

If the payment is not received within one year after the publication, please note that any new submissions for all authors of the unpaid appropriate paper will be rejected until the outstanding payment is confirmed.

5. Support for Submission from Outside of Japan

Non-Japanese authors submitting from outside of Japan who may have difficulties in paying the publishing fees, may apply for partial waiver of payment by submitting a letter of request at the initial submission. There is no special format for this letter of request.

Table 1: Topical Categories and Scope of the IEEJ Transactions

Society Transaction	Scope	
Transactions A (Fundamentals and Materials)	<p>(Common Interests) Education and Research Electromagnetic Theory Electromagnetic Environment Instrument and Measurement Light Applications and Visual Science History of Electrical Engineering</p> <p>(Fundamentals) Discharges and Plasma Pulsed Power</p>	<p>(Materials) Dielectric Materials Electrical, Electronics, and Insulating Materials Metals and Ceramics Magnetics</p>
Transactions B (Power and Energy)	<p>(Power System) Power System Planning and Operation Power System Control Power System Analysis and Simulation Power System Protection Power System monitoring and Control Energy System</p>	<p>(Energy Conversion and Transmission) Transmission and Distribution Lines and Cables Transmission and Distribution Apparatus, Insulators Switchgear and Protective Devices, Lightning Protection, Arc Phenomena Substation Apparatus and Devices Superconducting Devices High Voltage, Lightning and Surge Energy Conversion and Storage Other Power System Apparatus</p>
Transactions C (Electronics, Information and Systems)	<p>(Electronics) Electronic Materials and Devices Optics, Quantum Electronics Electrical and Electronic Circuit, LSI Information and Communication Technology Biomedical Engineering</p>	<p>(Information and Systems Engineering) Systems, Instrument, Control Intelligence, Robotics Media Information, User Interface Speech and Image Processing, Recognition Softcomputing, Learning Information System, Electronic Commerce Information Processing, Software Energy, Environment and Sustainability</p>

Society Transaction	Scope	
<p>Transactions D (Industry Applications)</p> <p>IEEJ Journal of Industry Applications</p>	<p>(Power Electronics) Power Semiconductor Devices and their Application Power Converter and Control Circuit Topology Power Supply Electric Machine Control Reactive Power Compensation and Harmonic Reduction Metal and General Industry</p> <p>(Industrial System) Industrial Instrument and Control Production Facility Control Information Oriented Industrial System Public Facilities Automobile Technology ITS Technology</p>	<p>(Electrical Machinery and Apparatus) Rotating Machine Rotating Machine Characteristic Linear Drives Magnetic Levitation and Magnetic Bearing Static Apparatus Superconductive Application Electric Railway</p>
<p>Transactions E (Sensors and Micromachines)</p>	<p>(Fundamental Technology) Design, Analysis, Simulation Material Material and device characterization Fabrication Packaging and assembling</p> <p>(Microsystem) Actuator Optical microsystem RF MEMS Power MEMS NEMS New terrain in microsystem</p> <p>(Sensor system) Sensing system Sensing algorism Sensor network Sensor application</p>	<p>(Physical sensor) Mechanical sensor Temperature and humidity sensor Light, radiation sensor Electrical, Magnetic sensor Resonant sensor Sensor using new theory or method</p> <p>(Chemical sensor) Gas sensor Ion sensor Bio sensor Biomimetic sensor Micro-chemical sensor Chemical sensor system</p> <p>(Bopmicrosystem) BioMEMS Micro-TAS Lab-on-chip Micro healthcare system</p>
<p>TEEE (IEEJ Transactions on Electrical and Electronic Engineering)</p>	<p>Covering all fields from Transaction A to E described above.</p>	

Table 2: Types of Submission and Documents to be Submitted at Initial Submission

		Paper	Technical Note	Letter	Discussion
Standard Number of Pages (Maximum Number of Pages)		6 pages or less (14 pages)	6 pages or less (14 pages)	2 pages or less (2 pages)	1 page or less (1 page)
Documents to be Submitted	Manuscript	○	○	○	○
	Extended Summary (Not applicable for “TEEE”)	○	○	-	-

Table 3: Types of Submission and Documents to be Submitted at Revised Submission

		Paper	Technical Note	Letter	Discussion
Documents to be Submitted	Revised Manuscript	○	○	○	○
	Revised Extended Summary (Not applicable for “TEEE”)	○	○	-	-
	Response paper to the inquiries	○	○	○	○

Table 4-1: Publishing Fees
(Manuscript using the IEEJ LaTeX Style File or MS-Word Template)

[JPY]

Manuscript Printed Pages	Manuscripts submitted by authors including a member of the IEEJ	Manuscripts authored by only non-members of the IEEJ
1	10,000	12,000
2	20,000	24,000
3	30,000	36,000
4	40,000	48,000
5	50,000	60,000
6	60,000	72,000
7	80,000	94,000
8	100,000	116,000
9	120,000	138,000
10	140,000	160,000
11	160,000	182,000
12	180,000	204,000
13	200,000	226,000
14	222,000	248,000

* Consumption tax is not included in above fees.

Table 4-2: Publishing Fees
(Manuscript if not applicable to Table 4-1)

[JPY]

Manuscript Printed Pages	Manuscripts submitted by authors including a member of the IEEJ	Manuscripts authored by only non-members of the IEEJ
1	16,000	18,000
2	32,000	36,000
3	48,000	54,000
4	64,000	72,000
5	80,000	90,000
6	96,000	108,000
7	122,000	136,000
8	148,000	164,000
9	174,000	192,000
10	200,000	220,000
11	226,000	248,000
12	252,000	276,000
13	278,000	304,000
14	304,000	332,000

* Consumption tax is not included in above fees.

25 mm

178 mm

Paper

Triple Space

Use doubleline [16 pt font Analysis of SO₂ Measurement Accuracy by Multiwavelength DIAL ← Center the title

12 pt Taro Denshi*^{a)} Member Hanako Denki** Non-member 9 pt

(Manuscript received Jan. 00, 2000, revised May 00, 2000)

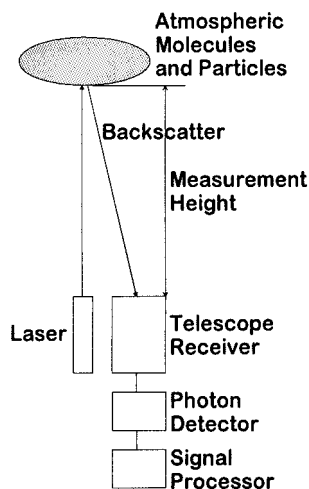
This paper presents two multiwavelength methods to improve the accuracy of a DIAL system for measuring SO₂ in the lower atmosphere : a dual-DIAL method using three or four wavelengths, and a curvefitting method using five wavelengths. By the selection of appropriate wavelengths, these methods can eliminate the effects of ozone and aerosols. Since there is no significant difference in accuracy between the four wavelength dual-DIAL and curvefit methods, the former is advantageous for SO₂ detection in view of the measurement and data processing speeds.

Indent two strokes each on both margins

8 pt Key words : laser radar, SO₂, DIAL, multiwavelength differential absorption

Use 2 lines for the heading Indent a stroke 10 pt 1. Introduction Indent a stroke

LIDAR (LIght Detection And Ranging) has been used for measurement of atmospheric pollutants by Raman scattering, resonant fluorescence, and differential absorption⁽¹⁾. Fig. 1 is a schematic diagram of a LIDAR system. This apparatus transmits laser radiation into the atmosphere, collects light backscattered by atmospheric molecules and particulates using a receiving telescope, and converts it to an electric signal using a photodetector such as a photomultiplier tube. The measurement height is obtained from the time delay between illumination and detection. Therefore, to measure the height profile one measures the received photon counts as a function of time delay relative to illumination using a multichannel scaler. The measurement range resolution ΔR is determined by the time width of the channel Δt=2ΔR/c, where c is the speed of light. The smaller the time Δt, the better the range resolution, but the photon count per channel becomes less and the relative error larger.



Do not fill the blank space around the figures with text

Center the caption

Fig. 1. Schematic diagram of a LIDAR system.

We performed a theoretical analysis of the measurement accuracy of conventional two-wavelength DIAL, and indicated the necessity of eliminating effects due to ozone and other substances which cause measurement error⁽⁵⁾. In this paper, we examined the measurement accuracy of dual-DIAL methods using three or four wavelengths (consisting of a combination of two two-wavelength DIAL pairs) and a curvefit method using five wavelengths.

2. Multiwavelength Differential Absorption

Two strokes space after the heading

2.1 Fundamentals of DIAL The received energy for a LIDAR is given by the following LIDAR equation :

[An equation starts at two-stroke indent] E_r(R, λ_i) = [E₀ηA] (ΔR/R²) β_r(R) ×

exp [-2 ∫₀^R (α₀ + α_x) dR'] (1)

Use 9 pt font

8 mm between the columns

8 pt a) Correspondence to : Taro Denshi. E-mail : taro@denshi.ac.jp *Technical Research Labs., Shin-nichi Electric Co., Ltd. 7-2, Gobancho, Chiyoda-ku, Tokyo 102-0076 **Technical Labs., Kagoshima Electron Corp. 2-100, Daikan-cho, Kagoshima 890-0099

24 mm

248 mm (60 lines)

Table should be prepared to fit one-column ; within 75 mm, or two-column ; within 165 mm

9 pt

Table 2. Nominal parameters and rated values of tested DC servo motor. Center the caption

rated output	0.8 kW	K_t	0.48 N·m/A
rated current	11 A	L	1.8 mH
rated speed	1,750 rpm	R	0.66 Ω
K_e	0.48 V·s/rad	J	$9.8 \times 10^{-3} \text{kg} \cdot \text{m}^2$

Double Space

Here $E_r(R, \lambda_i)$ is the backscattered photon energy received from range between R and $R + \Delta R$ from the illumination laser, λ_i the illumination wavelength, E_0 the illumination energy, η the optical efficiency of the

4. Conclusion

In this paper, we calculated the error due to ozone and aerosols in measurement of SO_2 concentrations of ppb order using DIAL. The statistical error of the return signal and background noise can be overcome by improving the system constant (laser output, receiver area, optical efficiency of the receiver). On the other hand, systematic errors due to ozone and aerosols are inherent in the measurement method, and cannot be eliminated solely by improving the system constant. In conventional two-wavelength DIAL, the systematic error is over 1.5 ppb and the measurement accuracy is insufficient. In order to improve the measurement accuracy, a multi-wavelength differential absorption method using three or more wavelengths is effective. In this paper we have considered dual-DIAL methods using three or four wavelengths and a curvefit method using five wavelengths, and indicated that the measurement errors due to ozone and aerosols can be reduced relative to conventional DIAL or eliminated. When these methods are compared, four-wavelength dual-DIAL is superior in view of measurement accuracy and measurement/processing speeds.

Acknowledgement

This research was supported by aaaa.

References

- (1) E.D. Hinkley, ed.: Laser Monitoring of the Atmosphere, Springer-verlag, Berlin (1976)
- (2) H. Edner, K. Fredriksson, A. Sunesson, S. Svanberg, L. Unéus, and W. Wendt: "Mobile remote sensing system for atmospheric monitoring", *Appl. Opt.*, Vol. 26, pp. 4330-4335 (1987)
- (3) H. Edner, P. Ragnarson, S. Svanberg, E. Wallinder, R. Ferrara, R. Cioni, B. Raco, and G. Taddeucci: "Total fluxes of sulfur dioxide from the Italian volcanoes Etna, Stromboli, and Valcano measured by differential absorption lidar and passive differential optical absorption spectroscopy", *J. Geophys. Res.*, Vol. 99, pp. 1820-1825 (1994)
- (4) K. Fredriksson, B. Galle, K. Nyström, and S. Svanberg: "Lidar system applied in atmospheric pollution monitoring", *Appl. Opt.*, Vol. 18, 2998-2302 (1979)

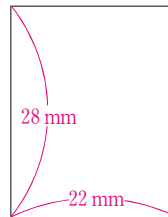
- (5) N. Goto: "SO₂ measurement by laser radar", Denki University Research Report No. 95085 (1995)
- (6) J. D. Klett: "Stable analytical inversion solution for processing lidar returns", *Appl. Opt.*, Vol. 20, pp. 211-215 (1981)

Use boldface

Double Space

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Analysis of SO₂ Measurement Accuracy by Multiwavelength DIAL

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Keywords : laser radar, SO₂, DIAL, multiwavelength differential absorption

LIDAR (Light Detection And Ranging) has been used for measurement of atmospheric pollutants by Raman scattering, resonant fluorescence, and differential absorption⁽¹⁾. Fig.1 is a schematic diagram of a LIDAR system. This apparatus transmits laser radiation into the atmosphere, collects light backscattered by atmospheric molecules and particulates using a receiving telescope, and converts it to an electric signal using a photodetector such as a photomultiplier tube. The measurement height is obtained from the time delay between illumination and detection. Therefore, to measure the height profile one measures the received photon counts as a function of time delay relative to illumination using a multichannel scaler. The measurement range resolution ΔR is determined by the time width of the channel $\Delta t=2\Delta R/c$, where c is the speed of light. The smaller the time Δt , the better the range resolution, but the photon count per channel becomes less and the relative error larger.

This paper examines DIAL (Differential Absorption Lidar), a method to obtain the concentration profile of the measurement target molecule from the backscatter intensity at two or more illumination wavelengths. The measurement target is atmospheric SO₂, which is a substance causing acid rain. Until now, measurements of atmospheric SO₂ have been limited mainly to cases of localized SO₂ concentrations, e.g. smokestack exhaust and volcanic eruptions⁽²⁾⁻⁽⁴⁾. In these cases, the SO₂ concentration is over 100 ppb, therefore the measurement was relatively easy and the measurement accuracy was not a problem. However, when measuring SO₂ in the ambient atmosphere, its concentration is of ppb order, and the measurement accuracy becomes an issue. We performed a theoretical analysis of the measurement accuracy of conventional two-wavelength DIAL, and indicated the necessity of eliminating effects due to ozone and other substances which cause measurement error⁽⁵⁾. In this

paper, we examined the measurement accuracy of dual-DIAL methods using three or four wavelengths (consisting of a combination of two two-wavelength DIAL pairs) and a curvefit method using five wavelengths.

The received energy for a LIDAR is given by the following LIDAR equation:

$$E_r(R, \lambda_i) = [E_0 \eta A] = \frac{\Delta R}{R^2} \beta \pi(R) \times \exp\left[-2 \int_0^R (\alpha_0 + \alpha_x) dR'\right]$$

.....(1)

Here $E_r(R, \lambda_i)$ is the backscattered photon energy received from range between R and $R+\Delta R$ from the illumination laser, λ_i the illumination wavelength, E_0 the illumination energy, η the optical efficiency of the

In this paper, we calculated the error due to ozone and aerosols in measurement of SO₂ concentrations of ppb order using DIAL. The statistical error of the return signal and background noise can be overcome by improving the system constant (laser output, receiver area, optical efficiency of the receiver). On the other hand, systematic errors due to ozone and aerosols are inherent in the measurement method, and cannot be eliminated solely by improving the system constant.

In conventional two-wavelength DIAL, the systematic error is over 1.5 ppb and the measurement accuracy is insufficient. In order to improve the measurement accuracy, a multiwavelength differential absorption method using three or more wavelengths is effective. In this paper we have considered dual-DIAL methods using three or four wavelengths and a curvefit method using five wavelengths, and indicated that the measurement errors due to ozone and aerosols can be reduced relative to conventional DIAL or eliminated. When these methods are compared, four-wavelength dual-DIAL is superior in view of measurement accuracy and measurement/processing speeds.

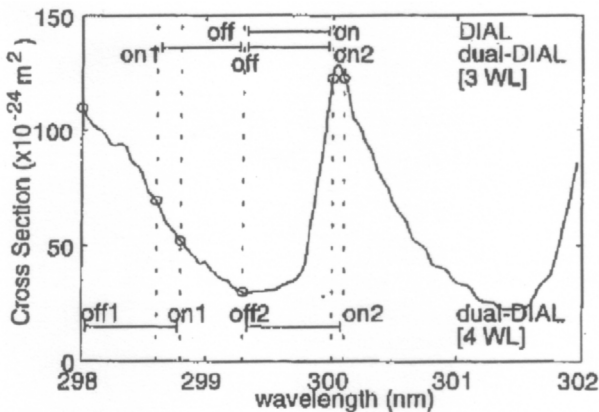


Fig. 1. Absorption cross section of SO₂ indicating wavelengths used in DLAL and dual-DIAL.

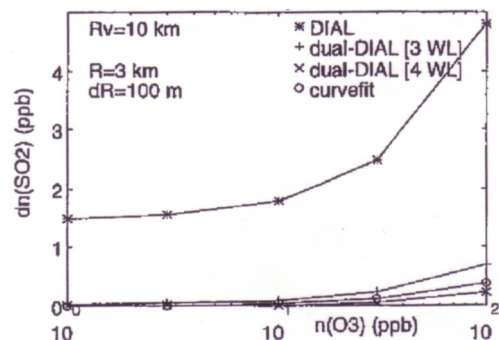


Fig. 2. SO₂ measurement error due to ozone.

Appendix 3

Guidelines for Figures, Photographs and Tables Preparation

1. Size of Figures, Photographs and Tables

The size of figures, photographs and tables should be prepared to fit one-column (width 75mm). Authors are encouraged to prepare figures, photographs and tables which indicating meaningful results in large size. Maximum width for a two-column figures, photographs and tables should be within 165 mm.

2. Lines and Symbols of Figures, Photographs and Tables

Straight and curved lines and symbols (e.g. Δ , \circ , \square , \times) in figures, photographs and tables should draw sharply and use appropriately heavy or thin lines.

3. Lettering in Figures, Photographs and Tables

- (1) All lettering in figures, photographs and tables must be in English.
- (2) Ensure that academic terms, numerals, symbols and units using in figures, photographs and tables are correspond to those using in the text.
- (3) Distinguish precisely between Roman type and Italic type. In principle, unit symbols should write in Roman type and quantity symbols should write in Italic type. (e.g. *a* rad, *um*/s)
- (4) Super/subscript numerals and symbols should be written specifically.
- (5) Font size in figures, photographs and tables of 7 point should be used. They must be readily legible for the readers.

4. Numbers and Captions of Figures, Photographs and Tables

- (1) Figures and photographs should be serially numbered as Fig.1, Fig.2, or Fig.3., not as Fig.1.1, Fig.1.2, or Fig. 1.3.
- (2) Tables should be serially numbered as Table 1, Table 2, or Table 3., not as Table 1.1, Table.1.2, or Table.1.3.
- (3) Figure and photograph captions should be placed directly below the figures or photographs. And their captions should be written in lower case letters with only the first letter of the first word capitalized. Subcaptions must be as (a), (b), or (c), and be placed directly below each figure and photograph, and avoid listing below the figure and photograph captions in a lump. As all figures and photographs should have captions, it is unacceptable without legend only Fig. \circ . or (a).
- (4) Table captions should be placed directly above the tables. The captions should be written in lower case letters with only the first letter of the first word capitalized. Subcaptions must be as (a), (b), or (c), and be placed directly above each table, and avoid listing above the table caption in a lump. As all tables should have captions, it is unacceptable without legend only Table \circ . or (a).

5. Other Requirements:

- (1) All figures, photographs and tables should be supplied as digital image in EPS, TIFF or JPEG format. Resolution of photographs should be greater than 1024 x 768(pixels).
- (2) All figures, photographs and tables will be published in color in the online journal without charge when authors submit a manuscript data in color. And the black and white data submitted by authors will be appeared in black and white in the online journal. (Presenting color figures, photographs and tables in TEEE print version can be done at the author's request and all charges for color is subject to charged to the author.) In any of these cases, authors have to create the manuscript data with great care so that their size, color combination and contrast of all figures, photographs, and tables must contain sufficient contrast and sharpness after confirming they appear clearly in the black and white print in A4 paper.