**ISSN :0011-748X** 

Volume 75, Issue 3, May 2025

# ISSN :0011-748X Defence Science Journal

https://publications.drdo.gov.in/ojs/index.php/dsj

Special Issue on Microwave, Antenna and **Communication (MAC 2024)** 





# **DEFENCE SCIENCE JOURNAL**

A Publication of DRDO

Defence Science Journal is a peer reviewed, bi-monthly, multi-disciplinary defence research journal of the Defence Research & Development Organisation (DRDO), Ministry of Defence, Govt of India, published by the Defence Scientific Information & Documentation Centre, Delhi. It is brought out in the months of January, March, May, July, September, and November. The Journal publishes research papers, review papers, short communications, and research notes in various disciplines of science and technology.

Papers published in the Journal are covered/indexed by-Cambridge Scientific Abstracts, Chemical Abstracts, Embase, Compendex, Geobase, Embiology, Elsevier Biobase, Fluidex, World Textiles, Scopus, Indian Science Abstracts, International Aerospace Abstracts, Science Citation Index, Omnifile Full-text Mega, Omnifile Full-text Select, ProQuest, World News Connection, Google Scholar, Indian Citation Index. Online published papers are assigned with Digital Object Identifier (DOI).

# **Editorial Board**

# Prof. A. Velayudham Anna University, Chennai, India Dr. Alexander N. Lukin Western-Caucasus Research Centre, Moscow, Russian Federation Prof. Ashwani Kumar University of Delhi South Campus, New Delhi, India **Prof. Binay Kanti Dutta** Indian Institute of Technology Kharagpur, West Bengal, India Prof. Clive Russell Woodley (Retd.) Imperial College London, London SW7 2BU, United Kingdom Prof. D.S. Ilcev Space Science Centre in Satellite Systems and CNS, Durban, South Africa **Prof. Debasis Chakraborty** Ecole Centrale School of Engineering, Hyderabad, India Dr. G.S. Mukherjee (Visiting Scientist) Defence Materials & Stores Research & Development Establishment (DMSRDE), Kanpur, India Prof. Gokarna P. Sharma Kent State Universitiy, Kent, OH 44242, USA Prof. Hari B. Hablani, INAE Indian Institute of Technology Indore, India Prof. Joseph C (Joe) Majdalani Auburn University Auburn, Auburn, AL 36830, USA Prof. Kamla Prasan Ray Defence Institute of Advanced Technology (DIAT), Pune, India Prof. Kantesh Balani Indian Institute of Technology Kanpur, India Prof. Luigi T. DeLuca (Retd.) Politecnico di Milano, 20156 Milan, Italy Dr. Manish Roy Defence Metallurgical Research Laboratory (DMRL), Hyderabad, India Prof. Nil Ratan Bandyopadhyay, FIE, FAScT Green Energy and Sensor System (SAMGESS), Shibpur, Howrah, India Dr P.A. Ramakrishna Indian Institute of Technology Madras, Chennai Prof. Soma Venugopal Rao ACRHEM, University of Hyderabad, Hyderabad, Telangana, India Prof. Sudarshan Kumar Indian Institute of Technology Bombay, Mumbai, India Dr. Sudip Rav School of Chemical Sciences, The University of Auckland, New Zealand

# Editor-in-Chief Ms. Kiran Chauhan Associate Editor-in-Chief Dr. Mohd. Yousuf Ansari Editor Mr. Yogesh Modi Senior Assistant Editor Ms. Purbi Dey Kanungo Assistant Editors Dr Faizul Nisha Mr. Tek Chand Chauhan Pre-Press Mr. Himanshu Dahiya Editorial Desk Ph: 011-2390 2469/65/64 E-mail: dsj.desidoc@gov.in Printing

Mr. Rajesh Kumar Singh

*For New Subscription, Renewals, Inquires, and Cheque Address* Ms. Dipti Arora DESIDOC, Metcalfe House, Delhi-110 054 Ph: 011-2390 2612 ; Fax: 011-2381 9151 E-mail: marketing.desidoc@gov.in

# Annual Subscription

# ₹ 3000.00 (INR)

(Discount: 15 % to Publishers, Vendors and Individuals)

Subscription to be paid in advance by bank draft in the favour of **Director**, **DESIDOC**. Local subscribers may pay by cheque, payable at Delhi.

Current and back issues are available at: https://publications.drdo. gov.in/ojs/index.php/dsj

The editor or publisher does not assume responsibility for the statements/opinions expressed by the authors of the papers.

© 2025, Defence Scientific Information and Documentation Centre (DESIDOC), Delhi.

# **Editorial Team**

# DEFENCE SCIENCE JOURNAL

VOLUME	75 NUMBER 3	MAY 2025	
IN THIS ISSUE			
Special Issue on Microwave, Antenna and Communication (MAC 2024)			
271-272	2 Microwave, Antenna and Communication (MAC 2024)		
	(Guest Editorial) Vijay Shar	ıker Tripathi	
	DOI : 10.144	29/dsj.20989	
273-277	Jamming Efficacy Analysis of Chaff using AI/ML		
	Nishan Arya, Elisha Chand, Anshul Mathur, Un Verandra Kumar, Alok Basita and Prash DOI : 10.1442	nesh Kumar, ant Vasistha 29/dsj.20929	
278-284	Study of Multi-state Phase Gradient Surface with Single Beam Anomalous Reflection RIS Applications	1 for Passive	
	Sylvie Rana, Yallanki Sai Sreenija and	1 A.R. Harish	
	DOI : 10.144	29/dsj.20928	
285-292	Computational-Efficient Signal Processing Solution to Frequency Quadrupler Based High-Free Signal Generator	Juency Vector	
	Devashish Arora, Girish Chandra Tripathi and Meer DOI : 10.144	1akshi Rawat 29/dsj.20915	
293-299	ML-Driven Optimisation of Luneburg Lens Design		
	Ravi Kumar Arya, Maxon Okramcha, Anant Rajput, K.M. Mohan, Adi Amitanshu Raj Neti, Priyanshu Ganwani, Maifuz Ali and Ash	itya Sharma, wani Kumar	
	DOI : 10.1442	29/dsj.20910	
300-303	Design and Development of a Conjoined Narrow Wall Slotted Waveguide Array Antenna w Lobe Levels	ith Low Side	
	Neeresh Kumar, Akshay Warkade, Bal Mukund Jha and Seema DOI : 10.144	Doongarwal 29/dsj.20897	
304-311	A Miniaturised Self-Multiplexing Antenna for Eight Distinct Sub-6 GHz 5G-NR Serv Applications	rices for IoT	
	Gunjan Srivastava, Vimal Kumar, Amit Sikder and Akh DOI: 10.144	<i>ilesh Mohan</i> 29/dsj.20898	
312-317	2-Bit Quad Band Reconfigurable Intelligent Surface for Modern Wireless Communication	s	
	Vimal Kumar, Amit Sikder, Gunjan Srivastava and Akh	ilesh Mohan	
	DOI : 10.144	29/dsj.20899	
318-324	Minimised Four-Port MIMO Antenna for Sub-6 GHz and Satellite Applications		
	Jayaraman G., Indrasen Singh and Dilip Kuman DOI : 10.1442	<i><sup>r</sup> Choudhary</i> 29/dsj.20900	
325-330	Design of a 3D Printed Helical Antenna having High Gain for 2.4 GHz ISM Band Applica	itions	
	Subhradip Bal, Subha Mandal, Md. Mustafa Abdullha and G	Gobinda Sen	
	DOI : 10.144	29/dsj.20901	

331-338	PSO-Based Resource Allocation in Cognitive Radio Ad-Hoc Network	
	Manuvarthi Mounisha, V. Krishna Vamsi, Vivek Rajpoot,	
	R. Anil Kumar and Ramesh K. Vermay	
	DOI: 10.14429/dsj.20908	
339-344	A Compact Dual-Band Linearly Co-Polarized Antenna Array System for In-Band Full-Duplex (IBFD) Applications	
	Amit Kumar, Phyo Mg Mg, Amit Sikder, Gunjan Srivastava and Akhilesh Mohan	
	DOI : 10.14429/dsj.20909	
General Pape	rs	
Aeronautical	System	
345-351	Experimental Validation of Remaining Useful Life of Electronic Boards in Complex Avionics Systems	
	Jitendra J. Jadhav, V.K. Chaubey and Chandrashekhar	
	DOI : 10.14429/dsi.20913	
<b>Combat Engin</b>	neering	
352-361	Design and Control of a Simplified NIBS PFC Converter Using Grasshopper-Optimized PI Controller for Battery Charging in Defence Applications	
	K.M. Vijayalakshmi and M.G. Umamaheswarir	
	DOI: 10.14429/dsj.20544	
362-370	Study and Modelling of Effect of Tilt Angle on Thermal Signatures of Different Emissivity Surfaces	
	Pushpit Tiwari, Amit Kumar Sharma, Ravindra Singh,	
	Sanjay Kumar Sharma and Pankaj Agarwal	
	DOI: 10.14429/dsj.20220	
<b>Electronics &amp;</b>	Communication Systems	
371-378	Design of Metamaterial Based Circularly Polarized Antenna for Anti-Drone Applications	
	Sukhdas Ahirwar, Amara Prakasa Rao and Mada Chakravarthy	
	DOI : 10.14429/dsj.19742	
379-385	Measurement of Shake in the Camera in a Shelling Zone	
	Manoj Sharma, Subrat Kar and Sumantra Dutta Roy	
	DOI : 10.14429/dsj.20789	
386-393	Investigations on Dual Band Filtering Antenna for Wireless Applications	
	Makkapati Himaja and S. Yuvaraja	
204 200	DOI: 10.14429/dsj.20852	
394-398	Low-Loss, Compact DS-OCSRR Shaped DGS Loaded HMSIW Band Pass Filter with High Fractional	
	Bandwidin	
	Sum Suresn. J and G. Soundarya DOI $\cdot$ 10 14420/4sj 20211	
D 1 C	DOI: 10.14423/dSJ.20211	
Back Cover:	Information for Contributors	
379-385 386-393 394-398 Back Cover:	<i>Sukhdas Ahirwar, Amara Prakasa Rao</i> and <i>Mada Chakravarta</i> DOI : 10.14429/dsj.1974 Measurement of Shake in the Camera in a Shelling Zone <i>Manoj Sharma, Subrat Kar</i> and <i>Sumantra Dutta Ra</i> DOI : 10.14429/dsj.2075 Investigations on Dual Band Filtering Antenna for Wireless Applications <i>Makkapati Himaja</i> and <i>S. Yuvara</i> DOI : 10.14429/dsj.2085 Low-Loss, Compact DS-OCSRR Shaped DGS Loaded HMSIW Band Pass Filter with High Fraction Bandwidth <i>Sam Suresh. J</i> and <i>G. Soundar</i> DOI : 10.14429/dsj.2022 <i>Information for Contributors</i>	

# (ii) Book/Monograph

Hitchins, Derek K. System engineering: A 21st century systems methodology. John Wiley, London, 2007. 502p.

DeMers, M.N. Fundamentals of geographic information systems. Ed. 3. John Wiley, New York, 2005.

# (iii) Chapter from a Book

Bodony, D.J. & Lele, S.K. Applications and results for large-eddy simulations for acoustics: Far-field jet acoustics. In LES for eddy acoustics, edited by C. Wagner, T. Huttl & P. Sagaut. Cambridge University Press, Cambridge, UK, 2005. pp. 289-310. doi: 10.1017/CBO9780511546143.008

Lokesha, B.N. Advanced avionics and electronic warfare system for fighter aircraft. In DRDO Technology Spectrum. Defence Research and Development Organisation, New Delhi, 2008. pp. 10-26.

# (iv) Conference Paper

Puszynski, J.A. Recent advances and initiatives in the field of nanotechnology. Paper presented at 31st International Pyrotechnic Seminar, Fort Collins, Colorado, USA, July 2004. pp. 233-40.

Ekstein, J.; Freitag, E.; Hirsch, C. & Sattelmayer, T. Experimental study on the role of entropy diffusion waves in low-frequency oscillations for a diffusion burner. In Proceedings of the ASME Turbo Expo 2004: Power for Land, Sea, and Air. edited by R.S. Harris. ASME, Fairfield, NJ, 2004. doi:10.1115/GT2004-54163

# (v) Report

Savage, S.J. Defence applications of nanocomposite materials. FOI-Swedesh Defence Research Agency, User Report No. FOI-R-1524-SE. December 2004.

# (vi) Patent

Man, T.Y.; Leung, C.Y.; Leung, K.N.; Mok, P.K.T. & Chan, M. Single-transister-control low-dropout regulator. US Patent No. 7285952, 23 October 2007.

# (vii) Standard

International Organisation for Standardisation. Document Management-Electronic document file format for long-term preservation-Part1: Use of PDF 1.4 (PDF/A-I). ISO 19005-1:2005, ISO, Geneva, Switzerland, 2005.

# (viii) Thesis/Dissertation

De Roek, W. Hybrid methodologies for the computational aeroacoustic analysis of confined, subsonic flows. Katholieke University, Leuven, Belgium, 2007. PhD Thesis.

# (ix) Personal Communication

Personal communications shall not be listed under references but included in the text itself. The references shall be given as shown below:

The number of registered publications under Copyright Clearance Centre (CCC), Salem, USA, now totals approx. 6000,000 titles used by 3,600 publishers (personal communication with CCC), whereas in 1986 there were only 58,000 publications registered from 1,100 publishers.

Apart from the above guidelines, the form in which the cited document is published, for example, microfiche, CD-ROM or other electronic medium; and the language of publication if other than English should be indicated in parentheses at the end of the reference. If the cited document is unpublished, it should be indicated in parentheses at the end of the reference as 'in press' with DOI No.

### (g) Tables

Tables should supplement and not duplicate the information contained in the text. They should be explicitly referred to in the text in numerical order with brief titles. Column headings should be brief, bold and the units of measurement should be placed below the headings in parentheses.

Maximum Five (5) Tables are allowed in a manuscript.

### (h) Illustrations

All figures (charts, diagrams, line drawings, and photographic images) should be of good quality and submitted both electronic and hard copy originals. Illustrations should be numbered in order of their occurrences in the text with Indo-Arabic numerals and with short descriptive captions. Lettering should be in capital only and remain legible after a reduction of 50-60 per cent. Scanned/photocopied images reproduced poorly should be avoided. Illustrations taken from other publications must be acknowledged. It is the author's responsibility to obtain permission for reprinting such illustrations in Defence Science Journal. The preferred format is encapsulated postscript (.eps) for line figures and .tif for halftone figures with minimum resolution of 300 dpi (dots per inch). Colour should be used only where absolutely necessary for understanding of the figure. Colour should not be used for distinguishing data in line diagrams.

Maximum Six (6) figures are allowed in a manuscript.

### (i) Symbols/Units

Non-standard abbreviations should be shown in brackets when first mentioned, and should be used whenever the same terms appear again in the text and not in the title and abstract. Usage of metric units is preferred.

### Nomenclature (i)

The nomenclature of mathematical symbols and signs used in the text should be given immediately after the keywords. Authors can follow any of the standard units and symbols developed by international agencies in their fields for this purpose.

### (k) **Special Items**

When chemical/mathematical equations are used in papers, these should be legible. The symbols, not covered in nomenclature (or when nomenclature is not given), should be explained immediately after their first usage in the text. Equations should be consecutively numbered in whole numbers in parentheses (for example, (2), (15), (19), etc.) at the right margin. Reference to the equations in the text should be abbreviated as Eqn (1), Eqns (5-7), etc. Complex structural formulae of chemical compounds should be prepared as illustrations. Capital, lower case and Greek letters should be distinguished clearly. Letters which are sometimes confused for one another (for example, O & 0; 1 & 1; V, v & n; r & p; X, x & °; K, k & k; E & e; etc.) should be clearly distinguished. A Greek letter should be spelt out in margin where it is first used.

### **Proofs and Complimentary Journal (D**)

The final proof of the paper will be sent for correction in three working days to the author for clearance before printing. All the author(s) will be supplied with a softcopy of issue, free of charge. Author will receive one printed copy of the issue as complimentary.

# **INSTRUCTIONS FOR CONTRIBUTORS**

# Objective

*Defence Science Journal*, a bi-monthly Journal of the Defence Research & Development Organisation (DRDO), publishes original research papers having a direct bearing on Military/Defence applications. It covers natural science, technology, and engineering.

# (a) Typescript Requirements

Research papers (max length: 3000 words or 10 typed pages of A4 size including figures) containing original research findings in a clear and concise manner. Papers reporting theoretical, laboratory and field test results are also accepted.

Review articles (max length: 5000 words or 20 typed pages of A4 size including figures) are expected to cover survey, integrate, and critically examine new information accumulated in recent years in a particular subject field. Review articles from subject experts are also commissioned by the Editor.

Short communications/research notes/scientific correspondence (Max length: 2000 words or 8 typed pages including figures) are normally brief reports or technical notes on the progress of ongoing research and/or an application.

# (b) Refereeing Process

Papers received for publication are to be peer reviewed by a panel or research experts.

# (c) Submission of Typescripts

Typescript should be neatly typed in single space on one side of the A4 size (210 mm x 297 mm) paper, with a margin not less than 40 mm on the left side. It should include: (i) title page with a running (short) title, (ii) abstract, (iii) keywords, (iv) nomenclature of symbols used, (v) tables/figures/illustrations typed/drawn on separate sheets along with their captions in serial order as these appear in text, and (vi) a separate list of figure captions. The reporting in the paper should be in third person.

Manuscripts should be submited online at: https://publications. drdo.gov.in/ojs/index.php/dsj in MS Word format. In case of problems in uploading, a copy can be sent at dsj.desidoc@gov.in

# Authors may furnish the following certificate at the time of submission of manuscript along with covering letter.

[This is to certify that the reported work in the paper entitled "......." submitted for publication in the Defence Science Journal is an original one and has not been submitted for publication elsewhere. I/we certify that citations to the previously reported works have been given and no data/tables/figures have been quoted verbatim from the other publications without giving due acknowledgement and without permission of the author(s). The consent of all the authors of this paper has been obtained before submitting.

[Signatures and names of all the authors]

## (d) Title Page

The title page should include: title of the article, name(s) of author(s) and affiliation(s); complete address (including telephone/fax numbers, e-mail address) of the author (in case of a single author paper) or the contact person (in the case of a Co-authored paper) to whom communications should be sent. It should also include a short title not more than 50 characters to be used as running title. The titles should be brief, clear and provide a broad introduction of the paper.

# (e) Abstract and Keywords

An abstract of about 200 words for research papers, 150 words for review articles, and about 100 words for research notes and short communications should be provided. Appropriate keywords should be given where necessary.

# (f) References and Footnotes

References to already published literature should be numbered consecutively in order of their citation in the text and placed at the end of the text. In the text these should be indicated by superscripts (number placed above the line) <sup>(1)</sup>. References to personal communication should not be placed under references, but cited in the text in the parentheses. A reference should be listed only once. Use of *ibid., idem., op.cit.,* should be avoided. An already cited reference when repeated, should be given in parentheses (for example, ref. 5, p. 79; ref. 15, p. 193; etc). Explanatory material may be given as an Appendix.

Defence Science Journal Style uses a notational method of referencing when referring to a source of information within the text of a document. In its simplest form, a citation is given in the text, consisting of a number in superscript. Examples of citations in different types of documents are given below:

# (i) Journal Article

Laxminarayana, Karthik & Jalili, Nadar. Functional nanotubebased textiles: Pathway to next generation fabrics with enhanced sensing capabilities. *Text. Res. J.*, 2005, **75**(9), 670-81. doi: 10.1177/0040517505059330

Weifan, C.; Fengsheng, L.; Jianxun, L.; Song, Hongchang & Yu, Jiyi. Nanometer  $Co_3O_4$  powder by solid phase reaction. *Cuitua Xucbao*, 2005, **26**(2), 1073-77 (Chinese).

Standard abbreviations as per the International Serials Catalogue of the International Council of Scientific Unions–Abstracting Board (ICSU–AB) should be used for the titles of journals. However, single and double worded journal titles (for example, *Nature, Science, Scientific American*) should be given in full.

Electronic sources should include the URL and date of access.

Wang, Z.J.; Birch, J.M. & Dickinson, M.H. Unsteady forces and flows in low Reynolds number hovering flight: Two-dimensional computations vs robotic wing experiment. *J. Experi. Biol.*, 2004, **207**(3), 449-60. doi: 10.1242/jeb.00739 http://jeb.biologists.org/ cgi/content/full/207/3/449 [Accessed on 17 November 2007].

(Contd on inner cover)



