

Bibliometric analysis of “IEEE Transactions on Electromagnetic Compatibility”: 2010-2015

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Abstract- Analysis of 982 research papers published in the Journal “IEEE Transactions on Electromagnetic Compatibility” during the period 2010-2015 has been carried out. The data was collected from the archives of the journal available in online form. This paper examines the articles for year wise growth of the articles published, authorship pattern, degree of collaboration, subject wise distribution of articles, average number of references per article etc.

Index Terms- Bibliometrics, authorship pattern and degree of collaboration

I. INTRODUCTION

Bibliometrics is an important tool for quantitative analysis of the research output produced by researchers. The term Bibliometrics was first coined by Pritchard (1969). Earlier Coles & Eales (1917) used the term “Statistical Analysis” for similar kind of study. Hulme (1923) used the term “Statistical Bibliography” for mapping the literature in graphical way. Dr. S. R. Ranganathan (1969) used the term “Librametry” for the study related to library and its services, applying statistical approaches. Pritchard used the term Bibliometrics to describe “all 'studies which seek to quantify the process of written communication’”. Fairthorne (1969) defined it as “The quantitative treatment of the properties of recorded discourse and behavior pertaining to it”. In other words Bibliometrics is the statistical analysis of bibliographic data, commonly focusing on citation analysis of research outputs and publications.

According to Organization for Economic Co-operation and Development(OECD) “Bibliometric analysis use data on numbers and authors of scientific publications and on articles and the citations therein (and in patents) to measure the “output” of individuals/research teams, institutions, and countries, to identify national and international networks, and to map the development of new (multi-disciplinary) fields of science and technology”. Researchers publish their research outputs in various journals. Bibliometric study of these journals helps us to find out the trend in the publication for making decisions. The factual inferences can be used to identify top performing journals in subject areas, top researchers in subject areas, trends in authorship and collaboration in research publications by scientists, citation studies and soon. Bibliometric methods which are commonly used by researchers to measure different aspects of publication are content analysis and citation analysis.

The present study uses content analysis method to identify the trend in papers published in IEEE Transactions on Electromagnetic compatibility during the period 2010-2015.

II. IEEE TRANSACTIONS ON ELECTROMAGNETIC COMPATIBILITY

IEEE Transactions on Electromagnetic compatibility is a peer-reviewed scientific journal published by IEEE Electromagnetic Compatibility Society. It is a bimonthly journal (ISSN No. 0018-9375) which publishes original and significant work of authors in field of electromagnetic compatibility (EMC). It also publishes special issues related to the subject apart from regular issues. The major subject area covered includes Electromagnetic Environments; Interference Control; EMC and EMI Modeling; High Power Electromagnetic; EMC Standards, Methods of EMC Measurements; Computational Electromagnetic and Signal and Power Integrity, Transmission Lines; Electrostatic Discharge and Lightning Effects; EMC in Wireless and Optical Technologies; EMC in Printed Circuit Board and System Design etc. The journal has Impact factor 1.297, Eigen factor 0.00508 and Article influence score 0.466.

III. OBJECTIVES OF THE STUDY

1. To determine the year wise distribution of articles.
2. To study subject wise coverage of journal articles.
3. To study the authorship pattern.
4. To study the length of journal articles.
5. To study number of references versus number of articles.

IV. LITERATURE REVIEW

Dr. Thanuskodi carried out Bibliometrics analysis of the journal titled “*Library Herald*” published during 2006-2010. The studies showed that out of 138 articles 72(52.17%) articles were single authored while 66(47.83%) articles were contributed jointly. It also showed that (89.85%) were from India and the rest (10.15%) were contributed from foreign sources.

Sujatha and Padmini analyzed 3442 papers published in the journal *IEEE Transactions on Antennas and Propagation* during the period 2010-2014. They found that on an average 688 papers are published annually between the above said period. Number of publications in the journal from Indian authors was found to be very less as compared to European and Western countries.

Jena studied papers published in *Indian Journal of Fiber and Textile Research* for the period of 1996-2004. The study shows

an increasing trend of articles from the year 1996 till 2004. The average citations per article were found to be 16.00. The average length of article is 6.45 pages.

Hazarika, Goswami and Das analyzed bibliometric trend of the Journal *Indian Forester* during the period 1991-2000. Study revealed that multiple authorship papers were dominant in the Journal (64.55%) followed by single author (35.45%) and double author (31.03%). Average length of papers showed that 45.29% papers covers 4-6 pages followed by 7-9 pages (27.96%) which shows the ideal length of a research paper.

Roy and Basak examined articles published in *Journal of Documentation* for authorship pattern, degree of collaboration, geographical distribution of papers and citation analysis. The studies found that majority of papers are multi-authored. The degree of collaboration is found to be 0.51. Contribution of authors from United Kingdom was highest. The average citation per paper was 43.

Santhi and Jeyachitra studied papers published in IEEE Transactions on Control systems Technology from 1998-2007. Study was carried out for each cited reference on following point – Number of authors, type of document, continent of origin of the document etc. The study revealed that one paper contribution constituted 85.4 percent of total output and the authors who have contributed 5-21 paper constitute 0.43% alone. The above study supports the fact that when the number of published paper increases, the number of contributed author decreases.

Paramasivam and Venkatachalam examined the journal titled “*The Indian concrete*” Journal from January 2012 to December 2012. The study revealed that maximum number of papers have been written by 23(39%) of two authors in the articles contribution, which shows collaborative research practice in The Indian Concrete Journal articles are mostly cited from

Journals, Books, Conferences, Proceedings and Technical Reports, ASTM standards .

Kumar & Moorthy carried out Bibliometrics analysis of DESIDOC Journal of Library & Information Technology during 2001-2010. According to the study maximum numbers of papers were published in 2008 & 2009. The maximum number of single authored papers was 37.6% followed by two authored papers with 36.9%.

V. METHODOLOGY

Six volumes, Vol. (52-57) containing 32 issues and 982 papers of *IEEE Transactions on Electromagnetic Compatibility* published during the year 2010 - 2015 are considered for the study. The data collected has been studied by applying filters on basis of different criterion. Quantitative techniques have been adapted for the study. The journal is analyzed for number of issues and papers published, number of authors, number of references, year wise growth in papers, subject wise coverage of articles for the period of study.

VI. ANALYSIS OF THE STUDY

- a) **Year wise distribution of papers:** Total 982 research papers were published by the journal with 6 volumes and 32 issues during the period of study (6 years). Maximum no. of papers published in 2015 with 209(21.28 %) while lowest in the year 2010 with 118(12.01%). There is increasing trend in publication of articles from the year 2010 to 2015. Table no. 1 shows distribution of issue wise and volume wise publication of papers for the period of study.

Table No. 1- Year wise distribution of articles

| S. No. | Vol | Year | Issue No.1 | Issue No. 2 | Issue No. 3 | Issue No. 4 | Issue No.5 | Issue No.6 | Total | Percentage |
|-----------------------|-----|------|------------|-------------|-------------|-------------|------------|------------|-------|------------|
| 1 | 52 | 2010 | 27 | 24 | 31 | 36 | - | - | 118 | 12.01 |
| 2 | 53 | 2011 | 34 | 36 | 36 | 28 | - | - | 134 | 13.66 |
| 3 | 54 | 2012 | 31 | 29 | 25 | 24 | 27 | 17 | 153 | 15.60 |
| 4 | 55 | 2013 | 24 | 20 | 23 | 23 | 23 | 50 | 163 | 16.60 |
| 5 | 56 | 2014 | 28 | 30 | 28 | 31 | 30 | 58 | 205 | 20.87 |
| 6 | 57 | 2015 | 18 | 19 | 40 | 33 | 45 | 54 | 209 | 21.28 |
| Total No. of articles | | | 162 | 158 | 183 | 175 | 125 | 179 | 982 | 100 |

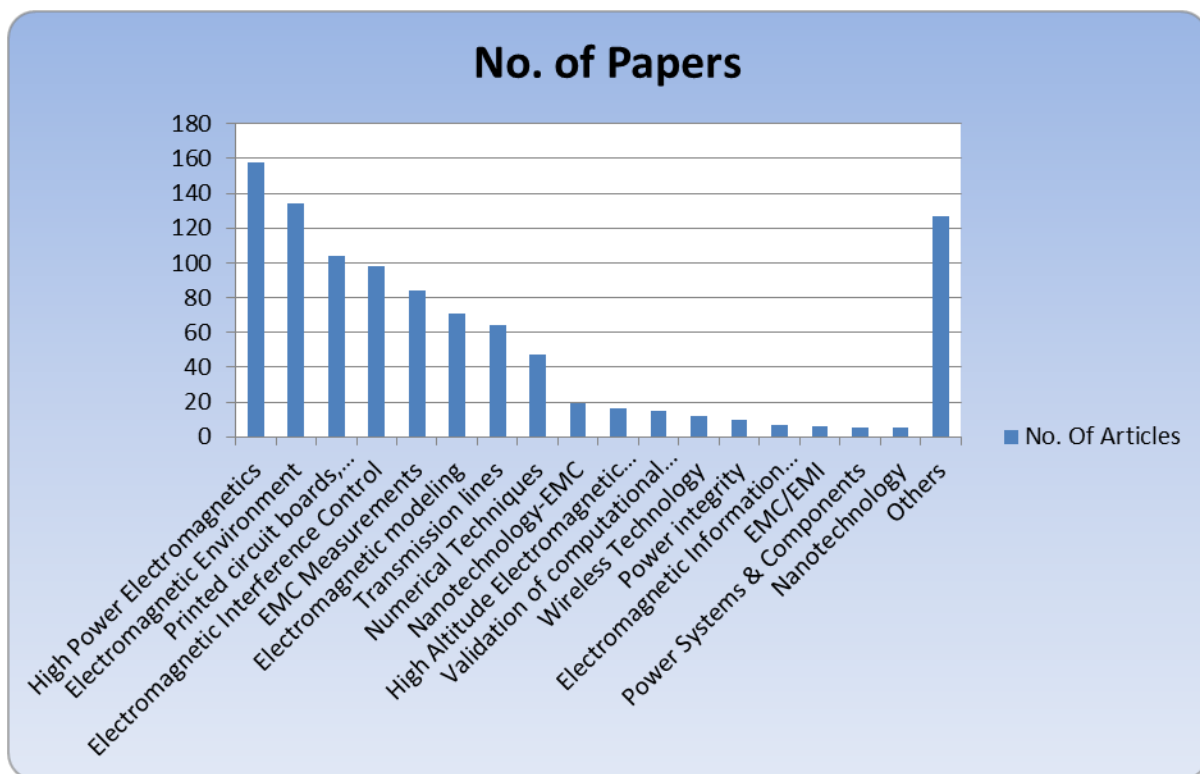
- b) **Subject wise coverage of journal papers:** IEEE Transactions on Electromagnetic Compatibility publishes papers on all aspects of electromagnetic. Table No.2 and Figure 1 reveals that maximum numbers of papers published were on the subject High Power Electromagnetic (16.07%) followed by Electromagnetic Environment (13.62%), Printed circuit boards,

Interconnect and signal integrity (10.58%), Electromagnetic Interference Control (9.96%), and EMC Measurements (8.82%). The journal covers all the domains of electromagnetic and this is what is reflected from the no. of papers published on the subject.

Table No. 2. Subject wise coverage of journal articles

| S. No. | Subject | No. of Papers | Percentage |
|--------|--|---------------|------------|
| 1 | High Power Electromagnetic | 158 | 16.07 |
| 2 | Electromagnetic Environment | 134 | 13.62 |
| 3 | Printed circuit boards, interconnects & signal integrity | 104 | 10.58 |
| 4 | Electromagnetic Interference Control | 98 | 9.96 |
| 5 | EMC Measurements | 84 | 8.82 |
| 6 | Electromagnetic modeling | 71 | 7.22 |
| 7 | Transmission lines | 64 | 6.5 |
| 8 | Numerical Techniques | 47 | 4.78 |
| 9 | Nanotechnology-EMC | 19 | 1.92 |
| 10 | High Altitude Electromagnetic Pulse(HEMP) | 16 | 1.61 |
| 11 | Validation of computational electromagnetic | 15 | 1.5 |
| 12 | Wireless Technology | 12 | 1.2 |
| 13 | Power integrity | 10 | 1 |
| 14 | Electromagnetic Information Security | 7 | 0.7 |
| 15 | EMC/EMI | 6 | 0.6 |
| 16 | Power Systems & Components | 5 | 0.5 |
| 17 | Nanotechnology | 5 | 0.5 |
| 18 | Others | 127 | 12.92 |
| 19 | Total | 982 | 100 |

Figure 1- No. of Papers Vs No. Of Subjects



c) **Year-wise Authorship pattern:** Table No. 3 reveals that out of 982 papers single authored contribution is 64(6.51%) while the remaining 918(93.49%) papers were contributed jointly.

Collaborative research is important feature of research in every field and also in this journal. Table No. 3 & Table No. 4 shows the authorship pattern of papers published during the period 2010 to 2015. Maximum number of papers i.e. 223 (22.70%) is contributed by 3 authors

followed by two authors with 212(21.60%), 4 authors 200(20.38%). 165 papers (16.80%) were contributed by more than 6 authors followed by 118 papers (12.01%) contributed by 5 authors and lastly only 64 papers (6.51%) contributed by single authors. The study shows that joint authorship is most preferred way of publication of the papers in the journal "IEEE Transactions on Electromagnetic Compatibility" during the period of study.

Table No. 3. Year-wise Authorship pattern

| Authorship | Year | | | | | | Total | Percentage (%) |
|------------|------|------|------|------|------|------|-------|----------------|
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | | |
| Single | 10 | 12 | 15 | 13 | 6 | 8 | 64 | 6.51 |
| Joint | 108 | 122 | 138 | 150 | 199 | 201 | 918 | 93.49 |
| Total | 118 | 134 | 153 | 163 | 205 | 209 | 982 | 100 |

Table No. 4. Authorship Pattern

| Authors | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | Total | Percentage (%) |
|-------------|------|------|------|------|------|------|-------|----------------|
| 1 | 10 | 12 | 15 | 13 | 6 | 8 | 64 | 6.51 |
| 2 | 21 | 39 | 30 | 40 | 51 | 31 | 212 | 21.60 |
| 3 | 27 | 33 | 29 | 34 | 53 | 48 | 223 | 22.70 |
| 4 | 27 | 21 | 35 | 31 | 34 | 52 | 200 | 20.38 |
| 5 | 12 | 15 | 13 | 21 | 29 | 28 | 118 | 12.01 |
| more than 6 | 21 | 14 | 31 | 24 | 32 | 42 | 165 | 16.80 |
| Total | 118 | 134 | 153 | 163 | 205 | 209 | 982 | 100 |

Degree of Collaboration (DC): The DC gives the proportion of multiple authored papers, as measures of strength of collaboration in a discipline. The DC can be interpreted as a degree that lies between 0 and 1. It gives a zero weight to single-authored papers and does not differentiate among levels of multiple authorships. The DC equals 1 for maximal collaboration.

Table 4(a) shows the degree of collaboration in the discipline of Electromagnetics. The degree of collaboration of authors in the papers may be counted based on the formula given by Subramanyam in 1983.

$$C = \frac{N_m}{N_m + N_s}$$

Where C= degree of collaboration in the discipline
 N_m= number of multi-authored papers
 N_s= number of single authored papers

$$C = \frac{918}{918 + 64}$$

$$C = 0.93$$

Table No. 4(a) Degree of Collaboration

| Year | Ns | Nm | Nm + Ns | DC |
|-------|----|-----|---------|-------|
| 2010 | 10 | 108 | 118 | 0.915 |
| 2011 | 12 | 122 | 134 | 0.910 |
| 2012 | 15 | 138 | 153 | 0.901 |
| 2013 | 13 | 150 | 163 | 0.920 |
| 2014 | 6 | 199 | 205 | 0.970 |
| 2015 | 8 | 201 | 209 | 0.961 |
| Total | 64 | 918 | 982 | 0.934 |

The degree of collaboration shows that research in the field of Electromagnetic compatibility is predominant by team research. Table 4(a) represents degree of collaboration over the years from 2010- 2015. It is observed that the degree of collaboration in the “IEEE Transactions on Electromagnetic Compatibility” varies from 0.901 to 0.970 which is very high. In the present study the average value of C is 0.94.

As a result, the degree of author collaboration in the journal under study clearly indicates its dominance on multiple author contributions.

d) Length of Articles: Table no. 5 reveals that the majority of papers 433(44.10%) have the length 9-12 pages followed by 396(40.33%) with the length 5-8 pages, 106(10.79%) with 1-4 pages while the remaining 47 (4.78%) papers have the length of 13 or more than 13 pages.

Table No. 5 - Length of Articles

| Pages | Year | | | | | | Total | Percentage |
|-----------|------|------|------|------|------|------|-------|------------|
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | | |
| 1-4 | 9 | 15 | 23 | 17 | 19 | 23 | 106 | 10.79 |
| 5-8 | 53 | 51 | 51 | 79 | 84 | 78 | 396 | 40.33 |
| 9-12 | 47 | 61 | 66 | 58 | 97 | 104 | 433 | 44.10 |
| 13 & more | 9 | 7 | 13 | 9 | 5 | 4 | 47 | 4.78 |
| Total | 118 | 134 | 135 | 163 | 205 | 209 | 982 | 100 |

e) Number of references versus number of papers: The table shows that in the year 2010 the references were 3002 but next year it came down to 2768 but since then there is gradual increase in the number of references listed in articles from 2010 to 2015, maximum number of 5047(24.14%) references in the year 2015. This also indicates that as there is increase in number of papers

in the journal there is increase in no. of references. The average references per article are also reflected in same way, i.e. for the year 2011 it came down to 20.65 from 25.44 in previous year. Later on there was gradual increase till 2014 to 24.53 and in year 2015 it again came down to 24.14.

Table No. 6- Number of references versus number of papers

| Year | Vol. | No. of references in issues | | | | | | Total | Total No. of articles | Average Ref per article | |
|------|------|-----------------------------|-----|-----|-----|------|------|------------------|-----------------------|-------------------------|-----------------|
| | | 1 | 2 | 3 | 4 | 5 | 6 | | | | |
| 2010 | 52 | 677 | 837 | 701 | 787 | - | - | 3002 | 118 | 25.44 | |
| 2011 | 53 | 665 | 674 | 815 | 614 | - | - | 2768 | 134 | 20.65 | |
| 2012 | 54 | 704 | 740 | 532 | 663 | 555 | 345 | 3539 | 153 | 23.13 | |
| 2013 | 55 | 634 | 444 | 628 | 673 | 440 | 1135 | 3954 | 163 | 24.25 | |
| 2014 | 56 | 694 | 691 | 727 | 744 | 748 | 1425 | 5029 | 205 | 24.53 | |
| 2015 | 57 | 511 | 399 | 989 | 766 | 1145 | 1237 | 5047 | 209 | 24.14 | |
| | | | | | | | | Total References | 23339 | 982 | 142.14/6 =23.69 |

VII. SUMMARY & CONCLUSIONS

It published 982 papers during the span of 6 years from 2010 to 2015 with maximum number of papers in the year 2015 and an average of 163 papers per year. It has been found that largest numbers of papers were published in issue no. 3, 6 and 4. The

Journal published 713 papers in core areas of electromagnetic like High Power Electromagnetic (158), Electromagnetic Environment (134), Printed circuit boards, Interconnects & signal Integrity (104), Electromagnetic Interference control (98),

EMC Measurements (84), Electromagnetic modeling (71), Transmission Lines (64). These are the fields which received highest attention in research justifying the journal title "Electromagnetic Compatibility". Majority of papers 223(22.7%) were contributed by 3 authors.

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