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Circularly Polarised Reconfigurable Antenna in 5G Application:A Bibliometric Study using Scopus Database

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ABSTRACT:

The field of wireless technology has come a long way from connecting humans to humans, human to machines and now machines to machines. The boom in the wireless communication and increased number of systems used in latest wireless and radar applications creates the need for reconfigurable antennas. This paper presents an analysis of a circularly polarized reconfigurable antenna for 5G applications. The activation mechanisms, design and ways to optimize the operation of reconfigurable antennas are discussed. With the world moving towards 5G, which expects its reach in remote areas as well, the circular polarization patch antennas are well suited for such purpose, and they can work efficiently in densely populated areas as well. The importance of reconfigurable antennas in a world which awaits the transformation of technology with the coming of 5G is discussed briefly. This review digs deeper into the factors which can optimize the performance of a reconfigurable antenna and the reasons for which the circular polarization is widely sought after. Reconfigurable circularly polarized antennas are used in wireless and satellite communication systems and finds its application in various areas. We have used numerous research papers for our literature survey which were published between 2002 and 2021 in this feild. The bibliometric survey done in this literature review were mainly based on the Scopus database and tools such as VOSviewer, Graph Receipe and ScienceScape.

Keywords: Reconfigurable, circular, polarization, Microstrip, Application, 5G, Antenna

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1. INTRODUCTION:

1.1 The need for 5G technology from the existing 4G technology emanates from growing demand for higher data rate transmission in different applications. This require different antenna reconfiguration from the existing 4G to 5G transmission for larger and broader spectrum coverage. Accordingly 5G antenna reconfiguration comes to the picture where the same antenna caters to the needs for diverse utilisation including cognitive radio

communication, radar and space applications. Wider spectrum coverage with high-speed data transmission is the bedrock of 5G technology, which in turn require reconfiguration of antenna to comply with requirements of 5G technology for broader bandwidth coverage in mobile communication and spread-spectrum signals and bandwidth efficient modulation techniques. It necessitates the frequency reconfigurability and at the same time, the size small and less complexity improves the performance of the microstrip patch antenna.

Reconfigurable antenna is a single patch antenna capable of generating different frequency bands through altering frequency, polarization, bandwidth & radiation properties. The antenna reconfiguration is implemented by employing different mechanism in the form of RF-MEMS, varactor diodes, PIN diodes (being most popularly used), field effect transistors, photoconductive elements etc. To achieve optimum result, reconfigurable antenna designers need to focus on multiple factors for consideration viz., optimum efficiency, stable radiation pattern, good impedance throughout the operation states.

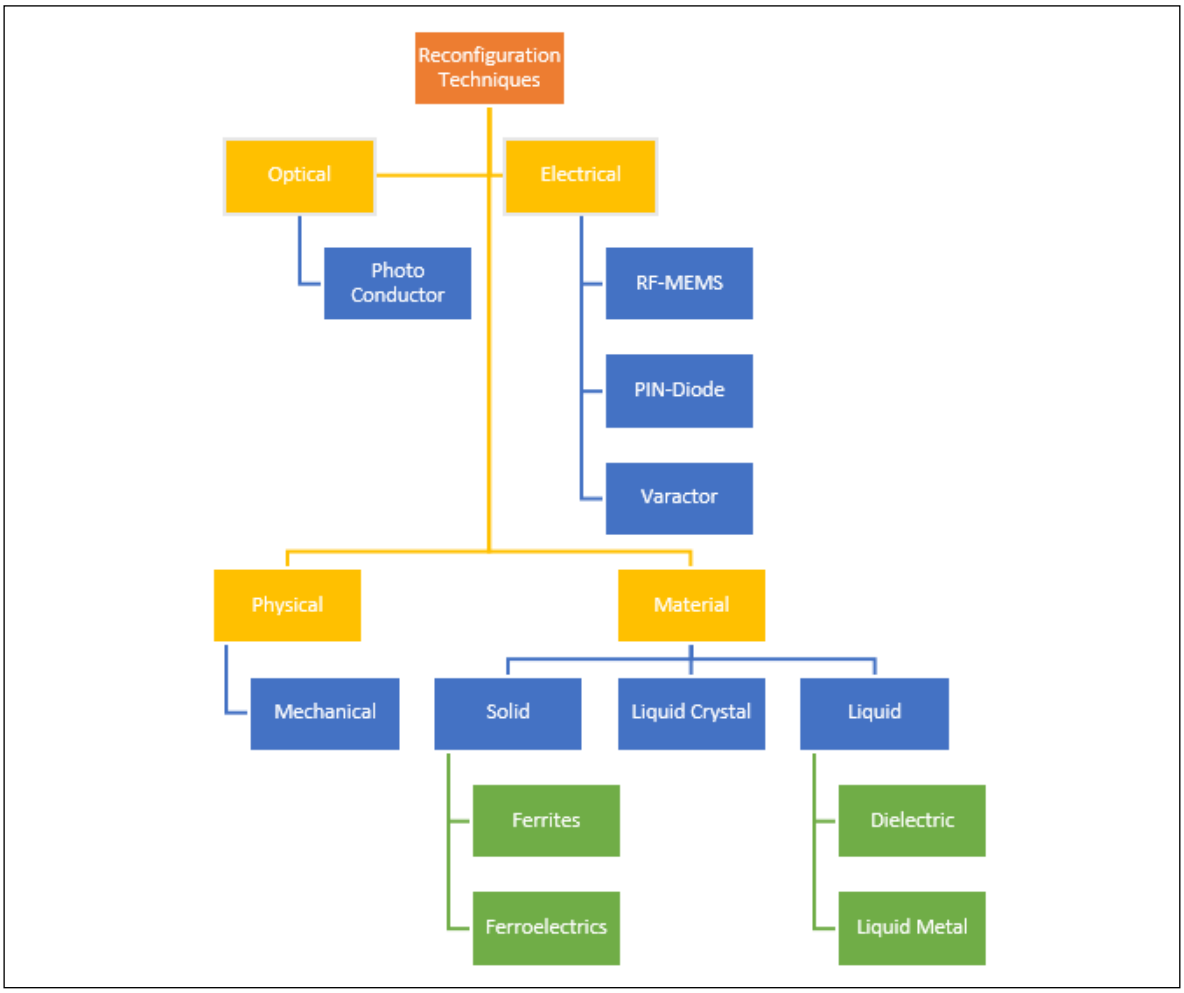


Figure 1 : A Tree Diagram on Reconfigurability Techniques

The microstrip patch, small in size, lightweight, planar, cost effective and conformable to any surface can be used as reconfigurable antennas.

Among the frequency, the pattern and the polarization reconfigurable antennas or their combinations, the CP reconfigurable techniques are the most discussed area. CP antennas help to reduce and prevent multipath scattering and fading problems. Thus it overcomes the channel interference in a densely populated environments. Popular circular polarization reconfiguration techniques exploit the fact to use symmetrical placements of PIN diodes on the antenna elements.

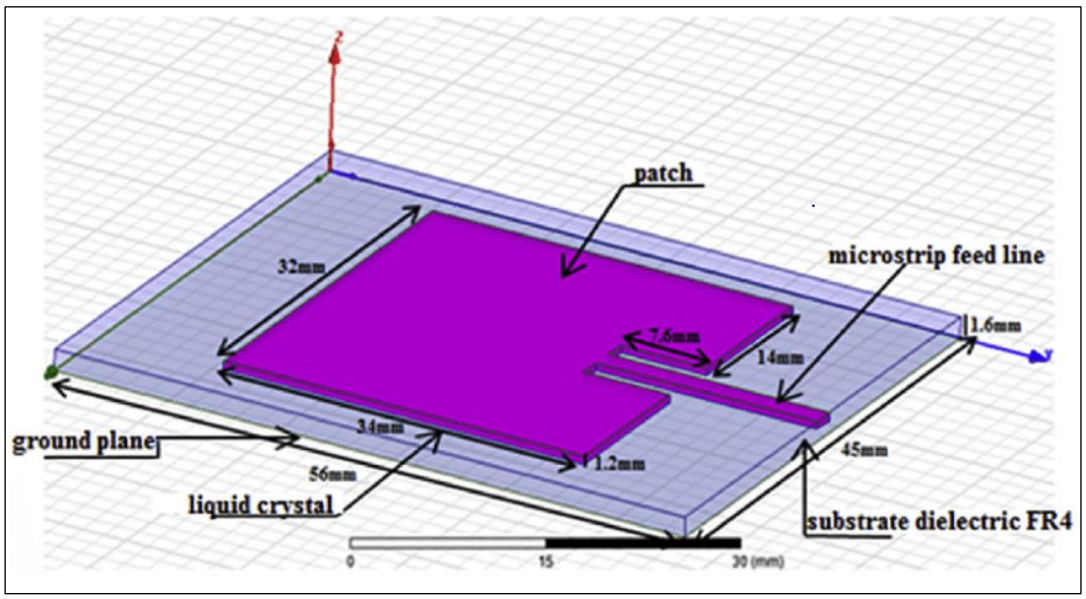


Figure 2 : A Microstrip Patch Antenna Design using Ansys HFSS

Circularly polarized (CP) antennas, apart from being used in wireless communication systems, find their application in satellite communications too as they reduce multipath effects besides mitigating polarization mismatch between the transmitting and receiving antenna thereby reducing polarization loss. Circular polarized antennas are advantageous as they can increase the efficiency of the radio communication system due to their ability to reduce the undesired fading effects caused due to multipath effects, realizing duplex channels for frequency reuse, and to enhance the capacity of the overall system as well as the quality of the link.

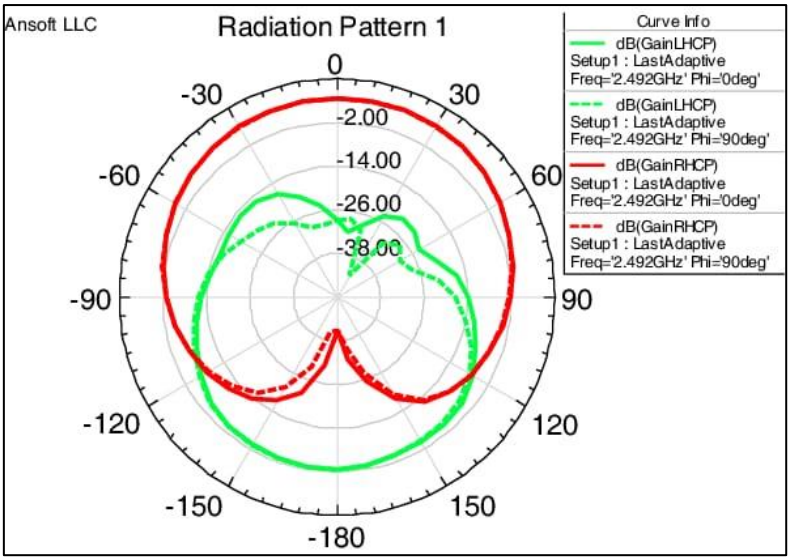


Figure 3 : Radiation Pattern of a MSA

The polarization reconfigurable antenna provides guard from the interfering signals present in the environment. They boost the quality of the link in the form of modified antenna diversity thereby offering an extra advantage. Moreover, they are used in radars and navigation system applications besides enhancing the overall capacity of the channel. Reconfigurable polarization characteristics can be achieved using switches. Polarization reconfigurable circular-polarized antenna find their application in GPS systems by using four photoconductive diodes and also by regulating the state of the electrical switches, thus the polarization states of the radiation can be varied accordingly from linear polarization to circular polarization, i.e. left hand polarization (counterclockwise) or right hand polarization (clockwise).In the 5G circular polarization reconfigurable-microstrip (patch) antenna, the PIN diodes or RF-MEMS can be regulated to make the antenna polarization reconfigurable to encompass right hand or left hand circular polarization.

1. Preliminary Data Collection

A query based on the words “Reconfigurable, Antenna, 5G, Microstrip” was entered in the SCOPUS database as shown in Table 1.

Table 1: List of Keywords: Primary and Secondary

Primary Keywords	"Reconfigurable " AND "circular polarization" AND "Microstrip" AND "Application"
Secondary Keywords	"Antenna" OR "5G"

Source: fetched from http://www.scopus.com on 15th May 2021

The basis for the research is the Scopus database using the keywords mentioned above as query strings. By using these keywords, 135 documents published in English language were retrieved and are shown in Table 2.

Table 2: Language of Publication

Language of Publication	Publication
English	**133**

Table 3 consists of two parts where the first part represents the data in the form of pie chart and the second part on the right shows the important keywords and the number of times they have come up in these documents.

Table 3: Important Keywords and their count

Keywords	Count
Microstrip Antennas	109
Circular Polarization	101
Slot Antennas	82
Polarization	75
Microwave Antennas	64
Reconfigurable Antenna	52
Antenna Feeders	42
Semiconductor Diodes	42
Right-hand Circular Polarizations	39
Bandwidth	38

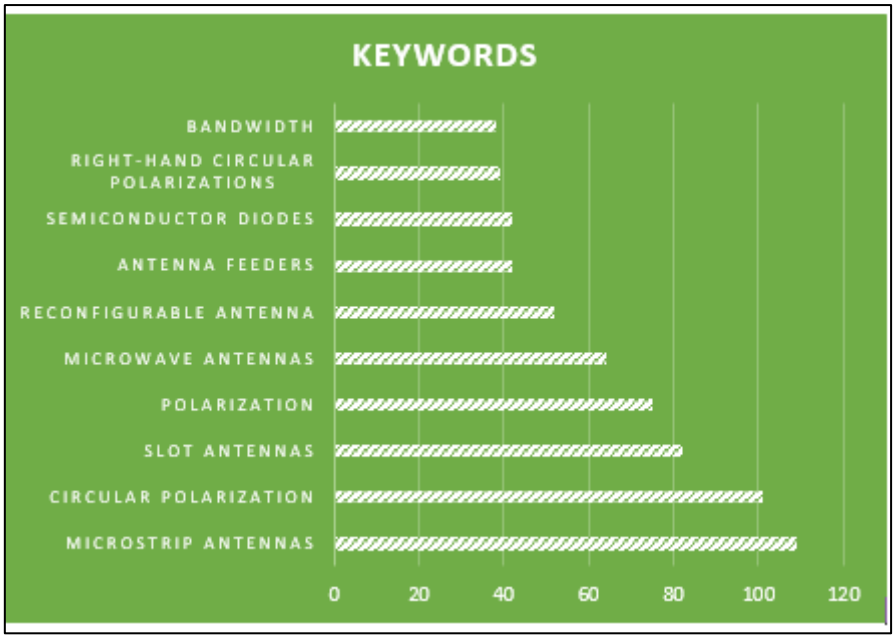


Fig. 4: Keyword by Count

Source: fetched from http://www.scopus.com on 17th May 2021

2. Bibliometric Information and Performance Analysis

The first towards building a strong Biblometric report is by posting our query request on SCOPUS database. The crucial information pertaining to the bibliometric analysis mainly the information of documents corresponding to authors, the title sources, year of publication, top countries publishing the documents and sponsors is fetched .csv format. Thereafter the entire data corresponding to the co-occurrence and co-authors is visualised and represented in the form of graphs and networks.

3. Results and Discussion

3.1 Preliminary Data Analysis

The documents related to Reconfigurable Antenna for 5G Application past 20 years from the year 2001 to 2021. Figure 5 as shown below exhibits the count of documents published per year. The diagram clearly shows that the count has seen a rise in documents from the 2013 and maximum in the year 2019 and 2020 with 20 documents.

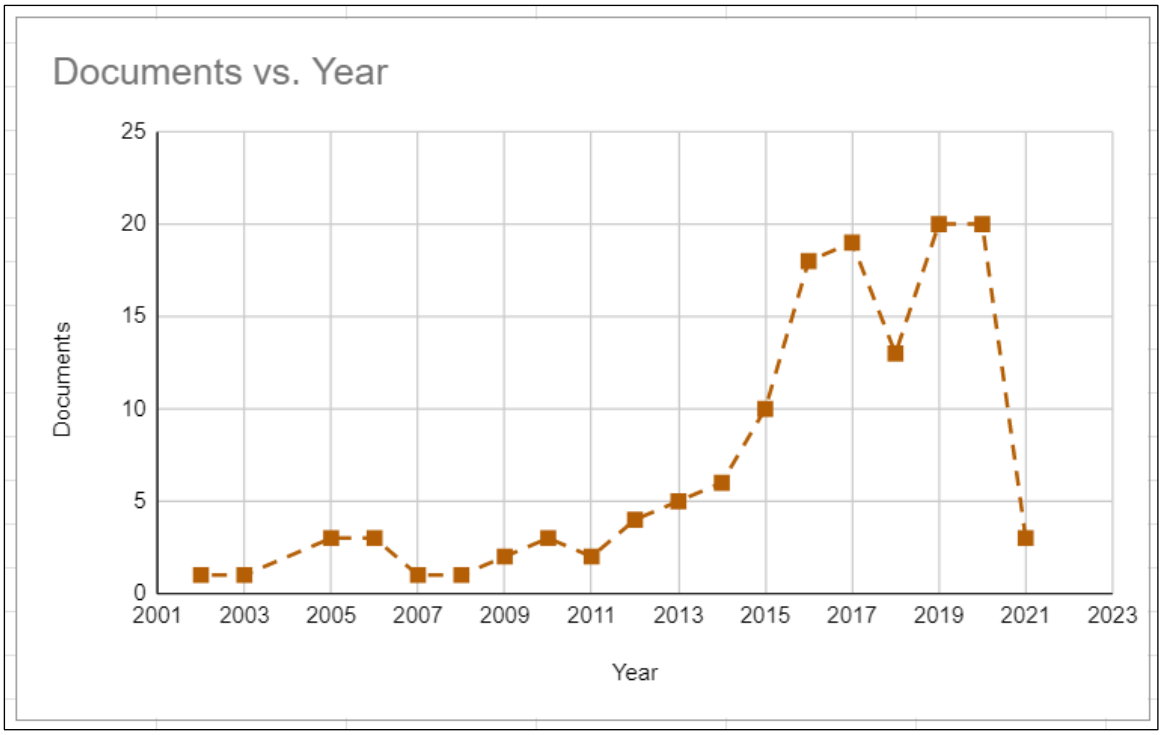


Fig. 5: Yearwise Publications

Year	Documents
2021	3
2020	20
2019	20
2018	13
2017	19
2016	18
2015	10
2014	6
2013	5
2012	4
2011	2
2010	3
2009	2
2008	1
2007	1
2006	3
2005	3
2003	1
2002	1

Table 4: Yearwise Documents

Source: fetched from http://www.scopus.com on 17th May 2021

The graph in Fig.6 helps us in understanding that the source with maximum number of documents was from IEEE Transactions On Antennas And Propagation with highest of 12 documents, IEEE Antennas And Wireless Propagation Letters with Microwave And Optical Technology Letters have 9 documents each followed by LETE journal Research with 5 and others with 3-4 each.

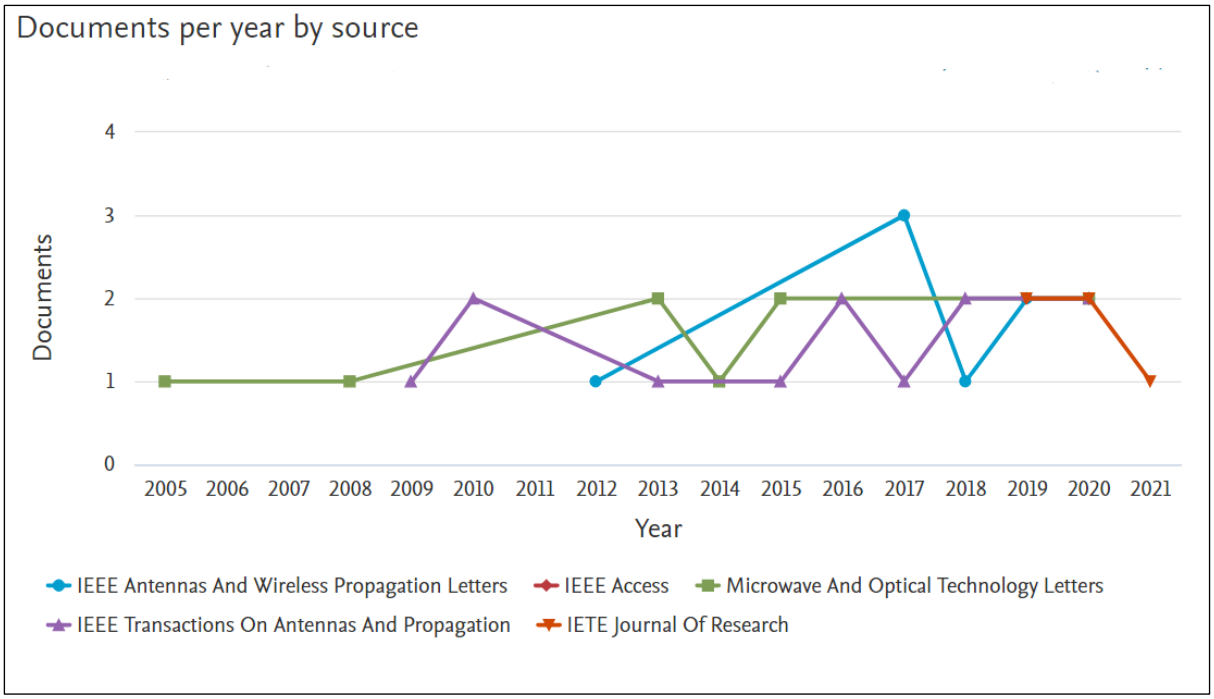


Fig. 6: Document per Year by Source

Table 5: Source by Documents

SOURCE TITLE	Column1
IEEE Transactions On Antennas And Propagation	12
IEEE Antennas And Wireless Propagation Letters	9
Microwave And Optical Technology Letters	9
IETE Journal Of Research	5
IEEE Access	4
IEEE Antennas And Propagation Magazine	4
Applied Computational Electromagnetics Society Journal	3
Electronics Switzerland	3
Iet Microwaves Antennas And Propagation	3
International Journal Of Microwave And Wireless Technologie	3
Progress In Electromagnetics Research C	3
AEU International Journal Of Electronics And Communication:	2
Frequenz	2
IEEE Antennas And Propagation Society AP S International Syn	2
IEEE Microwave And Wireless Components Letters	2

Source: fetched from http://www.scopus.com on 17th May 2021

Fig. 7 shows the renowned authors who have contributed tremendously in the field of research. We can see that Koul, S.K. has written 5 documents which is highest in this field while others such as Merugu ,Bharathi have 4 documents each . The remaining ones have like Basu, Gao, Liao each have 3 on their name while others have minimum 1-2 in their name. It is evident from this graph that this filed has many opportunities for research and authors as well.

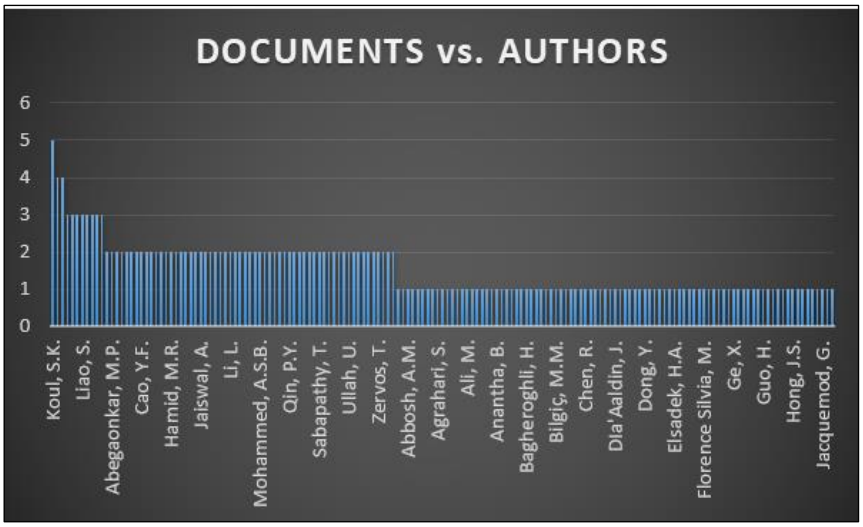


Fig. 7: Document by Author Name

Source: fetched from http://www.scopus.com on 17th May 2021

Mentioned graph in Fig. 8, Xidian University has affiliated 7 documents followed by University of Electronic Science and Technology of China, City University of Hong Kong, with 6 documents each then Jawaharlal Nehru Technological University Hyderabad, Osmania University, Indian Institute of Technology Delhi have affiliated 5 documents each and other following by 1-2 documents.

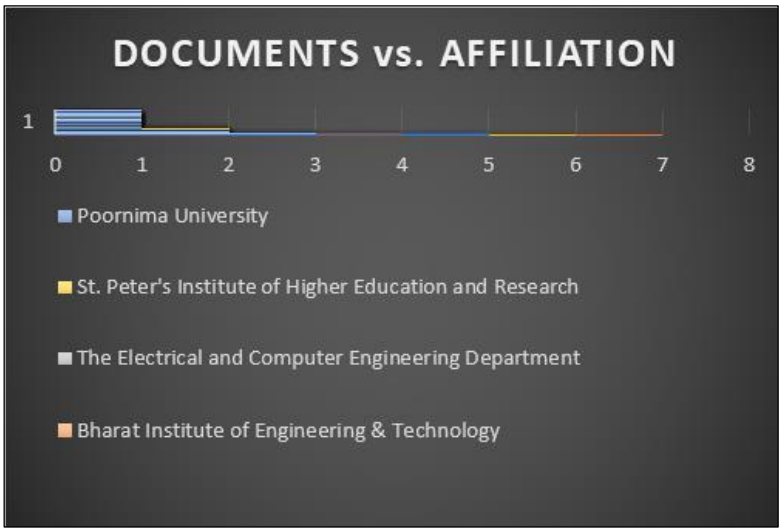


Fig. 8: Document by Affiliation

Source: fetched from http://www.scopus.com on 17th May 2021

The documents published by various countries or territories is shown in Figure 9 where India tops the rank with maximum i.e., 37 documents followed by 29 published by China and 15 from United States, Iran with 11 and United Kingdom with 9. These statistics show that there

is a lot of scope in other countries to boost their research in field of financial analysis mainly in the field of computation and statistics.

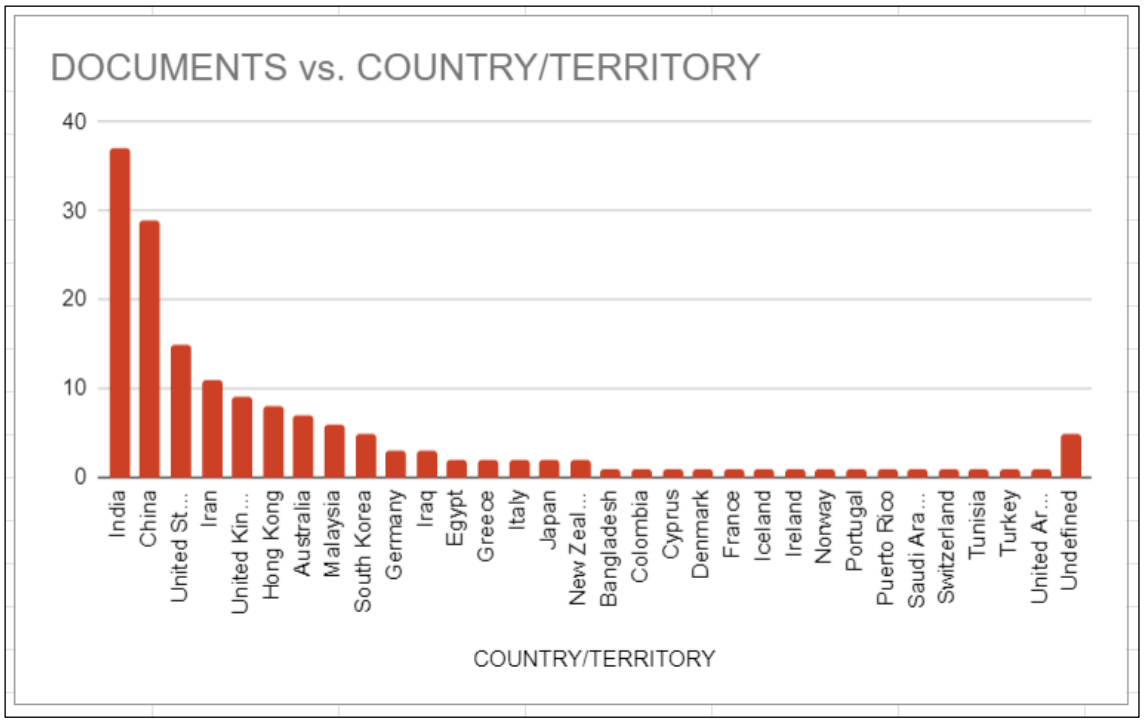


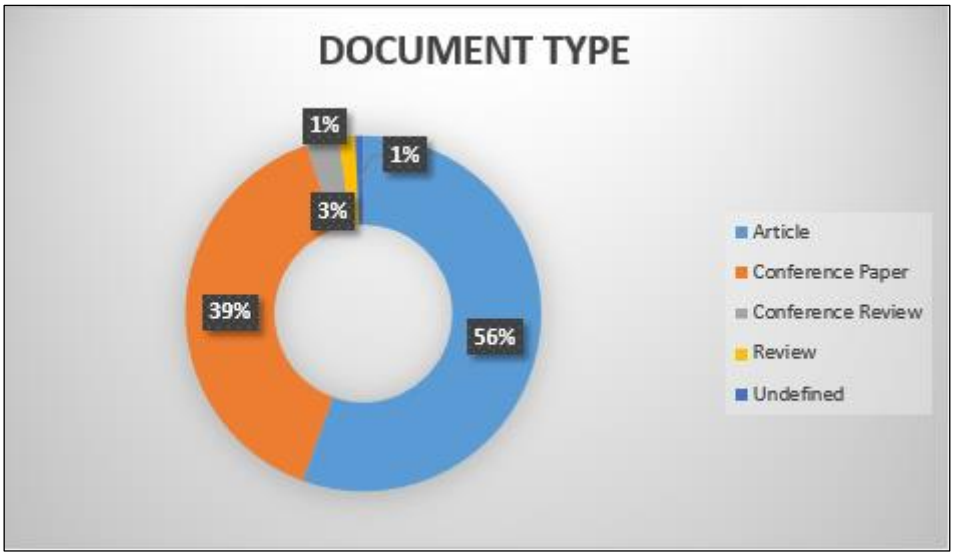
Fig. 9: Document by Country or Territory

Table 6: Documents by Country

COUNTRY/TERRITORY	
India	37
China	29
United States	15
Iran	11
United Kingdom	9
Hong Kong	8
Australia	7
Malaysia	6
South Korea	5
Germany	3
Iraq	3
Egypt	2

Source: fetched from http://www.scopus.com on 17th May 2021

Fig. 10 shows us that lest papers are published in review and 4 in conference review then a rise of 53 conference paper at last 75 Article papers have been published. Review and Conference Review numbers are less but they still have great scope of growth.



DOCUMENT TYPE	Column1
Article	75
Conference Paper	53
Conference Review	4
Review	2
Undefined	1

Fig. 10: Document by Type

Source: fetched from http://www.scopus.com on 17th May 2021

Figure 11 reflects the count of the publications pertaining to several subject areas in the field of Reconfigurable Antennas in 5G Applications. As seen below, the maximum publications are in the field of engineering followed by computer science and physics and Astronomy

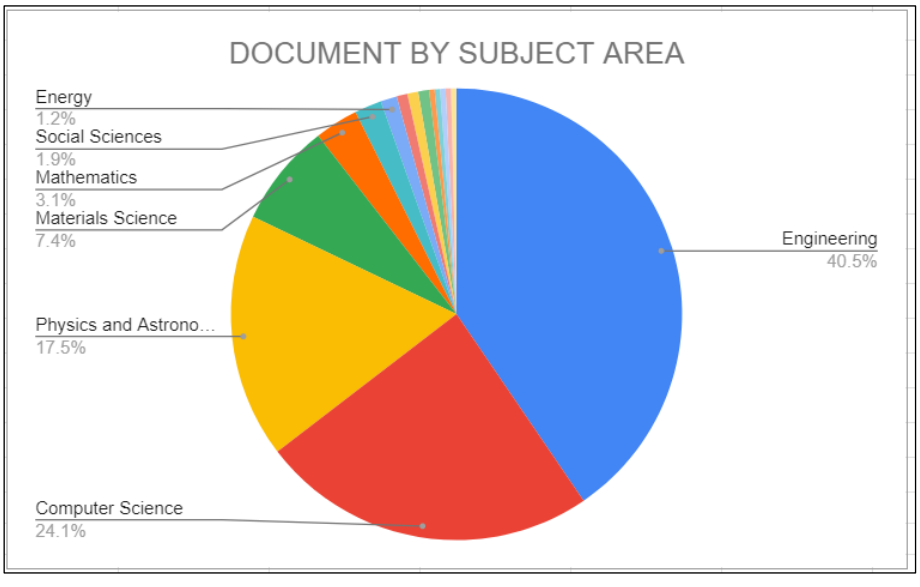


Fig. 11: Document by Subject

Table 7: Documents by Subject Area

SUBJECT AREA	Column1
Engineering	104
Computer Science	62
Physics and Astronomy	45
Materials Science	19
Mathematics	8
Social Sciences	5
Energy	3
Business, Management and Accoun	2
Earth and Planetary Sciences	2
Environmental Science	2
Agricultural and Biological Sciences	1
Biochemistry, Genetics and Molecu	1
Decision Sciences	1
Multidisciplinary	1
Pharmacology, Toxicology and Pha	1

Source: fetched from http://www.scopus.com on 17th May 2021

The record of the documents by various funding sponsors is shown in Figure 12. It is observed that National Natural Science Foundation of China has funded the highest number of documnts (11) followed by Defence Research and Development Organisation and Engineering and Physical Sciences Research Council and European Commission with many others with 2 documents each.

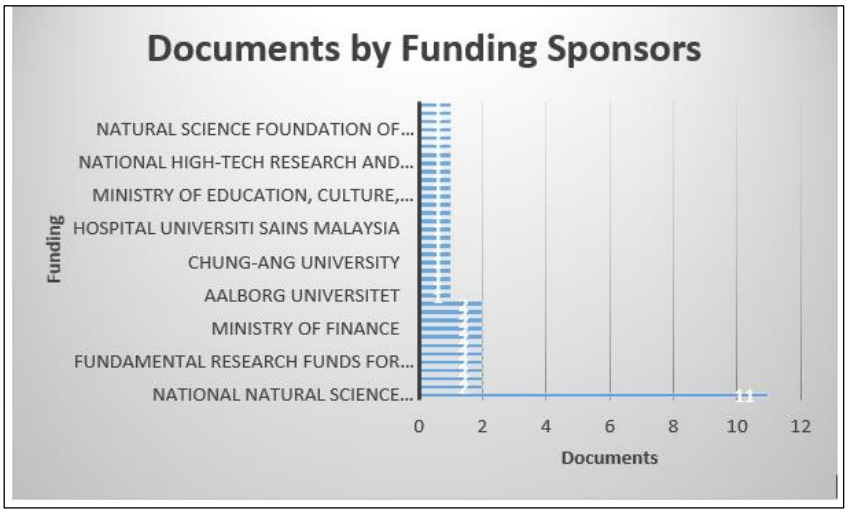


Fig. 12: Document by Funding Sponsor

Source: fetched from http://www.scopus.com on 17th May 2021

3.2 Bibliometric Analysis through Networked Diagrams

In our research paper for the Bibliometric Study on Circular Polarizing Reconfigurable Antennas for 5G Applications we used networked diagrams for better representation of various graphs based on different aspects. Network diagrams are a set of nodes and some lines which are meant to connect those nodes to each other. A network diagram basically shows how one event is connected to the other one showing us the important connections.

We used several softwares for the accomplishment of the network diagrams used in our bibliometric analysis. Some of them were Science Direct, Scopus Database, VosViewer, Graph Recipes etc.In addition to the network diagrams we also established few tables based on the analysis of the data extracted from Scopus Database.

In Fig.13 we can see the representation of the Sankey Diagram for our database

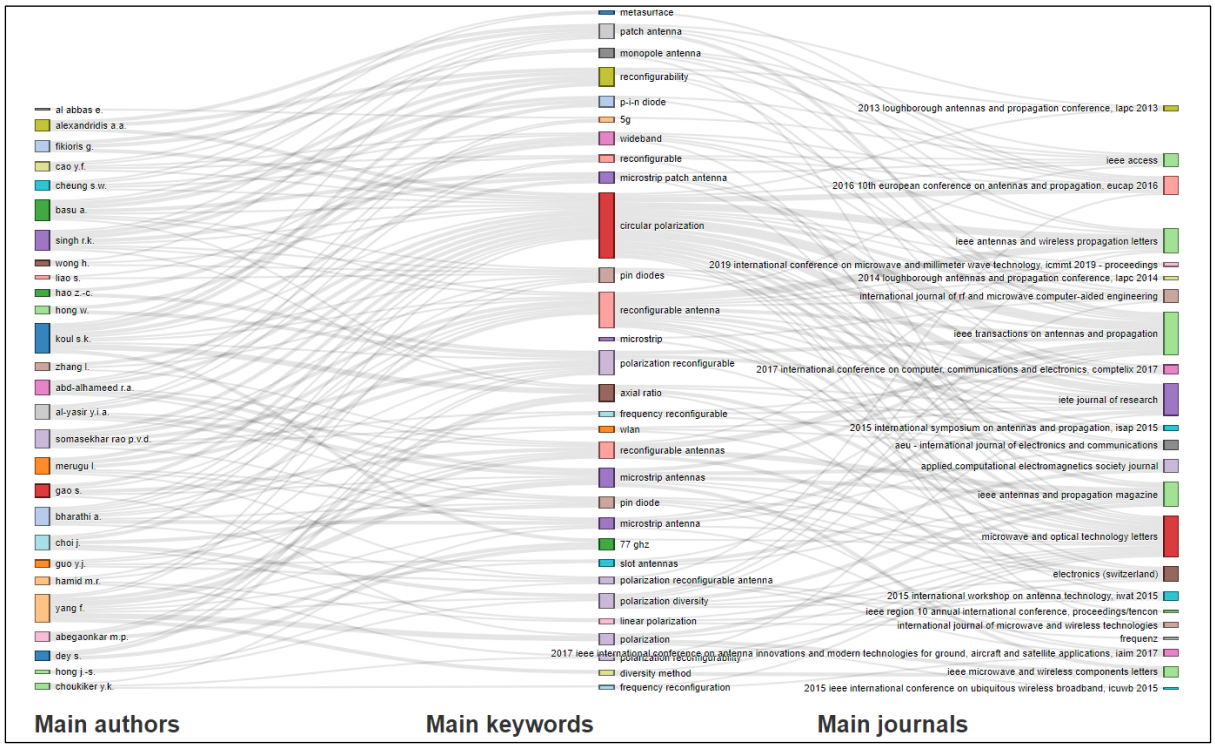


Fig.13: Sankey Diagram: Authors-Keywords-Journal
(Source: fetched from http://www.scopus.com on 17th May 2021)

In Fig.14 we can get an idea of how the main authors, main keywords and main journals are correlated to one another.

Fig. 14: Main Authors -Main Keywords -Main Journal
(Source: fetched from http://www.scopus.com on 17th May 2021)

In Fig.15 we can see the list of published papers/documents from the year 2002 to 2021 based on the topic of Circular Polarizing Reconfigurable Antennas ; also the number of papers published under that topic is mentioned.

Fig. 15: Top Publications from year 2002 to 2021

(Source: fetched from http://www.scopus.com on 17th May 2021)

In Fig.16 we can see the top keywords for the published papers from year 2002 to 2021. The most top keywords found in our database for the topic Reconfigurable Antennas for 5G Applications were: circular polarization, reconfigurable antenna, microstrip patch antenna, axial ratio, diversity method, patch antenna, 5G networks, left/right hand circualar polarization.

2002

- circular polarization 0 paper
- reconfigurable antenna 0 paper
- microstrip antennas 0 paper
- reconfigurable antennas 0 paper
- polarization 0 paper
- polarization diversity 0 paper
- axial ratio 0 paper
- microstrip antenna 0 paper
- polarization reconfigurable 0 paper
- pin diodes 0 paper

2003

- microstrip antennas 1 paper
- polarization 1 paper
- diversity method 1 paper
- circular polarization 0 paper
- reconfigurable antenna 0 paper
- reconfigurable antennas 0 paper
- polarization diversity 0 paper
- axial ratio 0 paper
- microstrip antenna 0 paper
- polarization reconfigurable 0 paper

2004

- circular polarization 0 paper
- reconfigurable antenna 0 paper
- microstrip antennas 0 paper
- reconfigurable antennas 0 paper
- polarization 0 paper
- polarization diversity 0 paper
- axial ratio 0 paper
- microstrip antenna 0 paper
- polarization reconfigurable 0 paper
- pin diodes 0 paper

2005

- microstrip antennas 2 papers
- polarization 2 papers
- circular polarization 1 paper
- reconfigurable antennas 1 paper
- polarization diversity 1 paper
- wideband 1 paper
- diversity method 1 paper
- slot antennas 1 paper
- microstrip 1 paper
- wlan 1 paper

2006

- reconfigurable antenna 1 paper
- microstrip antennas 1 paper
- reconfigurable antennas 1 paper
- polarization 1 paper
- antennas 1 paper
- adaptive arrays 1 paper
- antenna arrays 1 paper
- high-frequency ratio 1 paper
- land mobile radio diversity systems 1 paper
- polarization-agile antennas 1 paper

2007

- circular polarization 0 paper
- reconfigurable antenna 0 paper
- microstrip antennas 0 paper
- reconfigurable antennas 0 paper
- polarization 0 paper
- polarization diversity 0 paper
- axial ratio 0 paper
- microstrip antenna 0 paper
- polarization reconfigurable 0 paper
- pin diodes 0 paper

2008

- polarization 1 paper
- microstrip antenna 1 paper
- couplers 1 paper
- phase shifters 1 paper
- varactors 1 paper
- circular polarization 0 paper
- reconfigurable antenna 0 paper
- microstrip antennas 0 paper
- reconfigurable antennas 0 paper
- polarization diversity 0 paper

2009

- microstrip antennas 2 papers
- circular polarization 1 paper
- reconfigurable antennas 1 paper
- polarization 1 paper
- diversity method 1 paper
- antenna diversity 1 paper
- parasitic antennas 1 paper
- reconfigurable antenna 0 paper
- polarization diversity 0 paper
- axial ratio 0 paper

2010

- circular polarization 1 paper
- reconfigurable antenna 1 paper
- microstrip antennas 1 paper
- reconfigurable antennas 1 paper
- slot antennas 1 paper
- circular and linear polarization 1 paper
- equilateral-triangular patch 1 paper
- polarization 0 paper
- polarization diversity 0 paper
- axial ratio 0 paper

2011

- circular polarization 1 paper
- reconfigurable antennas 1 paper
- dual-band 1 paper
- microstrip patch antennas 1 paper
- genetic algorithm 1 paper
- ihop radiation 1 paper
- mems switches 1 paper
- reconfigurable microstrip antenna 1 paper
- rhop radiation 1 paper
- yagi-uda antennas 1 paper

2012

- circular polarization 1 paper
- reconfigurable antenna 1 paper
- metamaterial antenna 1 paper
- patch antennas 1 paper
- array 1 paper
- four-way power divider 1 paper
- nanosatellites 1 paper
- microstrip antennas 0 paper
- reconfigurable antennas 0 paper
- polarization 0 paper

2013

- circular polarization 2 papers
- microstrip antenna 2 papers
- reconfigurable antennas 1 paper
- axial ratio 1 paper
- pin diodes 1 paper
- monopole antenna 1 paper
- patch antenna 1 paper
- reconfigurability 1 paper
- rf switches 1 paper
- cognitive radio antenna 1 paper

2014

- slits perturbation 2 papers
- circular polarization 1 paper
- reconfigurable antenna 1 paper
- reconfigurable antennas 1 paper
- polarization reconfigurable 1 paper
- linear polarization 1 paper
- polarization reconfigurability 1 paper
- loop antenna 1 paper
- circular patch antenna 1 paper
- left/right hand circular polarization 1 paper

2015

- circular polarization 2 papers
- reconfigurable antenna 2 papers
- polarization 2 papers
- polarization diversity 2 papers
- microstrip patch antenna 2 papers
- microstrip antennas 1 paper
- polarization reconfigurable 1 paper
- reconfigurable 1 paper
- wideband 1 paper
- linear polarization 1 paper

2016

- circular polarization 6 papers
- reconfigurable antenna 3 papers
- metasurface 3 papers
- polarization diversity 2 papers
- reconfigurable 2 papers
- polarization reconfigurable antenna 2 papers
- slot antenna 2 papers
- reconfigurable antennas 1 paper
- axial ratio 1 paper
- pin diodes 1 paper

2017

- circular polarization 10 papers
- reconfigurable antenna 4 papers
- polarization reconfigurable 3 papers
- reconfigurable antennas 2 papers
- axial ratio 2 papers
- wideband 2 papers
- frequency reconfigurable 2 papers
- stacked patch structure 2 papers
- substrate integrated waveguide (siw) 2 papers
- microstrip antennas 1 paper

2018

- circular polarization 5 papers
- reconfigurable antenna 3 papers
- patch antenna 3 papers
- polarization diversity 2 papers
- monopole antenna 2 papers
- pin diode 2 papers
- microstrip antennas 1 paper
- reconfigurable antennas 1 paper
- microstrip antenna 1 paper
- pin diodes 1 paper

2019

- circular polarization 8 papers
- microstrip antennas 4 papers
- reconfigurable antenna 3 papers
- reconfigurable 3 papers
- microstrip antenna 2 papers
- monopole antenna 2 papers
- 5g 2 papers
- polarization-reconfigurable 2 papers
- reconfigurable antennas 1 paper
- polarization diversity 1 paper

2020

- circular polarization 8 papers
- reconfigurable antenna 6 papers
- axial ratio 3 papers
- pin diodes 3 papers
- polarization reconfigurable 2 papers
- wideband 2 papers
- microstrip patch antenna 2 papers
- reconfigurability 2 papers
- microstrip antennas 1 paper
- reconfigurable antennas 1 paper

2021

- circular polarization 1 paper
- reconfigurable antenna 1 paper
- polarization 1 paper
- patch antenna 1 paper
- pin diode 1 paper
- bandwidth 1 paper
- bilayer split ring 1 paper
- chiral metamaterial 1 paper
- directivity 1 paper
- falcate-shaped patch 1 paper

Fig. 16: Top Keywords from year 2002 to 2021

(Source: fetched from http://www.scopus.com on 17th May 2021)

Network Diagrams and Analysis:

Following represented are the network diagrams based on the Scopus database extracted for the topic of Bibliometric Study of Circular Polarizing Reconfigurable Antennas for 5G Applications.

In Fig.17 shows authors and the author keywords that are co-appearing in the alike paper that is created using the Minivan software. In this the green depictions are author keywords having 289 nodes and purple depictions are authors having 314 nodes.

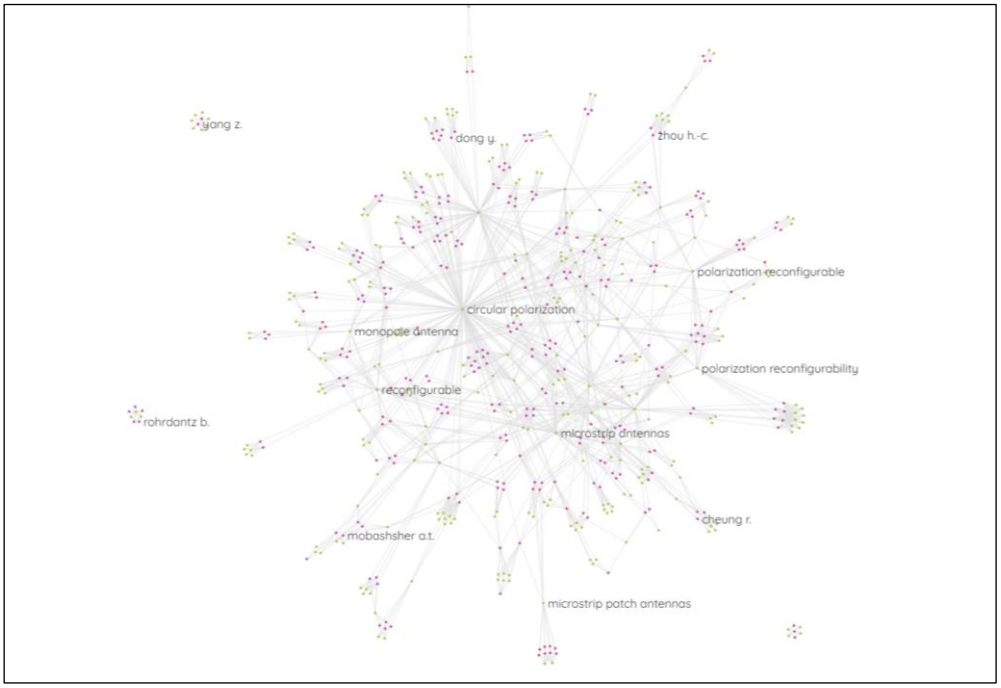


Fig. 17: Authors and the author keywords co-appearing in same paper
(Source: fetched from http://www.scopus.com on 17th May 2021)

Network diagrams showing the connection of the authors and source titles that are appearing together in the alike papers is shown in Fig.18 with the help of Graph recipes and the network graph represented in Fig.19 gives us the visualization of most top keywords from the database using the VosViewer software. Some of the top keywords being circular polarization, reconfigurable antennas and microstrip antennas.

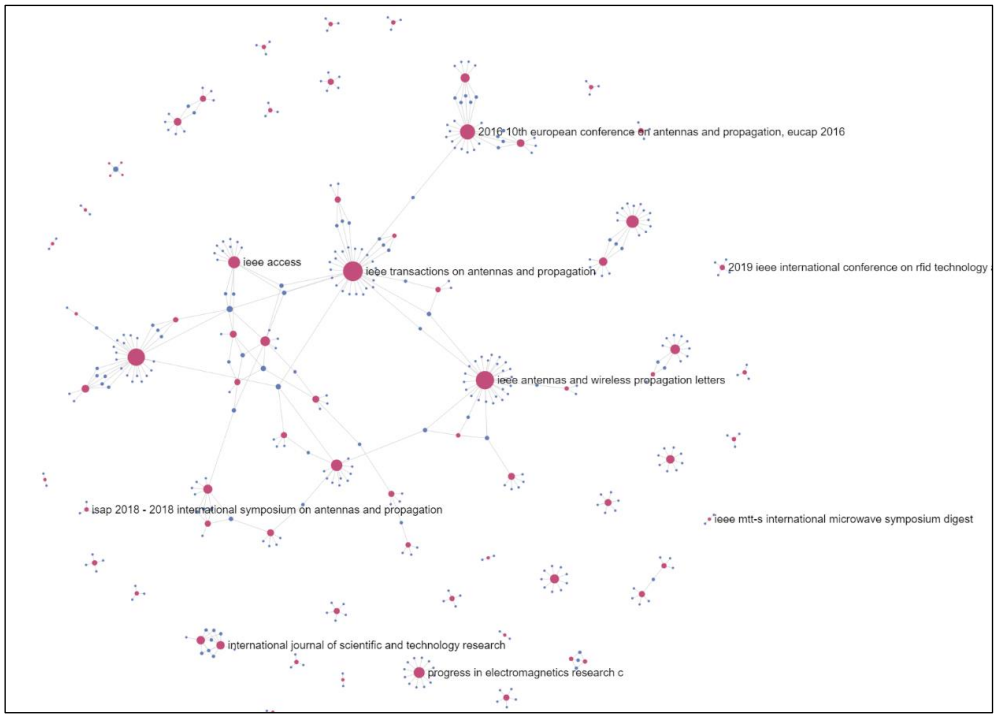


Fig. 18: Authors and source titles appearing together in same paper
(Source: fetched from http://www.scopus.com on 17th May 2021)

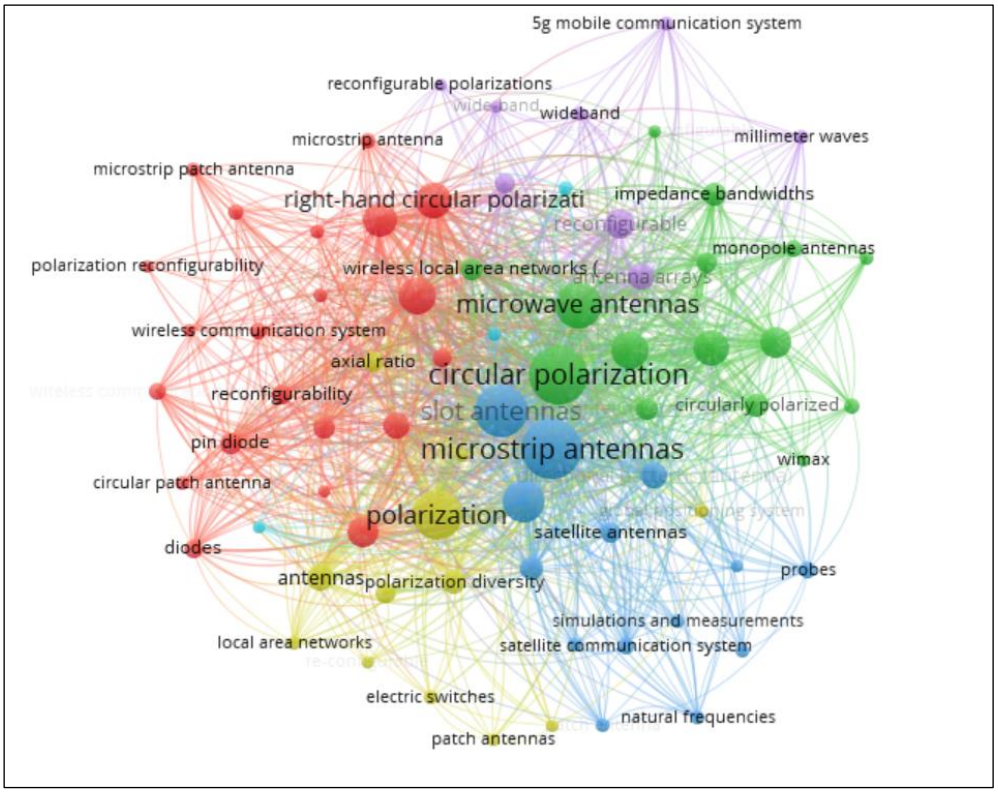


Fig. 19: Visualization of Networks based on Keywords
(Source: fetched from http://www.scopus.com on 17th May 2021)

Following are the network diagrams for the authors keywords appearing in the alike papers is shown in Fig.20. This are extracted using the software of Graph recipes.

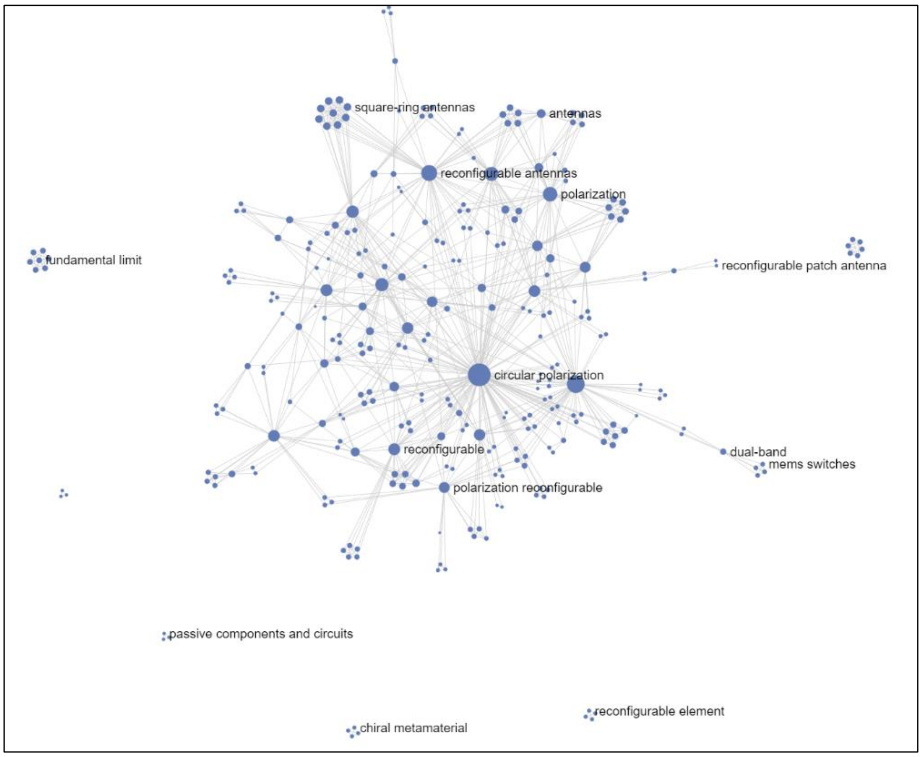


Fig.20: Authors keywords appearing in the same papers
(Source: fetched from http://www.scopus.com on 17th May 2021)

In Fig.21 we can see the graph representing co-citation of authors extracted using VosViewer and In Fig.22 we can see the network graph that represents source titles and author keywords that are co-appearing in the identical paper extracted using the software of graph recipe.

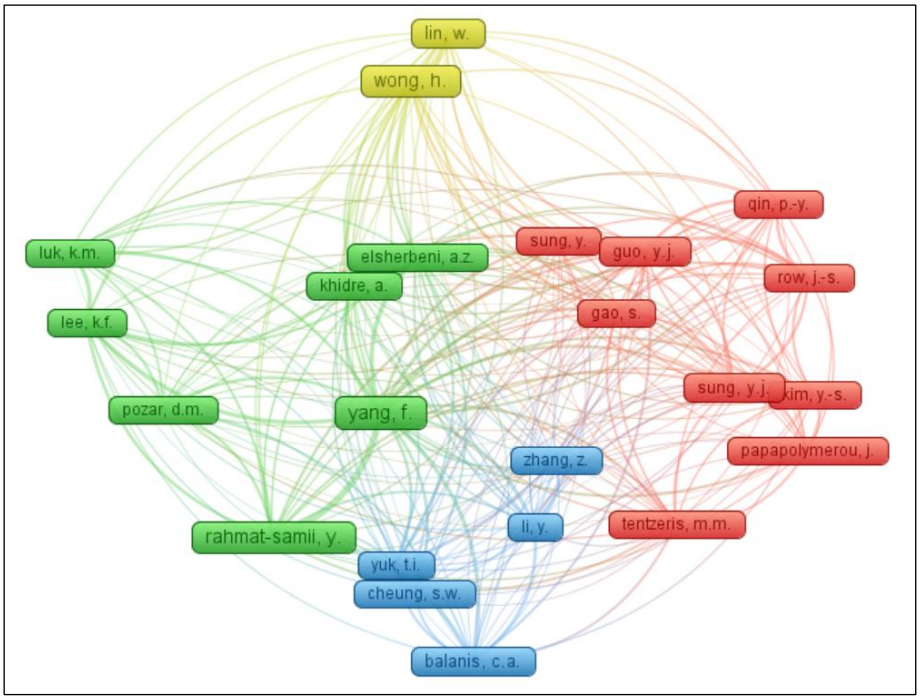


Fig.21: Network Diagram for Co-Citation of Authors
(Source: fetched from http://www.scopus.com on 17th May 2021)

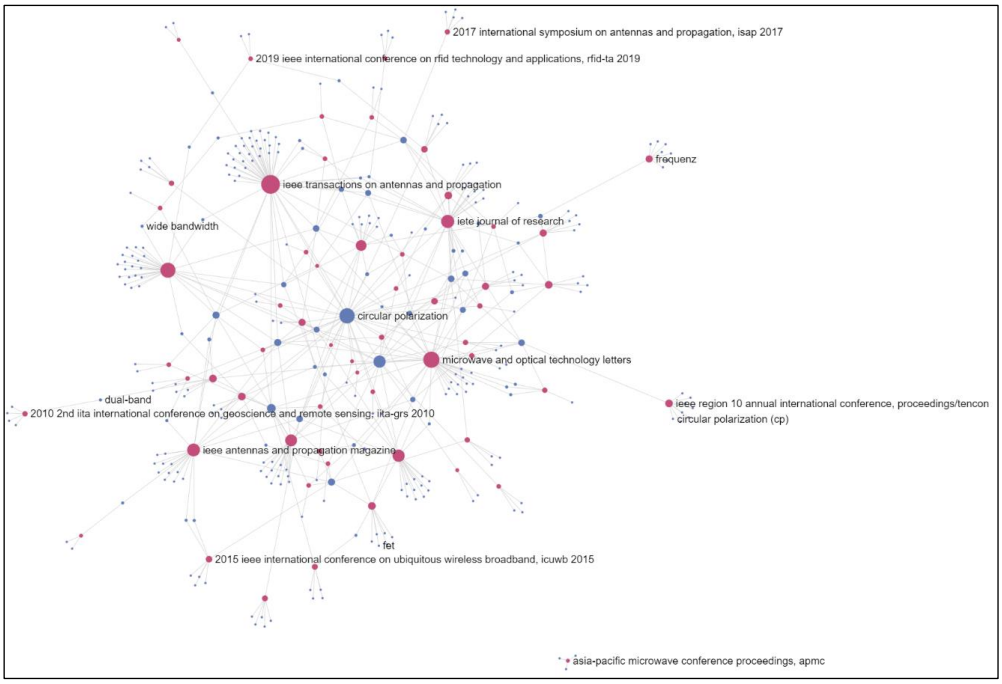


Fig.22: Source titles and author keywords co-appearing in the same paper
(Source: fetched from http://www.scopus.com on 17th May 2021)

In Fig.23 we can see the reference scape and graph in Fig.24 shows volumes of published documents over the year based on our topic of Bibliometric Study of Reconfigurable Antennas.

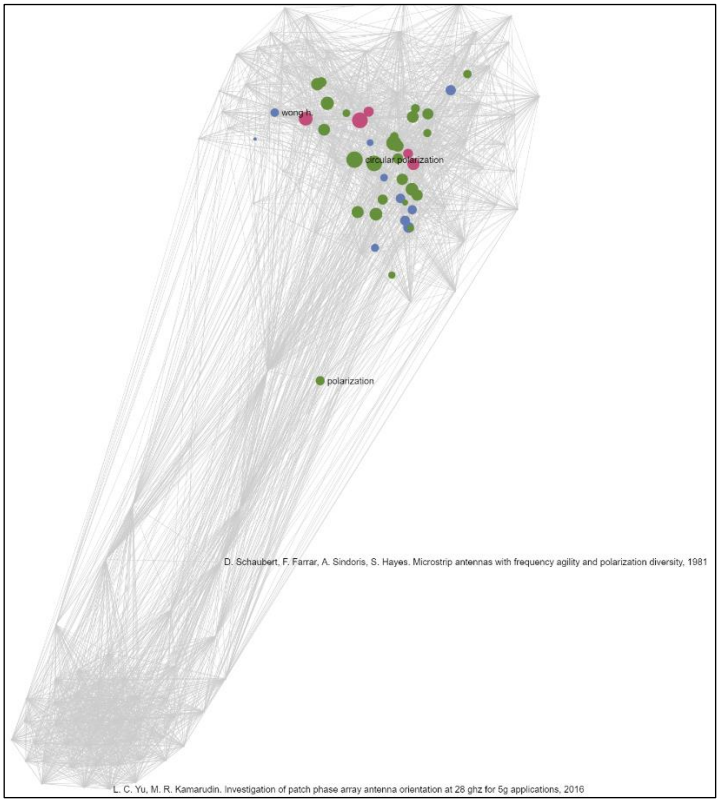


Fig.23: Reference-scape
(Source: fetched from http://www.scopus.com on 17th May 2021)

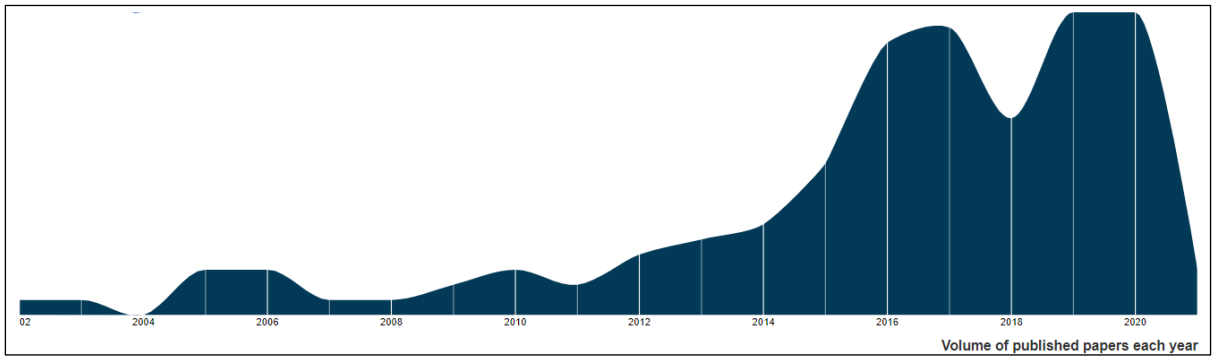


Fig.24: Volume of published papers from year 2002 to 2021
(Source: fetched from http://www.scopus.com on 17th May 2021)

4. Conclusion

A precise and comprehensive bibliometric survey is done in this paper in the field of circularly polarized reconfigurable antenna for 5G applications. The reconfigurability of an antenna can be achieved by altering the frequency, polarization or radiation pattern of an antenna by modifying them in a controlled and reversible manner. Making an antenna reconfigurable can increase the complexity of design which can interfere with the compatibility and cost efficiency of the antenna. Small size, less complexity, robust nature, ease of fabrication and its ability to confirm with planar and non-planar surfaces makes the microstrip patch antenna flexible to use in many applications and making it reconfigurable in a cost-effective and compatible manner is a challenge for antenna designers. Perfect efficiency, stable radiation pattern, good impedance throughout the operation states is important to yield maximum result. The paper gives good understanding of microstrip patch antenna and shows design, VSWR plot, return loss and radiation pattern of a 2.4GHz MSA.

Due to the ability to reduce multipath scattering and fading circularly polarization reconfiguration techniques are highly sought after and can enhance the performance of radio system. Switches are used to make an antenna reconfigurable. The reconfigurable antennas provide the cost-effective solution to meet the needs of multi frequencies which is the requirement of 5G communication.

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