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PROCEEDINGS

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Surabaya, Indonesia 60111

Words from the General Chair

Distinguished guests and participants,

Welcome to Indonesia, welcome to Surabaya, and welcome to the 5th IEEE COMNETSAT.

IEEE COMNETSAT is an annual conference jointly held by the IEEE Indonesia Section, the IEEE Indonesia Comsoc Chapter, the IEEE Indonesia Joint AESS/GRSS Chapter, and specially for this year's edition, the Institut Teknologi Sepuluh Nopember. Our venue is located in Surabaya, the second largest city in Indonesia, which is also the center of trade and economics linking the naturally-rich eastern archipelago of Indonesia and the more populated western part. As a consequence, Surabaya becomes an important hub, not only in the fields of trade but also in higher education and research, including those in the fields of communications. It goes naturally that Surabaya is a great choice for the venue of this conference that focuses on communications, network and satellite technology. This is not to mention that Surabaya is also an entry point to the beautiful province of East Java, which offers various tourism objects, either for the nature or the culture, or very often a combination of both. Surabaya itself has been an important port city since the era of Majapahit Kingdom in the 14th century and offers historical sites to both the Majapahit remnants and the traces of colonial past. Of course, Surabaya is also a transit point to the paradise island of Bali, which can be reached by plane in less than an hour.

However, we certainly hope that all of these backgrounds do not distract your concentration towards the conference at hand. In fact, we hope that the warm environment of Surabaya could help relax your mind a little bit and facilitate your preparation to participate productively in the conference. To make sure of that, IEEE COMNETSAT 2016 has been arranged by a fully committed team of professors and students from the Institut Teknologi Sepuluh Nopember. Our TPC Chair has accomplished an excellent job of reviewing processes to the submitted papers, with reviewers invited from all over the world guaranteeing the best quality of scientific materials. The entire program is held in one stream for two days, involving two keynote speakers from the scientific world and two workshops from the industry, thereby providing the audience with a current view from the two sides of the ever-evolving communication technology. The technical paper presentation is provided a range of time sufficient for a detailed delivery of the materials by the presenter and for a fruitful discussion that follows. Of course, these discussions can also be done during the coffee and lunch breaks, hopefully to the best effect of conceiving new collaborative efforts.

I would like to thank everyone who participates in this conference, either as a presenter or a regular participant. To myself it is a great honor to have such an opportunity to facilitate the organization of this conference, which is fully dedicated to the dissemination of important works in communications, network, and satellite technology. I would also like to thank the IEEE Indonesia Section, the IEEE Indonesia Comsoc Chapter, and the IEEE Indonesia Joint AESS/GRSS Chapter, who have trusted me in organizing this conference. Lastly but never the least, I am grateful to the professors and students, everyone in the organizing committee, without whose hard work the IEEE COMNETSAT 2016 would have never happened.

I realize that the organization of this conference is still far from perfect and might include so many errors and mistakes, for which I would humbly like to take the blame.

Please enjoy the conference and the city.

Best wishes,

Gamantyo Hendrantoro

Words from the TPC Chair

On behalf of the Technical Program Committee (TPC) chair, it is my honor and pleasure to welcome you to this exciting event, The 2016 IEEE International Conference on Communication, Networks and Satellite (COMNETSAT) in Surabaya, Indonesia. COMNETSAT is sponsored by Sepuluh Nopember Institute of Technology (ITS), Surabaya and co-sponsored by IEEE.

This year, we received 46 papers from 5 countries were submitted to the committee and subsequently reviewed by a group of excellent colleagues from around the world, who are authorities in their respective fields. The papers are spread over to the 4 conference tracks: Broadband and Photonic, Communication, Network, and Satellite. All papers were carefully peer-reviewed by 365 TPC members and a large number of reviews, with each paper reviewed by at least 3 reviewers. 22 papers were selected and edited from presentation and publications. This account for paper acceptance ratio of 48 %.

We would like to extend our sincerely thanks and appreciation to the exceptional work rendered by all TPC members and reviewers who made high quality reviews under a tight schedule.

I sincerely hope that you will have memorable experience at COMNETSAT 2016 and have a good trip in Surabaya, Indonesia.

Best wishes,

Eko Setijadi

Opening Message from IEEE Indonesia Section Chair

Dear General Chair, Keynote Speakers, colleagues, Professors, lecturers, researchers, ICT professionals, ladies and gentlemen, good morning.

On behalf of IEEE Indonesia section, I would like to express my sincere gratitude and welcome you to the 2016 IEEE International Conference on Communication, Networks and Satellite (COMNETSAT 2016). This conference is organized by Institut Teknologi Sepuluh Nopember and jointly sponsored by the IEEE Indonesia Section, IEEE Communications Society Indonesia Chapter, IEEE Aerospace and Electronic Systems/Geoscience and Remote Sensing Indonesia Joint Chapter.

COMNETSAT 2016 conference has been approved and Technical co-sponsored by IEEE, with the conference No # 39642.

Ladies and gentlemen,

This conference is really significant with the current situation, it is because the emergence of Communication, Network and Satellite technology has grown rapidly in conjunction with the development of many forms of digital media in Indonesia, as well as globally, in line to the Indonesia ICT Development Target in National Midterm Plan 2015 – 2019, and also related to Nawacita strategies, that Indonesia has ambitious plans and strategies to accelerate the economic development through ICT infrastructures.

Recently the government of Indonesia is forming a National Team, related to the 5G future development in Indonesia, consist of four Working Groups, such as Working Group Research and Technology, Working Group Industrial Relation, Working Group Regulation and Working Group Social Implication of Technology.

Ladies and gentlemen,

As an archipelago country consisting of 17,000 islands and straddling the equator, satellite technology is really important in Indonesia.

Indonesia is one of few developing countries which owned and operate its own domestic communication satellite system. Since 1976, a series of satellites, were built and launched.

Currently the most of TV broadcasters, Telco operators as well as Banking industries which operated in Indonesia are using satellite technology as their main backbone system, covering their signal coverage and data exchange across Indonesia.

The development of Communication, Network and Satellite technology towards 5G Technology and Internet of Things, are highly expected to become an active supporters, contributors and participants in the future digital business, information and social activities.

In year 2020, there are expected about 30 billion devices enabled to interact and communicate among themselves, exchanging data and information, senses about their environment, with the possibility to react autonomously to the real and physical world and influencing it by running processes with or without direct human intervention.

As a part of the global knowledge societies, we are invited and responsible for the contribution of the development of Communication, Network and Satellite technology, with enabling smart and strategic activities. Sharing knowledge and understanding through discussion in this conference, will also affect the future development of Communication, Network and Satellite technology.

Ladies and gentlemen,

As we may aware, IEEE is one of the largest professional associations in the world. Having been founded over 130 years ago, nowadays it brings together over 432,000 active members in more than 160 countries. This is the world's largest technical professional society, dedicated to fostering technological innovation and excellence for the benefit of humanity. IEEE provides more than 3.5 million digital libraries and currently has organized about 1,300 annual conferences, worldwide.

IEEE Indonesia section, which is a part of IEEE global, has already been established for 28 years. It currently has about 1,425 active members, and has been awarded 2015 outstanding Section membership recruitment performance from IEEE Headquarter. Among all grades of IEEE membership Indonesia, member grade and student grade are two largest membership grades that shares about 58% and 28% of all active member, respectively.

IEEE Indonesia Section has activities in 11 society chapters, namely Computer Society Chapter, Communications Society Chapter, Circuits and Systems Chapter, Engineering in Medicine and Biology Chapter, Solid State Circuits Society Chapter, Power and Energy Chapter, Education Society Chapter, Electron Devices Society Chapter, Power Electronics Society Chapter, Signal Processing Society Chapter and Social Implication of Technology Society Chapter.

Moreover, IEEE Indonesia section also has 3 joint chapters, namely Joint chapter of Microwave Theory / Antennas & Propagation, Joint chapter of Aerospace & Electronics Systems Society / Geoscience & Remote Sensing Society, and Joint chapter of Control System Society / Robotics & Automation Society.

IEEE Indonesia Section has 26 student branches (SB) chapters in several universities in Java, Sumatera, Bali and Sulawesi islands and four Affinity Groups, namely Women in Engineering, SIGHT in Telemedicine, SIGHT in Humanitarian Technology and Young Professional AG.

IEEE Indonesia section has also organized several activities almost weekly. Its activities are related to Technical, Education, and Social Activities, such as ICT Training, Workshop, International Seminar, Focus Group discussion, and Distinguish Lecturer Tour (DLT) activities all around Indonesia. The main discussed topics are related to the technology for humanity, such as Internet of Things (IoT), 5G, Big Data, Artificial Intelligent, Robotic technology, Engineering in Medicine and Biology, Antenna and Microwave, Satellite Technology, Circuit and Device, TV Digital, Renewable Energy, etc.

In terms of collaboration, IEEE Indonesia section has a good and mutual relationship with ICT organizations, Industries, Universities as well as the government in Indonesia. IEEE Indonesia also participated in the preparation of forming a new regulation related to the ICT in Indonesia, such as Near Field Communications (NFC), Short Range Device (SRD), Broadband Wireless Access (BWA), TV Digital Terrestrial, Internet Transaction Electronics (ITE) and also 5G.

Ladies and gentlemen,

Currently we are aware that the way the world works is changing, from resource based economy where things are shared or traded, to the knowledge economy, where we can share knowledge and information almost freely to improve our lives. If everyone had access to basic information and tools, then everyone would benefit from the creativity, innovation and ideas that everyone embodies.

Technology drives innovation, people can do more, do better. Technology drives higher quality of life, people can live better.

I do really hope in the near future the COMNETSAT event will be continued and strengthened, so the result will give more benefit and positive impact to the human being, especially for Indonesian people.

Finally, we do hope all of you will have enjoyable and valuable experience. During this 3 days conference, you may share your best knowledge in your area of research and professional activities.

Thank you.

Satriyo Dharmanto

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Program Schedule

Day One (Thursday, December 8, 2016)

08:00 – 08:30 **Registration**

08:30 – 09:00 **Opening Remarks**
General Chair of COMNETSAT 2016
Chairman of IEEE Indonesia Section
Head of Department of Electrical Engineering, ITS

09:00 – 10.00 **Keynote Speaker #1**
Never-Ending Demand of Frequency Spectrum
Dr. Ir. Titon Dutono, M.Eng

10:00 – 10:15 **Coffee Break**

10:15 – 11:55 **Paper Session: Communication**

10:15 – 10:35 COM-01
Optimized Target Packet Error Rate for a New Cross-Layer Scheme in AF Relay Selection System
Mahsa Shirzadian Gilan, Mohammad Yavari Manesh, Behrouz Maham

10:35 – 10:55 COM-02
MIMO Y Channel with Imperfect CSI: Impact of Training and Feedback Overhead
Hamideh Zebardast, Xiangyun Zhou, Behrouz Maham

10:55 – 11:15 COM-03
Enhancement of MC-CDMA Performance System Using Rotated Modulation
Khairunnisa Alfiyanti Suharja, Rina Pudjiastuti, Linda Meylani, Arfianto Fahmi

11:15 – 11:35 COM-04
Comparison of Selection and Maximal Ratio Combining in Cooperative Network Coding with AF and DF
Muhammad Iqbal, Suwadi, Wirawan, Rina Pudjiastuti

11:35 – 11: 55 COM-05
Performance Evaluation of the UFMC Scheme Under Various Transmission Impairments
Charleston Dale M Ambatali, Joel Joseph S. Marciano, Jr.

11:55 – 13:00 **Lunch**

13:00 – 14:00 **Tutorial #1 (PT. TELKOM)**
Indonesian Telecom Industry Point of View of Newly Emerging Telecommunication Technologies
Ir. Dian Rachmawan, M.Sc

14:00 – 14:15 **Coffee Break**

14:15 – 15:55 **Paper Session: Communication and Network**

14:15 – 14:35 COM-06
Design of Asynchronous Registers for Multimode Baseband Signals Processing
Hendra Setiawan

14:35 – 14:55 NET-1
Optical Link Design for WSN: Design of Software and Hardware
Dwi Setyawan, Wirawan, Istas Pratomo

14:55 – 15:15 NET-2
Internet of Medical Things for Cardiac Monitoring: Paving The Way to 5G Mobile Networks
Jusak Jusak, Heri Pratikno, Vergie Hadiana Putra

15:15 – 15:35 NET-3
Using Quality Threshold Distance To Detect Intrusion In TCP/IP Network
Hatungimana Gervais, Abdul Munif, Tohari Ahmad

15:35 – 15:55 NET-4
Increasing Performance of IDS By Selecting and Transforming Features
Indera Zainul Muttaqien, Tohari Ahmad

18:30 **Gala Dinner**

Day Two (Friday, December 9, 2016)

08:30 – 09:00 **Registration**

09:00 – 10:00 **Keynote Speaker #2**
Underwater Acoustics Communications
Dr. Ir. Wirawan, DEA, and Dr. Ir. Endang Widjiati, M.Eng.Sc

10:00 – 10.15 **Coffee Break**

10:15 – 11:35 **Paper Session: Broadband Photonic and Communication**

10:15 – 10:35 BP-1
VLC Design and Experiment Using 650 nm LASER Transmitter and Parallel Red Diffuse LED as Receiver
Herti Miawarni, Eko Setijadi

10:35 – 10:55 COM-07
Simulation Design of Triple Band Metamaterial Absorber for Radar Cross Section Reduction
Heri Agus Susanto, Eko Setijadi, Puji Handayani

10:55 – 11:15 COM-08
Designing SP4T Switching Circuit for Beamforming System Application at 2.35 GHz Frequency
Angga Hilman Hizrian, Fitri Yuli Zulkifli

11:15 – 11:35 COM-09
Effect of Vivaldi Element Pattern on The Uniform Linear Array Pattern
Nurhayati, Eko Setijadi, Gamantyo Hendrantoro

11:35 – 13:30 **Lunch**

13:30 – 14:30 **Tutorial #2 (MetraSat)**
The Indonesian Telecommunication Industry Anticipation of the New Generation of Satelitte Communication Technology
Ir. Bogi Witjaksono, M.Sc

14:30 – 14:45 **Coffee Break**

14:45 – 16:25 **Paper Session: Communication and Satellite**

14:45 – 15:05 COM-10
On the Spatial Separation of Multi-user channels Using 73 GHz Statistical Channel Models
Geamel Alyami, Ivica Kostanic

15:05 – 15:25 COM-11
MIMO Radar Waveform Design Using Interleaved-OFDM Technique
Devy Kuswidiastuti, Muhammad Rizky, Prasetiyono Hari Mukti, Gamantyo Hendrantoro

15:25 – 15:45 COM-12
Multiuser Separation and Performance Analysis of Millimeter Wave Channels With Linear Precoding
Waqas Ahmad, Geamel Alyami, Ivica Kostanic

15:45 – 16:05 SAT-1
Satellite Tracking Control System for UGM Ground Station based on TLE Calculation
Agfianto Eko Putra, Bakhtiar Alldino Ardi Sumbada, Anas Nurbaqin

16:05 – 16:25 SAT-2
Integrated Multi-Disciplinary Research-Education in Satellite Technology Through Student Community
Gamantyo Hendrantoro, Eko Setijadi

Day Three (Saturday, December 10, 2016)

09:00 – 11:00 **One Day Tour (*Extra Fee*)**

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Effect of Vivaldi Element Pattern on The Uniform Linear Array Pattern

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***Abstract*— This paper presents about the effect of Vivaldi element pattern on the Uniform Linear Array pattern. Vivaldi antenna can operate over wide bandwidth. Geometry of the radiating element influences element radiation pattern especially for frequency far from the center frequency. In this paper, we reported coplanar Vivaldi antenna with dimension 60x60 mm on FR4 substrate with permittivity 4.7. The antenna has differents element pattern at 2 GHz, 3 GHz and 4 GHz. It is shown that bad radiation pattern in certain frequency in broadband antenna can effects on the total array pattern. Differents element pattern, spacing and number of elements resulted different array pattern. We simulated variation 5 mm and 15 mm spacing between adjacent sides of Vivaldi elements and variation 3 and 10 number of elements in each frequency. From simulated resulted shows that the total array pattern has higher back lobe level than main lobe level for N=5, d=0.433λ at 2 GHz due to its elements pattern performance. Gain of the main lobe level is obtained as 10.81 dB at 3 GHz, N=5, d= 0.65λ. Gain of the array pattern increased and HPBW decreased with increasing number of elements. From simulated result, it reveals that good performance of element pattern and total array pattern is achieved at 3 GHz, 4 GHz and 2 GHz respectively. Increasing operating frequency will affect its sidelobe performance due to different spacing between elements relative to certain wavelength. Although broadband antenna has return loss below -10 dB in all band frequency, it must be better to know element pattern in each operating frequency. It can avoid bad performance of total array pattern in certain frequency. Simulation by using multiplication element pattern with array factor can reduce computation time compared with full wave simulation. But it does not consider mutual coupling effect.**

Keywords*— *Vivaldi; radiation pattern; antenna; array factor; array pattern.

I. INTRODUCTION

Array antenna has many advantages compared with individual element because it can increase gain and reduce beamwidth. The total array pattern can be influenced by radiation pattern of element and array factor. Array factor depends on the number of elements and space between elements, amplitude and phase of each elements. Weighting of the signal can improve antenna array performance. It can reject interference or improve beemsteering process without changing physical antenna[1]. Many paper has presented to get Array factor and total array pattern performance with dipole or isotropic elements[2].

There are many broadband Vivaldi antenna has been designed to get return loss performance[3] and radiation pattern performance[4]. Vivaldi antenna can be arranged in array[5] and applied for many application. Nowdays antenna is developed by reducing element size to earn low cost in fabrication. Wideband antenna can be constructed from small size of radiator with comparison of the length and width elements asymmetry[6] or symmetry. Many paper has been published to get vivaldi performance with many variety shape of radiator, variety feeding and substrate[7]. Sometimes broad band antenna has good return loss performance in all band frequency but the radiation pattern at each frequency have different shape especially for frequency which is far from the center frequency.

There are many methods of array antenna analysis in the linear, planar, circular or conformal array[8]. The more discussed array antenna about array configuration and array synthesis to change array factor and array pattern performance. The pattern synthesis by non uniform element position in linear array has been presented[9]. There are many array synthesis to get optimum array pattern with many complex algorithm by dipole or isotropic elements and none of them review about total array pattern of the broad band element. Before we optimise array configuration in broadband antenna. it could be better to know element pattern in each frequency to get better total array pattern.

In this paper we discuss about the effect of Vivaldi element pattern from each frequency in the uniform linear array. Vivaldi antenna has different radiation characteristic with dipole or isotropic element. It has endfire radiation. Principally of Vivaldi antenna is the current distribution happened between two exponential tapered slot. It is shown that bad radiation pattern in certain frequency in broadband antenna can effects on the total array pattern. The best way to improve total array pattern is enhance element radiation pattern performance first in each frequency for broadband antenna and then optimize array factor performance. It can avoid mistakes of mainlobe position of total array pattern. Total array pattern by using multiplication element pattern and array factor can reduce computation time compare with using full wave simulation. In this simulation, we did not

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consider mutual coupling effect. In the following section, it will explain about the effect of element pattern in each frequency to the total array pattern with varying spacing between element and varying the number of elements.

II. THEORY

A. Array Antenna

Antenna array can reach high gain and small half power beamwidth. Fundamental of array antenna is Uniform linear Array. Array Pattern(AP) in antenna array is multiplication radiation pattern of antenna element (g) and Array Factor

$$AP(\theta,\varphi) = g_{ae}.AF(\theta,\varphi) \quad (1)$$

Array factor from the isotropis point source is summing of the receive weighting

$$w_n = a_n e^{j\delta_n} \quad (2)$$

$$AF = \sum_{n=0}^{N} a_n\, e^{j\psi_n} e^{j\delta_n} = \sum_{n=0}^{N} a_n e^{j(\psi_n+\delta_n)} \quad (3)$$

$$\psi_n = kdu \quad (4)$$

$$kd\ cos\varphi\ or\ kd\ sin\theta \quad along\ x\ axis$$

$$kdsin\varphi\ or\ kd\ sin\theta \quad along\ x\ axis$$

$$kd\ cos\theta \quad along\ z\ axis \quad (5)$$

$$\psi_n = -kd\sin\varphi \quad \delta_n = -\beta d\sin\varphi_0 \quad (6)$$

Array factor will be maximum if ψ=0. For array antenna in the E plane configuration, Vivaldi elements is arranged along of y axis. It is endfire (φ_0=0^0) radiation.

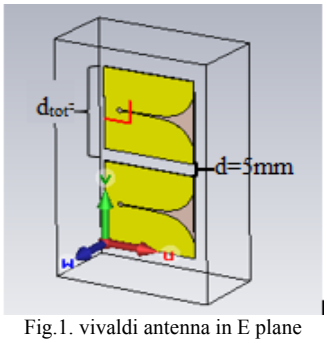

Fig.1. vivaldi antenna in E plane

d total in E plane is summation of width of the substrate ($w_{substrate}$) and spacing(d) between adjacent sides of elements.

B. Broadband Vivaldi Antenna.

Broadband or Ultra Wide Band antenna can be used in many application. Bandwidth of antenna relative from the center of frequency.

$$f_c = \frac{1}{2}(f_h + f_L) \quad (7)$$

Fractional bandwidth (FBW) can be defined :

$$BW = \frac{BW}{fc} = 2\frac{f_H - f_L}{f_H + f_L} \quad (8)$$

UWB have FBW more than 50% and Wideband has FBW 20% Vivaldi antenna is one types of broadband antenna, and the exponential tapered slot can be designed with the equation:

$$y = C_1 e^{Rx} + C_2 \quad (9)$$

$$C_1 = \frac{y_2 - y_1}{e^{Rx_2} - e^{Rx_1}} \quad (10)$$

$$C_2 = \frac{y_1 e^{Rx_2} - y_2 e^{Rx_1}}{e^{Rx_2} - e^{Rx_1}} \quad (11)$$

R=0.13 is exponential rate. Coplanar Vivaldi antenna is designed by FR4 substrate, with substrate thickness is 1.6 mm

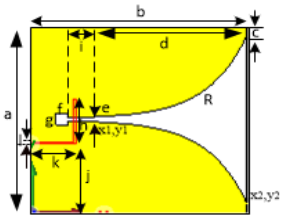

Fig.2. Coplanar Vivaldi Antenna

TABLE.I. PARAMETER OF ANTENNA

Dimension in mm			
a=60	d=40	g=5	j=15
b=60	e=0.6	h=28	k=25
c=17.5	f=5	i=0	l=2

III. SIMULATED RESULT AND DISSCUSSION

A. Return Loss

Bandwidth impedance of the antenna will be match if return loss has value below of -10 dB and it related with Voltage standing Ratio. If we set VSWR is 2, Reflection coefficient ($|\Gamma|$) of the antenna is 0.33 and in the decible scale will be found as -10dB. From the graph, it shows that from 2 GHz until 3 GHz, antenna have good return loss performance with minimum return loss is -34.08 at 2.166 GHz and the best VSWR is 1.04.

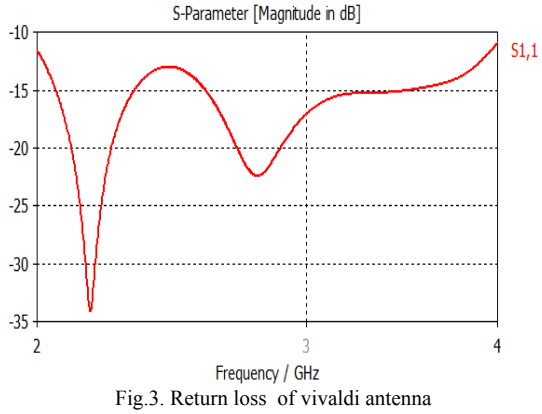

Fig.3. Return loss of vivaldi antenna

B. Radiation Pattern.

Radiation pattern is variation of the power radiated as function of elevation and azimuth degree.

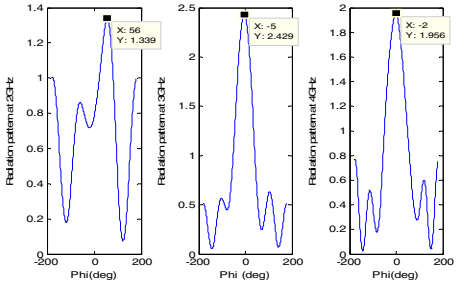

Fig.4. Element pattern in each frequency

Cartesian plot of gain in linear scaling at 2 GHz, 3 GHz and 4 GHz in theta 90 and varying phi is shown in fig 4. Absolute gain is obtained for 2 GHz is 1.339, for 3 GHz is 2.429 and for 4 GHz is 1.956. The best gain is reached in the center frequency at 3 GHz. Backlobe at 2 GHz is 1.002, at 3 GHz is 0.5147 and at 4 GHz is 0.7615. The worst backlobe is happened at 2 GHz.

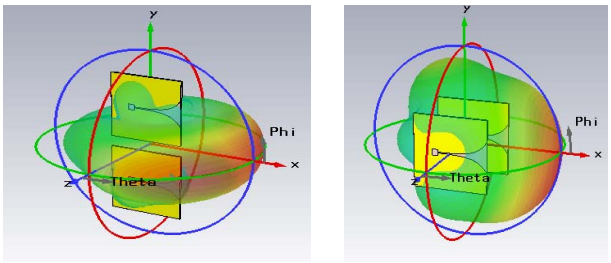

Fig.5. Vivaldi array in E plane and H plane

E plane and H plane in 3D plot of two Vivaldi array antenna is denoted in fig.5.We just simulate array in E plane and not simulated in the H plane yet. It is simulated by cst and matlab. We set spacing between elements by summation of width of substrate and distance of the adjacent side between elements(d). Array Factor and array pattern will be changed with varying space and varying number of element.

C. Array Pattern with varying spacing of elements

We simulated two different spacing of elements. For this simulation, we set the number of elements is 5.

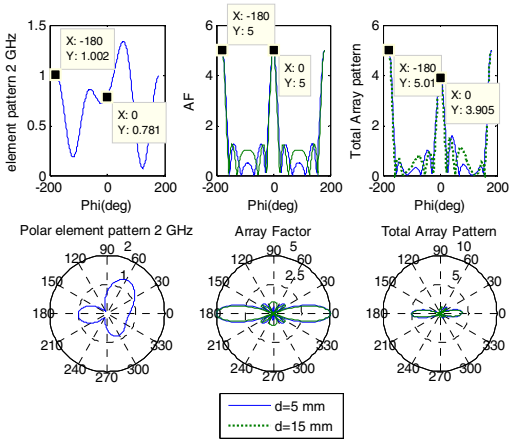

Fig.6. Cartesian and polar plot radiation pattern at f=2 GHz

Radiation pattern of Vivaldi antenna at 2 GHz shows asymmetry pattern. It has large main beam, high peak side lobe level and high back lobe level. It can be happened because the dimension of antenna smaller than a half of wavelength in 2 GHz (150mm). Difference radiation pattern for d=5mm and d=15mm is denoted in fig.6. For d=5mm, Spacing between adjacent sides of the elements is 5 mm and the the total space is 65mm. The total space for d=15mm is 75mm. It gets from summation of width of the substrate and d. It is related with wavelength as 0.433λ for d_total is 65mm and 0,5λ for d_total is 75 mm at 2GHz. Spacing between elements in dipole array antenna is different from in Vivaldi elements. In dipole array if we set spacing between elements more than 1 λ, it will appear grating lobe but in Vivaldi its depend on its element pattern. In coplanar Vivaldi antenna, current distribution propagate in the middle of radiator. It radiated between two exponential tapered slot. Width of the substrate in Vivaldi antenna will interfere spacing between element in array configuration. If element pattern has bad radiation pattern, the total array pattern will be bad too. Wider spacing between elements, it will slighty smaller beamwidth and higher side lobe level. It is seen that back lobe level higher than mainlobe level at 2 GHz.

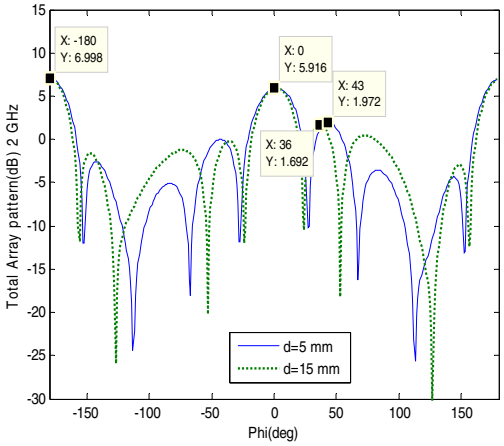

Fig.7. Total Array Pattern in decibel scale at f=2 GHz

TABLE.2. VARY SPACING AT 2 GHZ

Space elements	d=0.433λ (65mm)	d=0.5 λ (d=75mm)
Main lobe (dB)	5.916	5.916
Back lobe (dB)	6.998	6.998
Peak Side Lobe Level (dB)	1.972	1.692
HPBW(degree)	30	36

Wider spacing between elements can not higher gain and smaller HPBW with significantly of the total array pattern. It is shown that total array pattern yields higher back lobe level at 2 GHz than main lobe level. If we arrange array pattern from bad element pattern at certain frequency It could be reason that the main lobe not in the right direction.

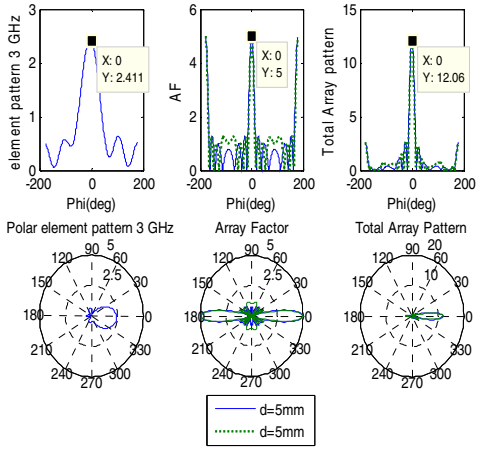

Fig.8. Cartesian and polar plot at f=3 GHz

In the center frequency (3 GHz), if spacing between elements is set at d= 5mm (0.65 λ), it will get smaller peak side lobe level than peak side lobe level at d=15mm (0.75 λ). It is different array pattern at 2 GHz. At 3 GHz, mainlobe gain can reach 12.06 in linear scale and lower backlobe level than at 2 GHz.

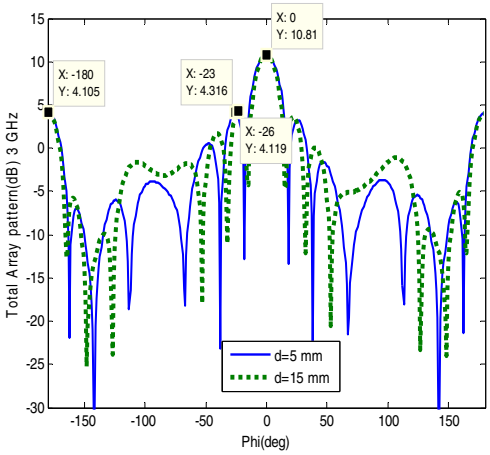

Fig.9. Total Array Pattern in decibel scale at f=3 GHz

TABLE.3. VARY SPACING AT 3 GHZ

Space elements	d=0.65λ (65mm)	d=0.75 λ (d=75mm)
Main lobe (dB)	10.81	10.81
Back lobe (dB)	4.105	4.105
Peak Side Lobe Level (dB)	4.119	4.316
HPBW(degree)	22	20

The total array pattern level has the same value for both diferent spacing. Extensive spacing of elements will increase side lobe level and reduce HPBW. It can shown from table 3 that side lobe level increase from 4.119 dB to 4.316 dB.

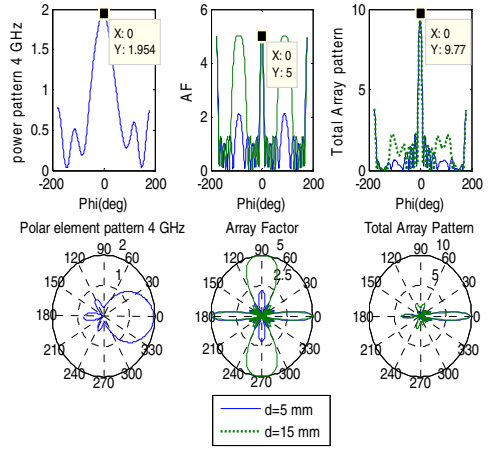

Fig. 10. Cartesian and polar plot at f=4 GHz

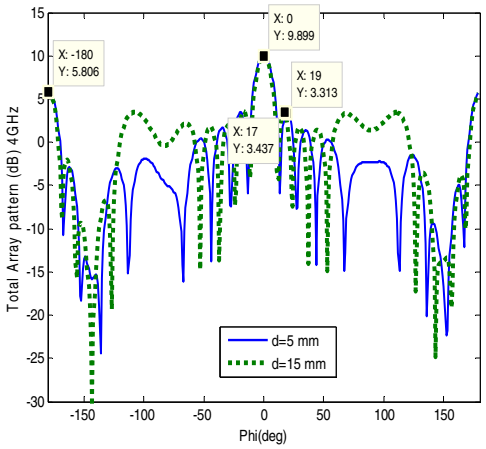

Fig.11. Total Array Pattern in decibel scale at f=4 GHz

TABLE.4. VARY SPACING IN 4 GHZ

Space elements	d=0.867λ (65mm)	d=1 λ (d=75mm)
Mainlobe (dB)	9.899	9.899
Backlobe (dB)	5.806	5.806
Peak Side Lobe Level (dB)	3.313	3.437
HPBW(degree)	16	14

Back lobe level and side lobe level at 4 GHz get worse performance than Back lobe level and side lobe level at 3 GHz. But the worst backlobe is get for 2 GHz. The best HPBW is get at 4 GHz. HPBW at 3GHz better than HPBW at 2 GHz.

D. Array Pattern with varying number of elements

Different number of elements can affect on array factor and total array pattern. In this paper, we simulated different number of element with equal spacing at d=15mm

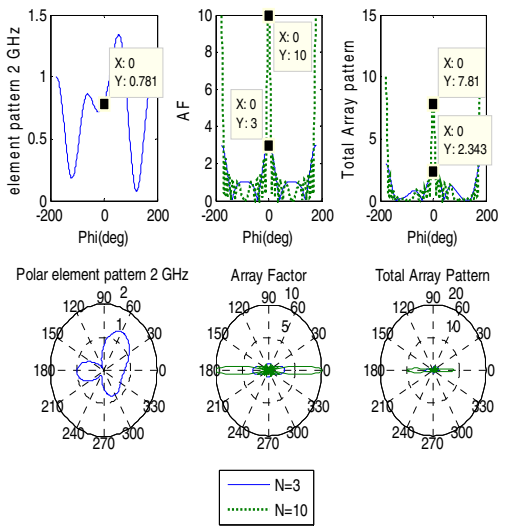

Fig.12. Cartesian and polar plot at f=2 GHz

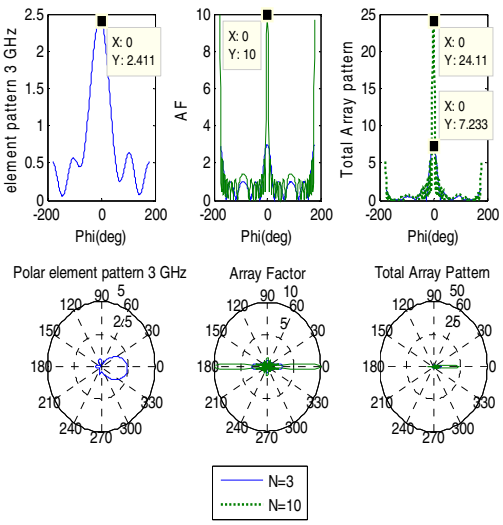

Fig.14. Cartesian and polar plot at f=3 GHz

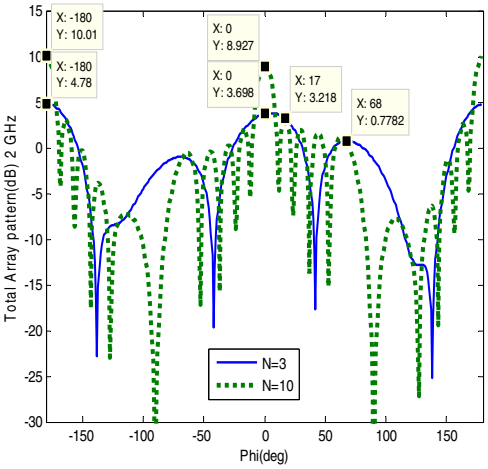

Fig.13. Array Pattern in decibel scale for f=2 GHz

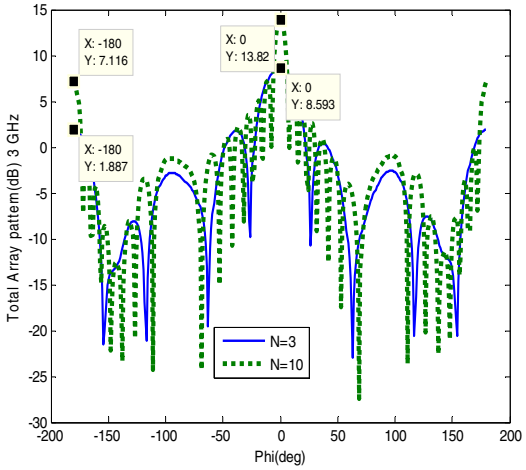

Fig.15. Array Pattern in decibel scale for f=3 GHz

TABLE.5. VARYING NUMBER OF ELEMENT IN 2 GHZ

Space elements	N=3	N=10
Mainlobe (dB)	3.698	8.927
Backlobe (dB)	4.78	10.01
Peak Side Lobe Level (dB)	0.7782	3.218
HPBW(degree)	58	14

Increasing number of elements will effect on total array pattern. It influences performance of main lobe, back lobe, peak side lobe level and HPBW. If antenna has bad radiation pattern, by increasing number of element, it will make higher back lobe level than main lobe level. It is shown that backlobe level for N=3 is 4.78 dB and back lobe level for N=10 is 10.01 dB. This appearance could make the peak of main beam not in the desired direction. HPBW for N=10 smaller than HPBW N=3.

TABLE.6. VARYING NUMBER OF ELEMENT IN 3 GHZ

Space elements	N=3	N=10
Main lobe (dB)	8.593	13.82
Back lobe (dB)	1.887	7.116
Peak Side Lobe Level (dB)	0.346	6.998
HPBW(degree)	36	8

Main lobe level at 3 GHz can reach 13.82 dB for N=10 and 8.593 dB for N=3. Increasing number of element will increase main lobe level of the antenna and reduce HPBW. HPBW for N=10 smaller than N=3. It is shown that HPBW for N=10 is 8^0 and HPBW for N=3 is 36^0. Performance of back lobe level and peak side lobe for N=3 better than for N=10. Backlobe level for N=3 smaller than backlobe level for N=10. Peak side lobe level for N=3 smaller than N=10.

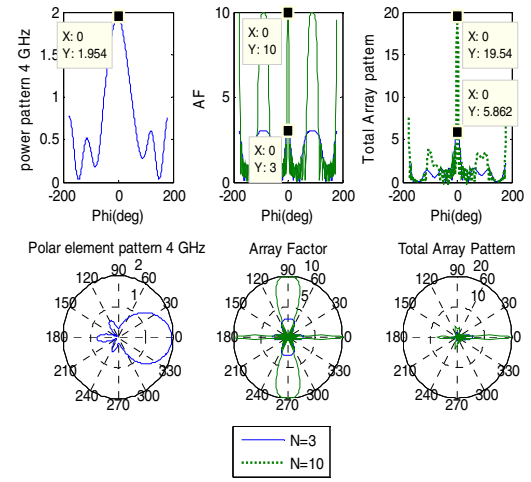

Fig.16 Cartesian and polar plot for f=4 GHz

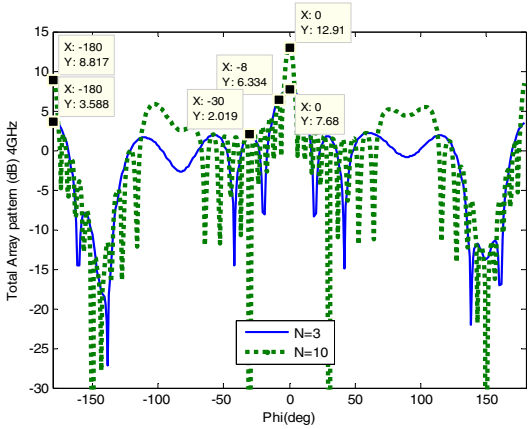

Fig.17. Array Pattern in linear and decibel scale at f=4 GHz

TABLE.6. VARYING NUMBER OF ELEMENT AT 3 GHZ

Space elements	N=3	N=10
Main lobe (dB)	7.68	12.91
Back lobe (dB)	3.588	8.817
Peak Side Lobe Level (dB)	2.019	6.334
HPBW(degree)	24	6

Peak side lobe level at 4 GHz higher than at 3 GHz. If we set spacing from adjacent sides is 15 mm or the total spacing is 75mm, it can be related in wavelength as 0,5λ at 2 GHz (wavelength=150mm), 0,75λ at 3 GHz (wavelength=100mm) and 1λ at 4 GHz (wavelength=75mm). It shows that In the same spacing from adjacent sides of elements (15mm or the total spacing=75mm) resulted difference spacing relative to the wavelength. It means that higher operating frequency in broadband antenna will increase spacing between element relative to the wavelength at certain frequency. It can effect on the total array pattern performance especially for side lobe level performance. Different spacing and different number of antenna element has different properties in each operating frequency.

IV. CONCLUSION

This paper studies the effect of Vivaldi element antenna from each frequency to the total array pattern. Broadband antenna could have different element pattern in different operating frequency. It depends on it's geometry of the radiating element and substrate. Antenna element could have asymmetry radiation pattern, high sidelobe and backlobe especially for frequency far from the center frequency. It will impact on the total array pattern. It makes backlobe or peak side lobe level of the total array pattern more than main lobe level. In coplanar Vivaldi antenna, current distribution propagate in the middle between two exponential tapered slot. Width of the substrate in Vivaldi antenna will interfere spacing between element in array configuration. Increasing spacing of antena element can not improve gain. It reduces slighty of HPBW and increase peak side lobe level. More number of antennas will create higher gain, smaller HPBW, higher peak of side lobe level of the total array pattern and increase number of side lobe. Operating frequency in broadband antenna will influence spacing between element. it can effect on the total array pattern performance. From simulated result shows that good performance of total array pattern can be reached for frequency 3 GHz, 4 GHz and 2 GHz repectively. It is consider that if we want to design array antenna from broadband antenna, it must be better to know the element pattern in each operating frequency.

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REFERENCES

[1] R.L. Haupt, "Antenna Arrays A Computational Approach, Approach-Wiley-IEEE Press, 2010

[2] S.F. Maharimi,M.F, M.F.A. Malek and S.C.Neoh, "Impact of Number Elements On Array Factor in Linear Arrays Antenna," IEEE 8 th International Colloqium on Signal Processing and its App, 2012.

[3] Nurhayati,E.Setijadi.G.Hendrantoro,"Comparison Study of S-Band Vivaldi-Based Antennas," IEEE Region 10 Symposium (TENSYMP) Bali, 2016

[4] A.M. De Oliveira, M.B. Perotoni, S.T. Kofuji and J.F. Justo, "A Palm Tree Antipodal Vivaldi Antenna With Exponential Slot Edge for Improved Radiation Pattern," IEEE Antenna And Wireless Prop Letters, Vol 14, 2015.

[5] N.Ardelina, E.Setijadi, P.H.Mukti," Comparison of Array Configuration for Antipodal Vivaldi Antenna,"ICRAMET, 2015

[6] J. B. Yang, S. Gogineni, B.C. Raga and J.Brozena, " A Dual-Polarized 2–18-GHz Vivaldi Array for Airborne Radar Measurements of Snow," IEEE Trans on Antenna and Prop, vol.64, No.2, Feb 2016

[7] S. Kasturi, D.H. Schaubert, "Effect of Dielectric Permittivity on Infinite Arrays of Single-Polarized Vivaldi Antennas," IEEE Transactions On Antennas and Prop, vol. 54, No.2, Feb 2006.

[8] R. J. Allard and H. Werner, "Radiation Pattern Synthesis for Arrays of Conformal Antennas Mounted onArbitrarily-Shaped Three-Dimensional Platforms," IEEE Trans on Antenna and Prop, vol 51, no 5, May 2013.

[9] H. Oraizi and M. Fallahpour," Nonuniformly Spaced Linear Array Design For The Specified Directivity/Sidelobe Level With Coupling Considerations," PIERS, vol 4,p. 185-209, 2008.

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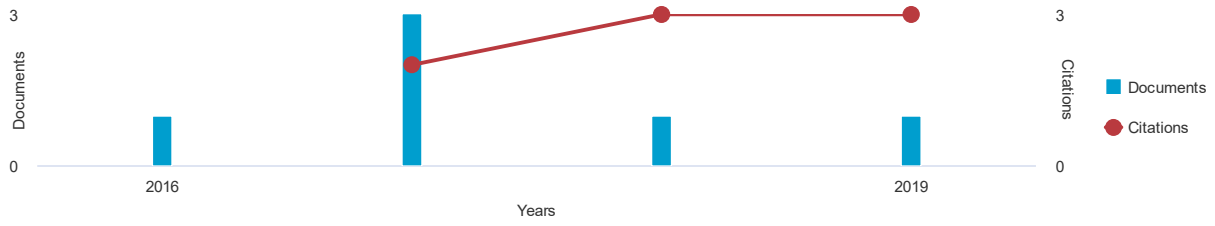

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