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OPENING SPEECH

TENSYMP GENERAL CHAIRS



Distinguished ladies & gentlemen.

Representing the organizing committee of the 2016 IEEE Region 10 Annual Symposium (TENSYP 2016), we would like to express our deep gratitude, to the researchers, paper authors, and all the participant of TENSYP 2016. Welcome to Bali Island in Indonesia!

Our special appreciations to our keynote speakers:

- ∞ Prof. Kukjin Chun
- ∞ Prof. Benjamin Wah
- ∞ Prof. Rod van Meter
- ∞ Prof. Soegijarjo Soegidjoko
- ∞ Dr. Basuki Yusuf Iskandar

Also many thanks to the Director of the IEEE Region 10 – Dr Ramakrishna Kappagantu – and all other officers of Region 10 who also attend this conference, while holding a Regional meeting co-located to this conference. Thank you for the opportunity given to us to carry out the TENSYP 2016.

Also thanks for the IEEE Indonesia Section Chair, Mr Satriyo Dharmanto; and all officers of Indonesia Section, for the support given to organize this conference. Thanks for Prof Gamantyo Hendratoro, the TPC Chair; and all other TPC member of the conference.

TENSYP is the second flagship conference belongs to the IEEE Region 10. The other is TENCON, which Indonesia Section has also hosted here – around the Sanur Beach, Bali – in 2011.

TENSYP is relatively new, indeed. This is only the fourth TENSYP. It is the duty all of us to grow this new conference series, to serve our contribution to the development, progress and welfare of countries in the Asia-Pacific region by disseminating technological knowledge and experience. Happily we announce that there were almost 213 papers submitted to the conference this year, of which only 96 papers were accepted, and about 75 were registered to be presented here.

Our region in Asia Pacific is the arguably de facto centre for the ICT research, development, and industry. Digital devices, services and applications proliferate in unprecedented growth. Only a small number will become success stories, anyway. The others, despite their idealistic technical plan, will succumb the poor access to technology, market, community, or investment.

It is indeed out duty as a community to arrange a coherence among those technologies, infrastructures, and business opportunities, to accelerate our common growth toward a digital society.

Other big challenges are to develop and deploy our technology in meaningful ways – in real applications to enhance the value of human life. This is our expectation when the we chose the topic of TENSYP this year: Smart Computing, Communications, and Informatics of the Future. While we carry out deeper researches on those smart services and platforms; we keep in mind that our works are to enhance the quality of life.

So, thanks again for your attendance and participations. All the best for you; all the best for the profession.



TENSYP 2016 General Chairs,
Ford Lumban Gaol, SM IEEE
Kuncoro Wastuwibowo, SM IEEE

OPENING SPEECH

TENSYMP TPC CHAIR



It has been an honor and a great experience for me to chair the TPC for 2016 TENSYPMP, which was inundated with lots of manuscripts of high quality. Over 213 papers 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 process produced at the end a set of fine scientific papers, which are presented in the conference and collected in the conference proceeding. The papers are almost uniformly spread over the conference tracks, the classification of which reflects the hierarchy with which we work, either in the industry or in the research fields: Architecture, Building Blocks, Critical Aspects, and Smart Applications.

It is our expectation in the TPC that these papers could contribute significantly to the progresses in science and technology and that the conference could facilitate the dissemination of the knowledge presented in the papers to a wide audience,

triggering further discussions and endeavors into better life for humanity.

Beside the papers, the conference also proudly hosts a number of prestigious tutorials and workshops. The topics vary from fog computing for IoT to green telecommunications to social value engineering, presented by experts in the corresponding fields. We think that this variety in tutorial topics reflect the diversity of interests among the participants of the conference.

The TPC wish that the diverse presentations could make the 2016 TENSYPMP beneficial for the research cycle in progress. The high quality technical papers and tutorials would not be possible without the greatest help from the reviewers as well as the support from the organizing committee, to whom the TPC are grateful. Finally, we wish all of you enjoyable atmosphere and productive discussions along the whole conference.

TENSYPMP 2016 TPC Chair,
Gamantyo Hendrantoro, SM IEEE

OPENING SPEECH

IEEE REGION 10 DIRECTOR



Welcome to the IEEE Region 10 Symposium (TENSYP) 2016 – one of the flagship conference belongs to the IEEE Region 10.

Our Region 10 consists of a large geographical area; spreading from Japan to Pakistan to New Zealand; including some most populous countries in the world. This region is arguably the most dynamic region, and still evolve to be more dynamic, in term of technological development and industry. This is the reason that we established TENSYP, our second flagship conference after TENCON.

TENSYP was started in 2013. Since that time TENSYP has become firmly established as a major regional and international activity, and is now an annual event. It is normally organized in 2nd quarter (March-June) of every year, addressing the cutting-edge engineering and technology research and development, in relevance to countries in the Asia-Pacific region.

With TENSYP, IEEE Region 10 aims:

- ∞ To provide a prestigious international forum for specialist presentations and interactions in one or more areas of Electrical, Electronics, Computer and Information technology through papers, exhibitions, plenary talk, tutorials, and other activities;
- ∞ To contribute to the development, progress and welfare of countries in the Asia-Pacific region by disseminating technological knowledge and experience.

- ∞ To encourage the study and discussion of technology and technological applications in a broad social, political and human context;
- ∞ To polish and boost the interpersonal and professional skills of volunteers with the guidance of leaders and the renowned personalities in the respective field of Engineering & Technology.

I would like to deeply appreciate the IEEE Indonesia Section, who this year organizes and carries out the TENSYP in Sanur Beach, Bali Island.

Congratulations to the Section Chair, Mr Satriyo Dharmanto, and all officers in Indonesia Section, Chapters, and Student Branches. Many thanks and appreciations to the General Chairs of this conference: Dr Ford Lumban Gaol, Mr Kuncoro Wastuwibowo; the TPC Chair Prof Gamantyo Hendranto; and all the volunteers, committee members, and reviewers of the conference. Great thanks to the keynote speakers, tutorial presenters, paper authors, and all participants of TENSYP 2016.

IEEE is an organization established by the engineers, and it is the home of engineers to work in partnership and collaboration to enhance the dynamics and quality of our researches, out academic and professional works, for our mission to advance the technology for humanity. We welcome all engineers, from the universities and the industry, to explore this organization. Let's make more exquisite outcomes, resulting from the synergy of the engineers from academy and business.

Again, congratulations to you all. Have your best time here, under the relaxing weather of Indonesia,

to discuss your ideas, to arrange warm networking sessions.



IEEE Region 10,
Ramakrishna Kappagantu, Director

OPENING SPEECH

IEEE INDONESIA SECTION CHAIR

Dear colleagues, Professors, lecturers, researchers, ICT professionals, ladies and gentlemen.

On behalf of IEEE Indonesia section, I would like to express my sincere gratitude and welcome you to the IEEE Region 10 Symposium (TENSYP) 2016. Thank you to the opportunity to organize this conference.

This conference is quite significant with the current situation in Indonesia, because currently the development of ICT infrastructure is one of the most growing infrastructures in the country. The development of Social media, and its application is become the most active communication tools.

Based on International Data Corporation, Indonesia has become the largest spender on ICT in South East Asia and is ranked 19th by spending globally. This is related to the Indonesia ICT Development Target in National Midterm Plan 2015 – 2019, that Indonesia has ambitious plans and strategies to accelerate the economic development through ICT infrastructures.

Furthermore, Indonesia Government seriously work together with the ICT Stakeholder, to complete the development of a critical hub to the Sub-Districts and Villages in Indonesia, named Palapa Ring, to connect 34 provinces and 440 cities/districts, stitching a circumference of 36,000 km fiber optics.

The Palapa Ring could easily provide Network Transit for Asia and Pacific Region, between the Indian and Pacific Oceans and the three Continents (Asia-Australia-Americas). It would be easy to access our neighboring ASEAN countries, Singapore, Brunei Darussalam, Malaysia, Philippines, and Thailand.

The three major global internet technology companies such as Microsoft, Google and Facebook are trying to approach with quite different technology, to enabling Internet for All last-mile connectivity in the developing country like Indonesia. Google is researching a solution called Project Loon. Facebook is experimenting with solar powered drones. And Microsoft is researching the use of TV whitespaces, IEEE 802.22, wireless regional area network.

The government is standing at their key position in the serious discussion with Google, for the partnering with three of Indonesia's biggest telecom companies, Telkomsel, XL Axiata, and Indosat Ooredoo, for a country-wide test period of Loon project, starting next year.

Google Loon project that began in 2011 as part of Google X, Alphabet's secretive "moonshots" lab is one of the ambitious initiative project to bring balloon-delivered internet access, to remote areas and developing countries that not covered by internet yet.

Indonesia marks the fourth country behind Brazil, New Zealand, and Australia in which Loon will fly its balloons more than 12 miles in the sky to beam down internet access, to any LTE-capable smartphone.

If we refer to the World Bank, technological progress is a considerable driving force behind economic growth, citizen engagement and job creation of the country.

Information and communication technologies, in particular, are reshaping many aspects of the world's economies, governments and societies. In developing countries, public officials, businesses and citizens are working together to harness the transformative power of ICTs to make services more efficient, catalyze economic development and strengthen social networks.

Based on ITU, currently there are more than 7 billion mobile cellular subscriptions worldwide, corresponding to a penetration rate of 97%. In Indonesia currently have about 250 million mobile cellular subscriptions, with penetration rate about 105%. Currently, 4G network has been initially implemented in several cities in Indonesia.

Mobile broadband penetration worldwide reaches 47% in 2015, a value that increased 12 times since 2007 and in Indonesia reaches 37%, about 88 million people using internet in 2015.

The development of wireless communication 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 50 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 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 1,600 annual conferences, worldwide.

IEEE Indonesia section, which is a part of IEEE global, has already been established for 28 years. It currently has about 1,500 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 7 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, Consumer Electronics Chapter and Social Implication of Technology Chapter.

Moreover, IEEE Indonesia section also has 4 joint chapters, namely Joint chapter of Microwave Theory / Antennas & Propagation, Joint chapter of Aerospace & Electronics Systems Society / Geoscience & Remote Sensing Society, Joint chapter of Control System Society / Robotics & Automation Society, and Join Chapter of Education Society / Electron Devices Society / Power Electronics Society / Signal Processing Society.

IEEE Indonesia Section has 22 student branches (SB) 4 SB chapters in several universities in Java, Sumatera, Bali and Sulawesi islands and three Affinity Groups, namely Women in Engineering, SIGHT in Telemedicine, and SIGHT in Humanitarian Technology.

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.

Recently, IEEE Indonesia section in collaboration with IEEE ComSoc Indonesia chapter has organized two days 5G training; with the trainer is the one of the worldwide recognized professor in the field of Wireless Communication. We continuing try to serve the members and ICT stake holder in Indonesia, with more technical, education and social activities that make them more benefit with the organization.

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.

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

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.

In this occasion, I would also like to say welcome to Bali, one of the famous destinations in Indonesia. Bali serves beautiful beach, culture, mountain and scenery with warm and friendly people, a vibrant culture and lifestyle.

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.



IEEE Indonesia Section,
Satriyo Dharmanto, Chair

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Comparison Study of S-Band Vivaldi-Based Antennas

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Abstract— This paper focuses on comparison between coplanar Vivaldi antenna, *Antipodal Vivaldi Antenna (AVA)* and *Balance Antipodal Vivaldi Antenna (BAVA)* on FR4 substrate, in the same size and type of substrate and the same opening rate of the exponential taper. The proposed antenna has overall size $1.1\lambda \times \lambda \times 0.016\lambda$ and works in 2-4 GHz. The best return loss has been obtained for BAVA of -47 dB at 2.374 GHz from simulated result. For overall of frequency, coplanar vivaldi antenna gets higher gain than AVA and BAVA. Directivity of coplanar Vivaldi is 7.859 dBi at 4 GHz. AVA has more asymmetric radiation pattern than BAVA. Side lobe level for coplanar Vivaldi antenna has better performance than AVA and BAVA.

Keywords—vivaldi; coplanar; Antipodal; BAVA; S-Band.

I. INTRODUCTION

There are many S Band application such as mobile satellite communication, radar, microwave imaging, medical imaging, health monitoring, telemetry and ground penetrating radars. A novel multiband square spiral ring (SSR) metamaterial-embedded printed Yagi antenna array in the S-band for WiFi, Bluetooth, WLAN, and WiMAX has been implemented at four distinct frequencies [1]. Patch antenna for S band nanosatellite communications has been presented with Four asymmetric V-shaped slits in the diagonal directions on the square patches [2]. Impedance and radiation characteristics of linear tapered structure has been investigated in the S-band and achieved a very wide frequency band, symmetry radiation pattern, and high gain [3]. But in that papers the return loss not accopy overall frequency in S Band application (2-4 GHz) and It has more area geometry.

One of the famous directional antenna using horn antennas, but horn antenna is too bulky and has more volume area. Vivaldi element is a broadband and directional antenna can be applied in bandwidth 3.4 to 7 GHz [4]. Vivaldi antenna was directional antenna that introduced by Gibson [5]. In that paper, antenna works in UWB frequency and just presented one type of antenna that is called coplanar Vivaldi. Vivaldi antenna has significant gain, with directional radiation pattern, planar structure, less volume than horn antenna, easy to fabricate and low cost.

Another types of Vivaldi antenna is Antipodal Vivaldi Antenna (AVA). Palm Tree with Exponential Slot Edge Antipodal Vivaldi Antenna is designed for main lobe gain improvement[6]. Wideband Antipodal Vivaldi antenna to improve radiation pattern [7]. Parametric study Dual elliptically Tapered Antipodal Slot Antenna is investigated for UWB [8]. Many technique and many application single element of AVA by modification size of geometry or adding corrugate edge has been recently presented to get performance of radiation pattern. Single element Antipodal Vivaldi Antenna, two and four elements of Vivaldi antenna array in planar and H plane have been compared [9]. Research about Antipodal Vivaldi antenna single and array has drawn great investigated.

Antipodal Vivaldi Antenna (AVA) can reach wider bandwidth than coplanar vivaldi. But it accomplished of cross-polarization as the frequency of operation is increased. To get the better performance of this problem, by build on another dielectric layer namely Balanced Antipodal Vivaldi Antenna (BAVA) can improve the performance [10]. Dielectric Lens BAVA introduced can increase radiation pattern performance and cross-polarisation [11].

All those characteristics of vivaldi is accepted for broad band frequency. Performance of Vivaldi is responsive by varying the geometry parameters of the radiators and feeding. In conventional Vivaldi antenna without corrugate or without adding several tehniques, the significant of wave propagation is between two inner exponential tapered generally in the slotline to the beginning of tapered slot antenna. The completion of the antenna is very dependent on exponential tapered. From above discussion, there were papers that only discuss one type Vivaldi antenna due to the effect of major geometrical parameters and none of three types of antenna are compared collectively. This paper investigates comparison of Coplanar Vivaldi Antenna, AVA (Antipodal Vivaldi Antenna) and BAVA (Balanced Antipodal Vivaldi Antenna) in the same size and type of substrate, in the same opening rate of exponential flare and in the same width of feeding. Three Vivaldi antenna works in S Band (2-4) freequency. This paper presents performance of return loss, VSWR, polar radiation pattern, gain, side lobe level from simulated result of three Vivaldi antenna.

This paper is systematized as Section I introduction, Section II discusses design of the antenna, Section III presents the simulated result and discussion and section IV is Conclusion

II. DESIGN OF THE ANTENNA

Vivaldi antenna is designed on a FR4 substrate with a dimension of $1.1\lambda \times \lambda \times 0.016\lambda$. Vivaldi antenna are defined as three part: patch, substrate and groundplane. Substrate has relative dielectric constant $\epsilon_r = 4.3$, loss tangent $\tan \delta = 0.002$, substrat height 1.6 mm and copper height 0.035

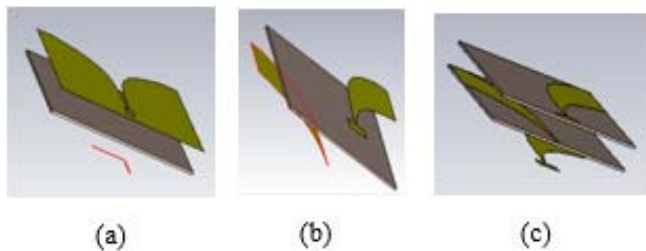


Figure 1. (a) Coplanar Vivaldi (b) AVA (c) BAVA

Fig.1 shows differences between Coplanar Vivaldi Antenna, Antipodal Vivaldi Antenna (AVA) and Balanced Antipodal Vivaldi Antenna (BAVA). Coplanar Vivaldi Antenna only have one radiated layer on the top of substrate and feeding in the bottom side. Antipodal Vivaldi Antenna (AVA) has two radiated layer on the top and bottom side with opposite direction Balance Antipodal Vivaldi Antenna(BAVA) has three radiated layer on the top, middle and bottom and separated by two substrate. The exponential taper is determined by the opening rate (R), point (x_1, y_1) and (x_2, y_2) for inner edge of exponential taper and (x_3, y_3) , (x_4, y_4) for outer edge of tapers and it can be defined as

$$y = C_1 e^{Rx} + C_2 \quad (1)$$

$$C_1 = \frac{y_2 - y_1}{e^{Rx_2} - e^{Rx_1}} \quad (2)$$

$$C_2 = \frac{y_1 e^{Rx_2} - y_2 e^{Rx_1}}{e^{Rx_2} - e^{Rx_1}} \quad (3)$$

R is exponential opening rate, C_1 and C_2 is denoted as constant that is related with equation (2) and (3). Where x_1, y_1 shows the beginning coordinates of opening rate and x_2, y_2 shows the end point of opening rate (R). Increasing value of R will diminish of mouth opening Vivaldi antenna. Smaller value of R will expand of mouth opening. The slope of opening rate also depends on position of x_1, y_1 and x_2, y_2 . While for Antipodal Vivaldi Antenna(AVA) and Balanced Antipodal Vivaldi Antenna (BAVA), the outer edge tapers build depend on x_3, y_3 and x_4, y_4 coordinat as shown in figure 2.b

Coplanar Vivaldi

$$x_1 = b - d \quad y_1 = \frac{a}{2} - \frac{c}{2} \quad (4)$$

$$x_2 = b \quad y_2 = \frac{a}{2} - c \quad (5)$$

AVA/BAVA

Inner edge taper

$$x_1 = b - d \quad y_1 = \frac{a}{2} - \frac{c}{2} \quad (6)$$

$$x_2 = b \quad y_2 = \frac{a}{2} + \frac{c}{2} \quad (7)$$

Outer edge taper

$$x_3 = b - d \quad y_3 = \frac{a}{2} - \frac{c}{2} \quad (8)$$

$$x_4 = b - h \quad y_4 = 0 \quad (9)$$

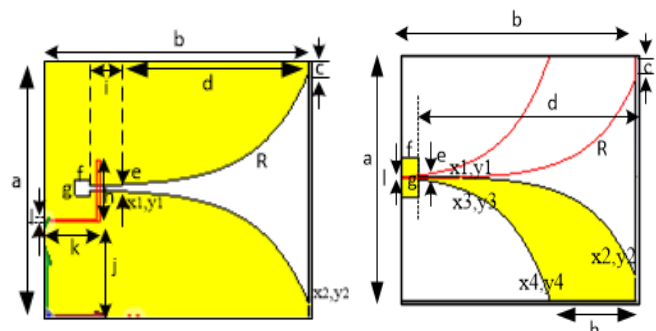


Fig. 2. (a) Geometri Vivaldi (b) Geometri AVA and BAVA

Fig 2a. Shows coplanar Vivaldi antenna on the top view and fig 2b shows Antipodal Vivaldi Antenna(AVA) and Balanced antipodal (BAVA) on the top view. Difference types of AVA and BAVA can be shown in fig 1b and 1c. An optimal structure parameters are obtained as follows in Table.1.

Table 1. Dimension Of Design Parameters

Parameter	Coplanar (in mm)	AVA (in mm)	BAVA (in mm)
a	110	110	110
b	100	100	100
c	7.5	7.5	7.5
d	72	98	98
e	1.1	1.5	1.5
f	6	8	8
g	6	16	16
h	27	-	-
i	16	-	-
j	36	-	-
k	28	-	-
l	1.5	1.5	1.5
R	0.05	0.05	0.05

Table 1 presents the optimal parameter result for coplanar Vivaldi antenna, AVA and BAVA. It is shown that AVA and BAVA has identical size. Antenna dimension in a, b, c, k, l and R have the same value for all type of antennas. a and b is width and length of antenna, c and R is parameter that specify opening rate of the antenna and l is width of the feeding.

A. Coplanar Vivaldi antenna

Coplanar Vivaldi antenna has two tapered slots on the same side of the dielectric substrate. Feeding antenna in the opposite of dielectric substrate. Coplanar Vivaldi antenna operates without ground layer. Bandwidth of the antenna is purposeful by configuration of feeding, geometry of cavity, substrate size, and exponential opening rate. All of that parameter will influence the return loss performance. Bandwidth for Vivaldi antenna can be indicated with a half of comparison high frequency by lower frequency and it is related with comparatively of length and width of the substrate with the equation:

$$b/a \sim 0.5 \ln(l/a_0) \quad (10)$$

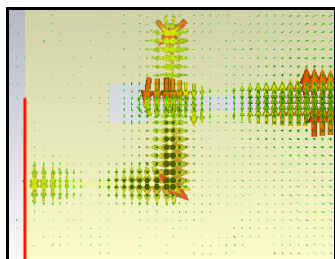


Fig. 3. E Field Coplanar Vivaldi antenna

Fig. 3 shows E Field Coplanar Vivaldi antenna. We can see that wave will propagate in slotline and between two inner edge taper. It shows linear polarization in the feed line and in the slotline between two inner exponential taper. Balun is the region where the unbalanced feed line into a balanced slotline to the exponential tapered. Cavity is rectangular shape of the beginning slotline

B. AVA and BAVA

Antipodal Vivaldi Antenna (AVA) is one kind of Vivaldi antenna that consists of two copper radiator in the top and bottom side of the antenna substrate. AVA only has one layer of substrate. The two radiators are symmetry in the center width of substrate in the opposite direction. One part radiator behaves as ground. In AVA, electromagnetic field will be radiated in slotline because there is transition radiated wave from one part of radiated layer to another side which is separated by one dielectric substrate. Dimension of exponential radiator and ground will effect return loss and radiation pattern performance.

BAVA consists of three copper layers and separated by two dielectric substrats. One of the radiated layered in the middle side has opposite direction with two radiated layered in the top and in the bottom side. Top and bottom radiated layer

have the same direction. BAVA antenna can reduce the crosspolarisation compared with AVA because the ratio of slot width to dielectric thickness is large especially for low frequency.

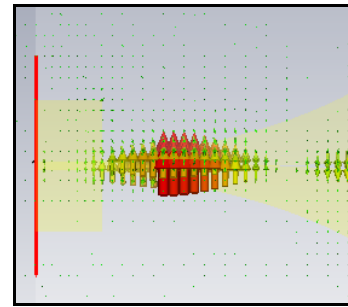


Fig. 4. E Field feeding AVA/BAVA antenna

Figure 4 shows E field polarization for AVA/BAVA antenna. Polarization is defined as the orientation of electric field component to the plane that contains waveform. We can see from figure 4 AVA and BAVA has linear polarization and wave will propagate in the middle of two tapered slotline.

III. SIMULATED RESULT AND DISSCUSSION

A. Return Loss (S11) and VSWR

Return loss (S11) indicates how matched an antenna to the input transmission line. Return loss is parameter in decibel unit that related with ratio reflected power to incident power. The best return loss is below -10 dB and it is related to reflection coefficient and Voltage Standing Wave Ratio. Good return loss indicated good impedance matching and wave will be radiated perfectly to free space. Simulated result of reflection coefficients (S11) coplanar Vivaldi antenna, AVA and BAVA are shown in fig.5.

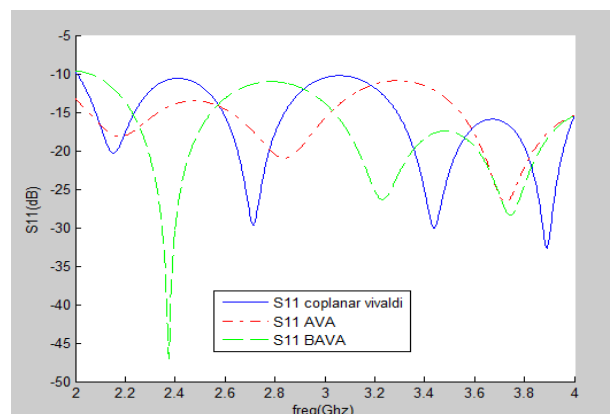


Fig 5. Simulated Return Loss S11 (dB) vs frequency (GHz)

Fig.5 presents the return loss of three antennas. Antennas are designed in the same dimension of substrate, same opening rate, same material and operate over 2 to 4 GHz. It shows that the return loss is good and less than -10 dB in desired frequency range. The best return loss has been obtained for

BAVA is -47 dB at 2.374GHz and the second for coplanar Vivaldi antenna is -32.68 dB at 3.89 and the third return loss for AVA is -26.755 dB at 3.76 GHz. Bandwidth Vivaldi antenna can be categorized as broad band antenna because fractional bandwidth of antenna more than 0.2 and it can be denoted by

$$FBW = 2 \frac{f_H - f_L}{f_H + f_L} > 0.2 \quad FBW = 2 \frac{4 - 2}{4 + 2} = \frac{4}{6} = 0.67 > 0.2 \quad (11)$$

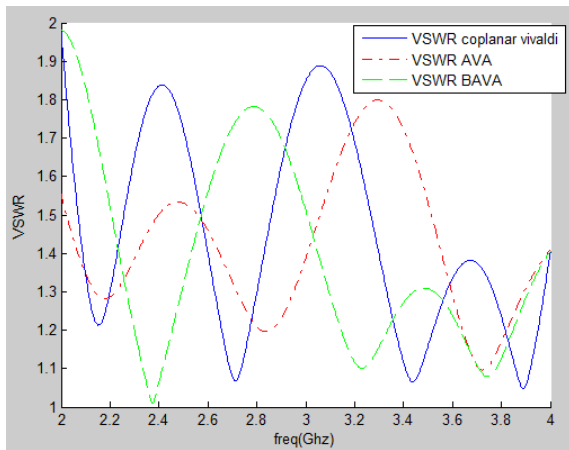


Fig. 6. Performance simulated VSWR

Fig 6. Shows VSWR of three antennas. It is indicating that in the frequency range 2-4 GHz, antenna has VSWR less than 2. The best VSWR is obtained for BAVA at 2.374 GHz as 1.0089

B. Radiation Pattern

A valuable parameter for identify the performance of an antenna is gain. 3D radiation pattern at 3 GHz of the proposed Antenna is shown in fig.7. Vivaldi antenna has directional radiation pattern with stable radiation.

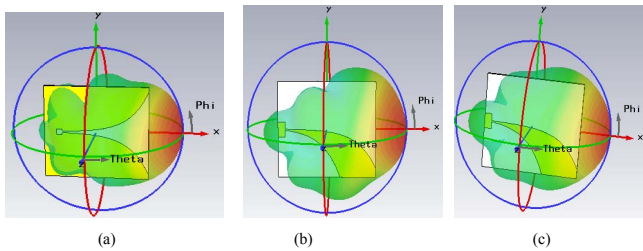


Fig. 7. 3D Radiation pattern at 3 GHz

Fig.7 depicts gain for coplanar Vivaldi antenna as 7.300 dB or directivity of coplanar is 7.859 dBi. gain for AVA is 6.281 dB or directivity of AVA is 6.698 dBi and gain for BAVA is 6.345 dB or directivity of BAVA is 6.907 dBi. That's value is shown from simulated result. It can show that highest gain is given by coplanar Vivaldi antenna and BAVA has better gain compared with AVA at frequency 3 GHz in the same size of geometry, same type of substrat and the same opening rate.

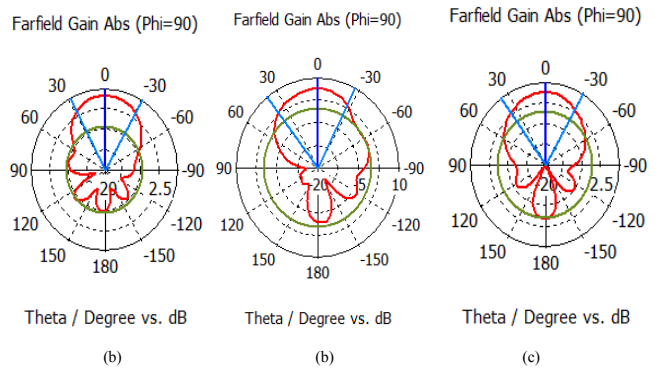


Fig.8. Simulated radiation patterns theta 90
(a) coplanar (b) AVA (c) BAVA

Fig. 8 shows polar plot for theta 90 with angle step width phi. From radiation pattern in fig.8 at 3 GHz, coplanar Vivaldi antenna has smaller side lobe than AVA and BAVA. From polar plot, AVA has asymmetric radiation pattern and BAVA has more symmetric radiation pattern than AVA in the same model. From simulated result, Angular width (3dB) coplanar Vivaldi antenna is 58.7 deg with side lobe level -11.4 dB. Angular width(3dB) AVA shows 66.3 deg with side lobe level -6.7 dB. Angular width(3dB) BAVA is 66.8 deg with side lobe level -7 dB. From that result we can make conclusion that in polar plot for theta 90 degree, coplanar Vivaldi antenna has the best angular width and side lobe level. And BAVA has better angular width and side lobe level than AVA.

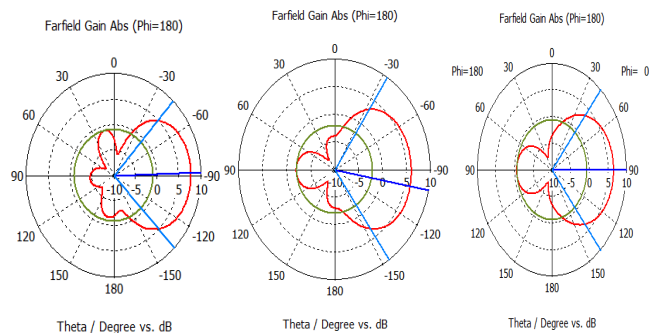


Fig. 9. Simulated radiation patterns Phi 180
(a) coplanar (b) AVA (c) BAVA

Fig.9 presents polar plot for phi 180 with angle step width theta in XYZ coordinates. From simulated result, angular width(3dB) of coplanar Vivaldi antenna is 100.2 deg with side lobe level is -9.2 dB. AVA shows angular width(3dB) is 111.6 deg. with side lobe level -8.2 dB. BAVA shows angular width(3dB) 103.7 deg with side lobe level -7 dB. From that result, for phi 180 degree coplanar Vivaldi antenna gets the best angular width(3dB) and side lobe level. And angular width(3 dB) of BAVA better than AVA. But sidelobe level of AVA better than BAVA.

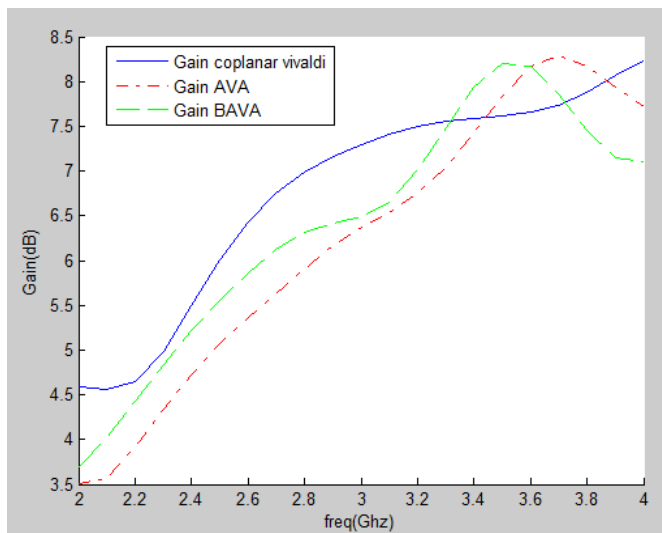


Fig. 10. Gain Vivaldi Antenna

Maximum gain can be observed in Fig.10 and it shows a rising trend across the frequency range especially for coplanar Vivaldi antenna. Gain for coplanar Vivaldi improve from 4.56 to 8.224 dB over the operating frequencies 2-4 GHz with the max gain 8.224 dB. Gain for AVA increase from 3.50 to 7.72 dB with the max gain 8.286 dB at frequency 3.59 GHz. Gain for BAVA go up from 3.59 to 7.667dB with the max gain 8.103 dB. From fig.10 we can see that in frequency 2 – 3.3 GHz, for the same size and types of substrate and the same opening rate, maximum gain is reached by by Coplanar Vivaldi antenna , BAVA, and AVA respectively. But for frequency 3.3-3.9 GHz maximum gain is reached by AVA in 3.59 GHz of 8.286 dB

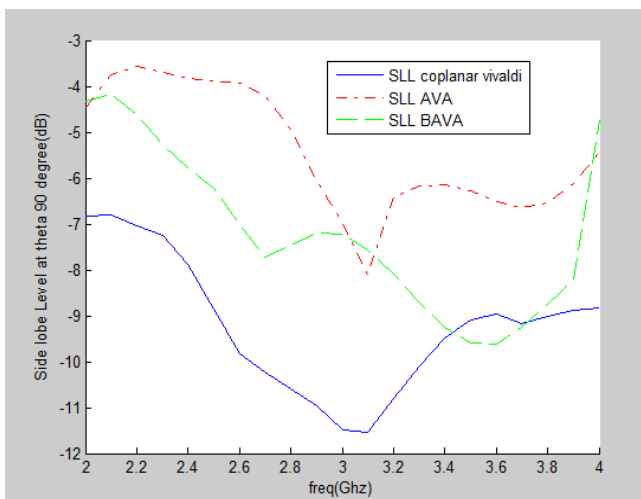


Fig. 11. Side Lobe Level at theta 90 degree

Besides gain, sidelobe level is used to characterize radiation patterns. Sidelobes are smaller beams that are away from the main beam. These sidelobes are usually radiation in avoid directions, because it will decrease mainlobe. As demonstrated in fig.11 Side lobe level Coplanar Vivaldi antenna is better than AVA in all frequency, and BAVA has better Side Lobe Level than AVA in overall frequency.

Table 2. Comparisan radiation pattern at 3GHz

Vivaldi Antenna	Coplanar	AVA	BAVA
f (GHz)	3	3	3
Rad.effic (dB)	-0.5588	-0.4169	-0.5623
Total.Effic (dB)	-0.9626	-0.5330	-0.7467
Gain(dB)	7.300	6.281	6.351
Farfield Gain Abs (Phi=180)			
Angular width(3deg)	100.2	111.6	103.9
Side lobe level(dB)	-9.2	-8.2	-7
Farfield Gain Abs (Theta=90)			
Angular width(3deg)	58.7	66.3	66.8
Side lobe level(dB)	-11.4	-6.7	-7

Table.2 shows the comparison 3D radiation pattern and Polar plot XYZ coordinates for coplanar Vivaldi, AVA and BAVA. It can be observed, at phi 180 degree, coplanar vivaldi antenna has smallest angular width (3dB) and followed by BAVA and AVA respectively. From the table coplanar has better side lobe level than AVA and BAVA

Table 3. Comparison in S-Band frequency (2-4GHz)

Vivaldi Antenna	Coplanar	AVA	BAVA
Return Loss	-32.6 dB at 3.89 GHz	-26.75dB at 3.76 GHz	-47,00 dB at 2.374 GHz
VSWR	1.047 at 3.89 GHz	1.096 At 3.89 GHz	1.008 At 2.374 GHz
BAVA is best in return loss and VSWR			
Gain (dB)	8.224 dB at 4 GHz	8.286 dB At 3.7 GHz	8.104 dB At 3.5 GHz
AVA is highest gain But for general of frequency Coplanar Vivaldi antenna is the best gain from 2 –3.3 GHz			
Side lobe level	-11.535dB at 3.1 GHz	-8.080 dB At 3.1 GHz	-9.627 dB At 3.6 GHz
Coplanar is good performance in Side Lobe level at phi 90 degree			

Table 3. presents comparison Return loss, VSWR, Gain and Sidelobe level for three Vivaldi antenna. BAVA shows the best return loss and VSWR. AVA and BAVA attain wider bandwidth than coplanar Vivaldi antenna. Although AVA gets best gain in 3.7 GHz, but long term of frequency coplanar is the best gain and side lobe level.

Table 4. Comparison references paper

Ref	Types of antenna	freq(GHz) S11<-10dB	Size (mm)	Gain	
1	Yagi array Square spiral Ring	S Band	2.79	140x61	10.6 dB
			3.86		5.26 dB
			4.01		6.7 dB
2	Patch with four asymmetric V shaped slits	S Band	2.245- 2.307	80x 80	7.29 dBi
3	Linear Tapered Antenna	S Band	1.3 - 2.65	385 x 300	12 dB
4	Coplanar Vivaldi	UWB	3.4-7	112x40	7.4 dB
6	AVA		5.6-11	36.3x59. 81	8.3 dB
7	AVA		6-18	31.2x45	8.4 dB
8	AVA	UWB	4-20	75x51	10 dB at 10GHz
9	AVA	S- Band	3.04-4	120.3- 87.2	5.287 dBi
10	Coplanar Vivaldi	UWB	3.5- 10.6	123.51 x 96.77	-
11	BAVA	UWB	3-18	96x50	4-13dB

In table.4 Reference [1],[2] antenna not accopy all S Band frequency. Reference [3] used linear tapered antenna and has larger size than our design. Reference [4][6][7][8] not accopy all S-Band (2-4 GH) but it is started operating in higher frequency than our design (more than 3 GHz) so it has smaller geometry area. Reference [9] has less gain than our design. Reference [10] gain not presented and it work in UWB frequency from 3.5 GHz for return loss <-10 dB. Reference [11] with smaller size and started from 3GHz. All those paper just compared only one type of Vivaldi antenna due to the effects of major geometrical parameters and none of those compared three types of antenna collectively. in the same size, type of substrate and the same opening rate of flare.

IV. CONCLUSION

Comparison study between coplanar Vivaldi antenna, *Antipodal Vivaldi Antenna* (AVA) and *Balance Antipodal Vivaldi Antenna* (BAVA) on FR4 substrat with a dielectric constant of 4.3 in the same size, same type of substrate and the same opening rate of the exponential taper has been presented. Coplanar vivaldi antenna, AVA and BAVA has good radiation and reflection characteristics in S-Band frequency band. The best return loss has been obtained for

BAVA -47 dB at 2.374 GHz and the second for coplanar Vivaldi antenna -32.68 dB at 3.89 and the third return loss for AVA -26.755 dB at 3.76 GHz. Three element antenna has VSWR lower than 2. Although AVA gets best gain in 3.7 GHz, but from long term of frequency coplanar is the best gain. Gain for coplanar vivaldi antenna is 7.300 dB or directivity of coplanar 7.859 dBi. From polar radiation pattern at phi 180 degree and theta 90 degree, coplanar Vivaldi antenna has smaller side lobe than AVA and BAVA. AVA has more asymmetric radiation pattern than BAVA. Side lobe level for coplanar Vivaldi antenna better than AVA. Thus this paper can be references which type of Vivaldi antenna with the best performance to our S band Application. Furthermore there is still room for improvement vivaldi performance and compared it performance with measurement result.

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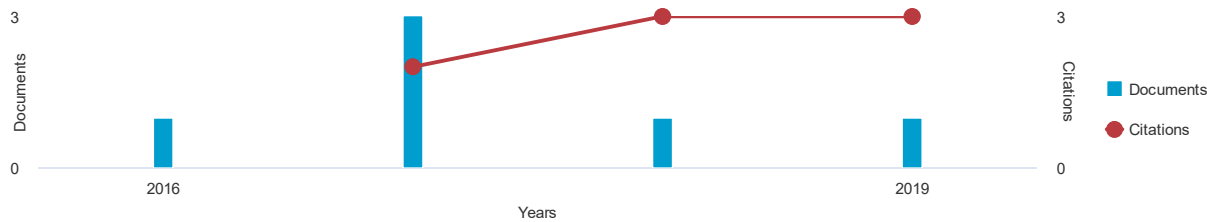
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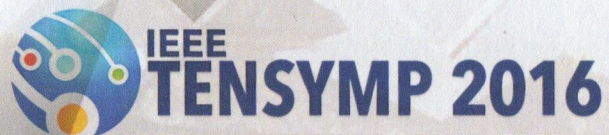
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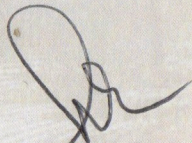
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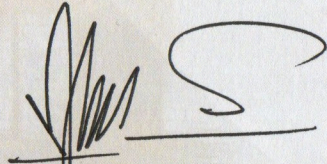
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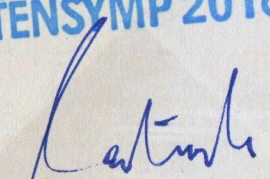


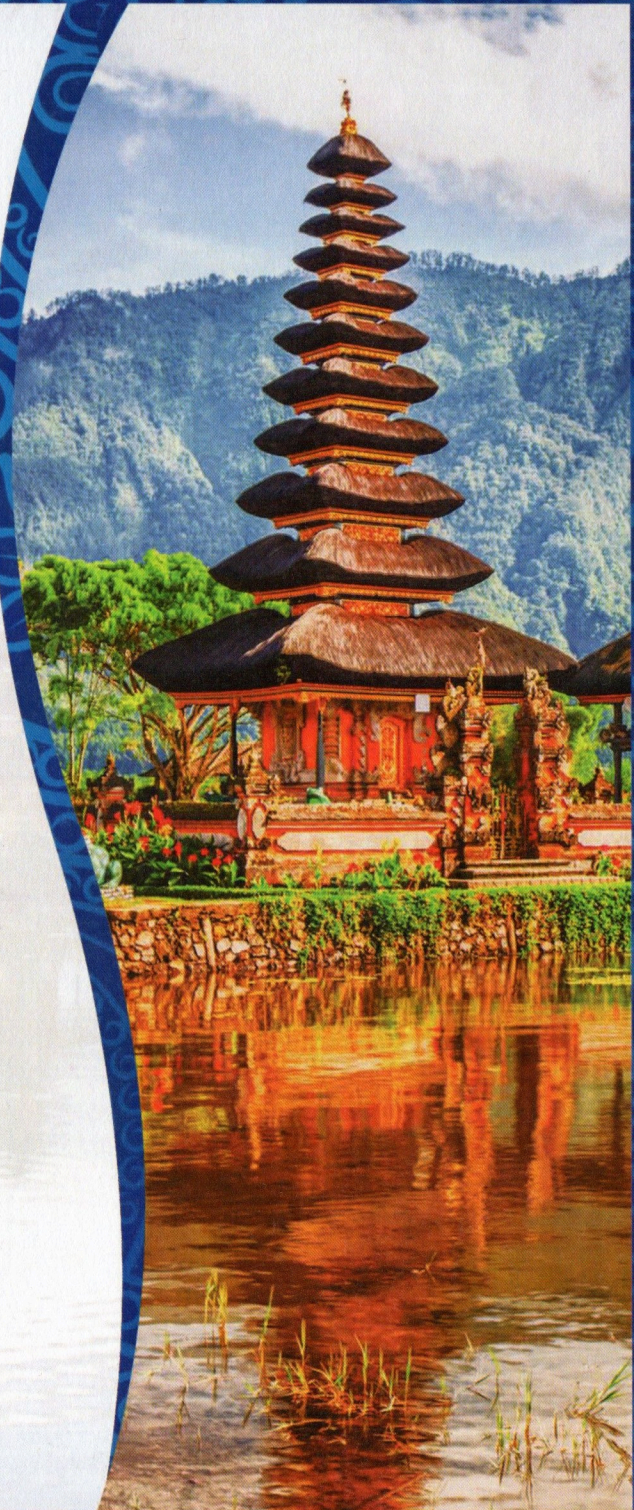
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