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Design of a Broadband Biconical Antenna with Sleeve Balun for Improving Radiation Pattern

Graduate School of Chosun University

Department of Electronic Engineering

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요 약

방사 패턴 개선을위한 슬리브 발룬이있는 광대역 생체 안테나 설계

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광대역 통신 시스템은 더 높은 데이터 속도로 더 많은 정보를 제공 할 수있는 기능을 갖추고있어 매일 더 까다로워집니다. 무선 통신 시스템에 대한 지난 몇 년간 광대역 안테나에 대한 관심이 높아지고 있습니다. 지난 10 년 동안 광대역 안테나에 대한 많은 연구가 진행되었습니다. 전 방향 특성으로 인해 간단한 구성 및 광대역 주파수 응답 바이 코니 컬 안테나가 광대역 통신에 광범위하게 사용됩니다. 유한 안테나는 주파수 의존성을 나타내지 만 유한 안테나는 주파수 독립성을 나타냅니다. 광대역 통신의

경우, 이중 원뿔형 안테나 설계는 여전히 하나의 주요 과제에 직면하고 있습니다. 주파수가 증가하면 안테나의 방사 패턴이 손상되어 결과적으로 안테나의 3dB 빔 폭이 높아질수록 작아집니다 주파수. 이 심각한 문제의 주요 원인은 전체 안테나 구조에서 표면 전류가 고르지 않기 때문입니다. 안테나에 전류를 공급하기 위해 긴 동축 케이블을 사용하는 경우 안테나의 방사 패턴을 왜곡하는 케이블의 외부 실드에 전류가 흐릅니다. 이 현상을 케이블 효과라고합니다. 이전 연구에서 주파수가 증가함에 따라 더 부드러운 방사 패턴이 부족한이 논문은 방사 패턴 안정성으로 3dB 빔폭을 개선하는 데 중점을두고 있습니다. 거의 모든 이전 연구에서 광대역 바이 코니 컬 안테나 설계의이 도전적인 부분은 고려되지 않았습니다. 이 논문에서 제안 된이 원뿔형 안테나는 원뿔, 원통 및 링의 세 부분으로 구성되며, 방사 패턴을 개선하기 위해 링과 원통의 독특한 혼합 된 모양의 가장자리를 도입합니다.

모든 평형 안테나의 경우 평형 피드 "balun"설계의 요구 사항을 충족시키는 것이 매우 중요한 문제입니다. 발룬은 부하와 소스에 최대 전력을 공급할 수 있습니다. 슬리브 발룬은 동축 케이블 공급으로 인한 바람직하지 않은 방사선을 개선하기 위해 특정 주파수에서 동축 공급과 함께 사용됩니다. 그러나 슬리브 발룬은 단일 주파수 만 작동합니다. 여기에서 개별 슬리브 발룬은 서로 다른 주파수에서 작동하도록 설계되었습니다.

이 논문은 3-40 GHz 주파수 범위에서 방사 패턴을 개선하기 위해 슬리브 발룬과 연결된 바이 코니 컬 안테나의 설계를 나타냅니다. 이 이중 원뿔형 안테나는 방사 패턴을 개선 할 목적으로 새로운 원뿔 모양의 내부 실린더 가장자리와 각 원뿔에 링이 있습니다. 안테나의 방사 패턴에서 긴 동축 케이블 공급의 영향을 최소화하기 위해 더 높은 주파수에서는 슬리브 발룬이 특정 주파수로 연결됩니다. 안테나 및 발룬의 모델링 및 시뮬레이션은 CST Microwave Studio 를 사용하여 수행됩니다. 시뮬레이션 된 결과는 3dB 각 빔폭을 갖는 개선 된 E- 평면 방사 패턴이 원하는 3-40 GHz 범위에 걸쳐 101.1 에서 83.3 도로 변하는 것을 보여준다.

Abstract

Design of a Broadband Biconical Antenna with Sleeve Balun for Improving Radiation Pattern

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Broadband communication system has the capability to provide more information with higher data rates which makes it more demanding day by day. In the past few years for wireless communication system, there has been growing interest on broadband antennas. In the past decade a number of studies has been focused on broadband antennas. Due to omnidirectional characteristics, simple configuration and broadband frequency response biconical antennas are extensively used in wideband communications. Infinite size of biconical antennas show the characteristics of frequency dependency while finite size antennas show frequency independency. In case of broadband communications biconical antenna design is still facing one major challenge: the maintenance of constant radiation pattern over a broad frequency band(e.g. several gigahertz and more). With the increasing frequency, the radiation pattern of the antenna becomes corrupted as a result antenna's 3 dB beamwidth becomes smaller at high

frequencies. The major reason behind this serious problem is uneven surface current distribution on the whole antenna structure. When long coaxial cable is used for feeding the antenna current flows on the outer shield of the cable which distorts the radiation pattern of the antenna; this phenomenon is called cable effect. Previous research in lacks the smoother radiation pattern with the increasing frequencies, this paper is focused on improving 3 dB beamwidth with radiation pattern stability. In almost all previous research works, this challenging part of wideband biconical antenna design has not been considered. The proposed biconical antenna of this thesis has three parts: cone, cylinder and ring and it introduces unique blended shape edge of the ring and cylinder to improve the radiation pattern.

For any balanced antenna, to meet the requirement of balanced feed “balun” design is very important issue. Balun can deliver maximum power to the load and the source. Sleeve baluns are used here with coaxial feeding at specific frequencies for the purpose of improving undesirable radiation due to the coaxial cable feeding. However sleeve baluns operate only single frequencies, here, individually sleeve baluns are designed which operates at different frequencies.

This thesis represents the design of a biconical antenna connected with sleeve balun for improving radiation pattern over 3-40 GHz frequency range. This biconical antenna has new blending shaped edge of inner cylinder and ring to each cone for the purpose of improving radiation pattern. At higher frequencies to minimize the influence of the long coaxial cable feeding in the radiation pattern of the antenna, sleeve baluns are connected here at specific frequencies. The modeling and simulation of antenna and baluns is done by using CST Microwave Studio. The simulated result shows improved E-plane radiation pattern having 3-dB angular beamwidth varies from 101.1 to 83.3 degree over desired 3-40 GHz range.

1. INTRODUCTION

1.1 OVERVIEW

At present there is demands for wireless broadband communications are increasing because of the need to produce more information with higher information rates. Broadband antennas are needed to supply wireless broadband communications, and numerous broadband antennas are developed [1-4]. There are most referred omnidirectional antennas that are suitable for wireless broadband communications such as discone antenna, biconical antenna... If these antennas have infinite size, the characteristics of them are frequency-independent. However, once these antennas have finite size, their characteristics accept frequency, and miniaturizing the antennas causes an increase of return loss at low band. While 2-D UWB antenna structures will simply be factory-made [20], they're not extremely appropriate in applications requiring omni-directional radiation patterns. Moreover, they're the inspiration for many modern-day In wise application one achievable due to attain omni-directional radiation is to use a biconical antenna. at the facet of horn antennas, biconical antennas are thought of to be one all told the oldest UWB antenna varieties. UWB antennas [38] A number of the first biconical antennas ever created have their roots qualitative analysis back to the second half of the nineteenth century. Sir jazz musician Lodge was 1st to patent implementation of such AN antenna in 1898 [6]. Biconical antennas made by Lodge are the earliest antennas employed in wireless systems [Krauss (1988)]. by increasing the thickness of the antenna to extend the information measure and therefore the conducting halves of the antenna are made as 2 infinite round shape conducting surfaces with finite gap at the feed purpose. The infinite biconical antenna is often analyzed within the same manner because of the cable. The resistivity of the antenna is often determined from voltage and current. Voltage is obtained by desegregation on the constant radius r. the full current is found by desegregation current density. The resistivity of the antenna is real because the antenna is infinite in extent with no discontinuities and manufacture pure traveling waves. To study the input ohmic resistance and radiation characteristics Schelkunoff planned a convenient model. The biconical structure was additionally changed by exchange one amongst the cones with a disk formed ground plane to make a discone antenna developed by Kanonian. The name comes from the distinctive form, that incorporates a disc and a cone. The disc section is insulated from the cone by a block of materials that conjointly acts as spacers keeping the 2 sections apart at a set distance. This distance is one of the factors that confirm the general frequency of the antenna. The infinite biconical antenna is formed Progress in RF technology over the last decades raised sturdy interest in UWB systems. Several antenna designers developed new ideas and rediscovered older ones to realize constant wideband resistivity properties. However, so much less attention was paid to realize a frequency freelance pattern, which plays a awfully vital role for maintaining low antenna distortions. In [11]–[13]. The progress of UWB applications, like UWB channel sounding, high rate short vary wireless native space networks, frequency observance and etc., has led to extensive investigations within the space of broadband antenna techniques. Typical UWB antennas are biconical, discone,double-ridged conductor [3]. A biconical antenna for the three.1 to 10.6 GHz waveband will be found in

[4]. In [5] a discone Associate in Nursingtenna with an operational bandwidth from 282 megacycle per second to eight.93 GHz has been introduced.An antenna composed of the uneven biconical antenna and inverted discone antenna covering the spectrum band180 megacycle per second - eighteen GHz are planned in [46]. The double-ridged conductor horn antennas are usually designed to own an oversized resistivity information measure and a extremely directive graph. However, styles with broad and low directive radiation patterns will be found in [7].Another category of UWB antennas are log-periodic antennas. A problem with these antennas is that the high distortion of short pulse signals [8]. The design of UWB antenna is completely different from that of its narrowband counterpart. Firstly, the antenna ought to have aliquot information measure of zero.2 or absolute information measure of five hundred megacycle. Secondly, the antenna ought to have consistent radiation characteristics throughout the band. Thirdly, the antenna ought to be low profile and flattened for simple integration into the mobile and moveable devices. The electrical characteristic of a MB-OFDM are: wide information measure and constant gain response. additionally to the same characteristics a periodical system needs linear section response. The mechanical characteristic needs like low profile, low value and straightforward integration are same for each the systems.

Previous analysis in [7] lacks the power tool graphical record with the increasing frequencies, this paper is concentrated on up three sound unit beamwidth with graphical record stability. In most previous analysis works, this difficult a part of broadband biconical antenna style has not been considered[12][13][14]. The planned biconical antenna of this paper has 3 parts: cone, cylinder and ring and it introduces distinctive emulsified form fringe of the ring and cylinder to boost the graphical record.

For any balanced antenna, to fulfill the need of balanced feed “balun” style is extremely vital issue. Balun will deliver most power to the load and therefore the source[15][16]. Sleeve baluns are used here with coaxal feeding at specific frequencies for the aim of up undesirable radiation because of the cable feeding. but sleeve baluns operate solely single frequencies, here, on an individual basis sleeve baluns are designed that operates at completely different frequencies.

Bandwidth–heavy applications within the close to future, very similar to those accessible these days, can involve transferring high–resolution pictures and videos to multiple users. Application concepts from the antecedently mentioned, in progress project sponsored by Google make sure this trend. One application utilizes live streaming video of presidency workers’ daily activities to extend transparency of native governments. Another proposes remote–controlled work robots that modify folks to scrub their living rooms whereas they're at work (Google Moderator, n.d.). this kind of application depends on the idea of pervasive computing or “the web of Things,” a term initial coined by Mark Weiser (Mattern and Floerkemeier, 2010; Obaidat and Woungang, 2011). Pervasive computing refers to the introduction of the many embedded and mobile devices that are interconnected to produce improved quality of life through computing technologies. Pervasive computing will relate to any of the appliance areas represented higher than with explicit impact on the longer term of health care and education.

The development of wearable sensors at intervals consumer goods will give verdant physiological knowledge to assist physicians additional accurately diagnose and treat chronic diseases. From watching general important signals to motion analysis for stroke rehabilitation and treating Parkinson's illness, these wearable sensors are cited as health body space networks (HBANs) (Delmastro and Conti, 2011). Developers of HBANs get to limit power and information measure consumption of sensors for larger comfort and satisfactoriness. If a user were needed to recharge his shirt or alternative consumer goods enabled with HBAN technologies each hour approximately, for instance, then the utility of exploitation the HBAN on an everyday basis as supposed would be restricted

1.2 Objectives

Due to position characteristics, straightforward configuration and broadband frequency response biconical antennas are extensively utilized in band communications [5][6][7][8][9][10][11] . Infinite size of biconical antennas show the characteristics of frequency dependency whereas finite size antennas show frequency independence. Just in case of broadband communications biconical antenna style continues to be facing one major challenge: the upkeep of constant graph over a broad frequency band (e.g. many rate and more)[7]. With the increasing frequency, the graph of the antenna becomes corrupted as a result antenna's three dB beamwidth becomes smaller at high frequencies. The most important reason behind this significant issue is uneven surface. The main goals and ideas of this thesis work are:

- Design a broadband biconical antenna
- Implementing radiation pattern stability over the broad frequency spectrum 3-40 GHz band
- Improvement of 3dB beamwidth of the antenna radiation pattern with lower gain which is suitable for broadband antennas.
- Designing sleeve balun for reducing unwanted current distribution along the transmission line of the antenna and getting smoother radiation pattern

1.3 Thesis layout

Rest of the thesis is organized as follows: Chapter 2 provides the theor y and background overview and applications of the broadband antenn a. Chapter 3 discusses the detail design procedure of the proposed bic onical antenna and definition as well as characteristics of the biconica l antenna. Chapter 4 discusses the detailed design procedure of the pr oposed sleeve baluns and the importance of baluns for antennas. Chap ter 5 discusses a complete analysis is being made on simulated and m easurement results where the antenna parameter are described on the basis of the reflection coefficient, VSWR, radiation pattern, gain.Simil arly, a comparison is made with the existing antennas to validate its n ovelty. Finally, chapter 6 concludes the thesis and presents some concl usion of this study.

2. Broadband Antenna

Section 2.1 offered an overview of Broadband Technology. As already stated, the thesis aims at designing antennas for broadband applications. A general overview of wideband antennas is addressed in this section, methodology for obtaining the Broadband requirement and its limitation.

2.1 Theory and Background

The IEEE standard definitions of antenna terminology describe antenna or aerial as a means of radiation or radio wave reception. Antenna history dates back to 1865 when Maxwell described electrical and magnetic field behavior. In 1886, Hertz confirmed Maxwell's claim through the first wireless system. He also designed a loop antenna and invented a parabolic cylinder reflector antennas. In 1901, Marconi carried out the first transatlantic transmission from Poldhu to Cornwell, England to St. Johns, Newfoundland. Lodge (1903) patented a syntonic radio system after Marconi that represented the first UWB antenna based on the narrowband domain radio theory. He also developed the spherical dipoles, square plate dipoles, biconical dipoles, and bowtie dipoles. J. In millimeter-wave systems, C. Bose (1888) carried out pioneering work. He showed the full transmitting and receiving network about 60 GHz, which included the first horn antenna, the collecting the funnel the first horn antenna.

It is possible to classify antennas into four basic types based on the operating frequency. Next, VHF frequencies and below are used with electrically weak antennas such as short dipole or loop antennas that are much less than a wavelength. The major drawbacks of these antennas are low input resistance and high input reaction. Large antennas are also unreliable due to ohmic structural losses. Second, from HF to low GHz range, resonant antennas are used. Due to simple structure with good input impedance, large beam and low to moderate gain, these antennas are common. The resonant category includes a half-wave dipole antenna, microstrip antenna, and Yagi-Uda antenna. Falls in the resonant 11 antenna band. Second, UHF and above broadband antennas. Spiral and log periodic antennas are such an effective region which characterizes broadband antennas. Because at a given frequency solely some of the antenna is chargeable for radiation, the gain is low. But having gain that is almost constant with frequency, while small, maybe an advantage. Third, an opening antenna used at and above UHF. Such antennas are usually long in one or more dimensions with several wavelengths. Antennas such as horn aperture and antenna reflector transmit EM wave through the door. Such antennas have a medium bandwidth with narrow beam leading to high gain.

2.2 OVERVIEW of BROADBAND ANTENNAS

According to The New IEEE normal lexicon of Electrical and natural philosophy terms, the information measure of Associate in Nursing antenna is outlined as „the vary of frequencies among that its performance, in relevancy some characteristics, conforms to a given standard‟. This characteristic is taken as an input electrical phenomenon or graph. The input electrical phenomenon is a lot of sensitive to frequency, a typical standard is that the voltage stationary wave quantitative relation (VSWR) ought to be but one.5 or 2. Equivalently, the come loss ought to be but fourteen dB or ten dB severally. The term broadband could be a relative live of information measure. The information measure of narrowband antenna is typically expressed as a p.c mistreatment of the formula.

$$BW = 2(fu-fl)(/fu+fl) \qquad (2.1)$$

fu - higher frequency

fL - lower frequency

Whereas for broadband antennas it's sometimes expressed as a quantitative relation mistreatment

$$BW=fu/fl \qquad (2.2)$$

Some samples of the foremost in style broadband antennas within the literature are classified into four categories: biconical antenna, frequency freelance antenna, shaped antenna, and coplanar broadband antenna.

2.2.1 BICONICAL ANTENNA

Biconical antennas made by Lodge are the earliest antennas employed in wireless systems [Krauss (1988)]. The infinite biconical antenna is created by increasing the thickness of the antenna to extend the information measure and therefore the conducting halves of the antenna are made as 2 infinite round shape conducting surfaces with finite gap at the feed purpose. The infinite biconical antenna is often analyzed within the same manner because of the cable. The resistivity of the antenna is often determined from voltage and current. Voltage is obtained by desegregation on the constant radius r. the full current is found by desegregation current density. The resistivity of the antenna is real because the antenna is infinite in extent with no discontinuities and manufacture pure traveling waves. To study the input ohmic resistance and radiation characteristics Schelkunoff planned a convenient model. The biconical structure was additionally changed by exchange one amongst the cones with a disk formed ground plane to make a discone antenna developed by Kanonian. The name comes from the distinctive form, that incorporates a disc and a cone. The disc section is insulated from the cone by a block of materials that conjointly acts as spacers keeping the 2 sections apart at a set distance. This distance is one of the factors that confirm the general frequency of the antenna.

2.2.2 FREQUENCY INDEPENDENT ANTENNA

Until 1950‟s, broadband antenna has been spoken because the antennas whose radiation characteristics were acceptable over a frequency vary of two or 3:1. A breakthrough in antenna evolution was created that extended the data live to 40:1. These antennas were referred to as frequency freelance antennas by Rumsey (1957). He ascertained that the impedance associate degreed pattern properties of an antenna are frequency freelance if the antenna form is such by the angles. The elemental principle for true frequency independent antennas is that if all the size of a superbly conducting antenna are changed in linear proportion to a amendment in wavelength, the performance of the antenna isunchanged. though the finite biconical antenna is such by the enclosed cone angle, it is frequency dependent as a result of once the infinite biconical is truncated to finite biconical, impedance and pattern characteristics is changed thanks to the mirrored waves from the ends of the cone.

The second class of frequency freelance antenna relies on the self complementary principle. The electrical phenomenon of self-complementary antenna is achieved using Babinet‟s principle that in optics states that once the sector behind a screen with an opening is extra to the sector of a complementary structure the add is adequate the field when there's no screen. The spiral and their variation round shape spiral are created to be either specifically or nearly self-complementary yielding extraordinarily wide sensible frequency freelance spiral antenna was created by Dyson (1959). The radiation takes place once the circumference is one wavelength. The other antenna with frequency freelance property is that the log periodic antenna introduced by DuHamel and Isabell (1957). the opposite kinds of the log periodic structure are log periodic dipole array, 2 or four arm log spiral antennas and round shape log spiral antennas [Mayes (1992)]. Although, frequency freelance antenna has wide information measure, it has two limitations. Firstly, although the frequency freelance antennas are infinite inprinciple satisfying Rumsey‟s demand, in follow they're truncated that makes the antenna massive in terms of wavelength. Secondly, they radiate totally different frequency components from totally different elements of the antenna. thanks to these limitations the antenna willbe used solely wherever the wave shape distortion is tolerated.

2.2.3 FRACTAL ANTENNAS

Mandelbrot created recursively generated pure mathematics that has incomplete dimensions based on the conception of pattern [Balanis, (2005)]. These antennas are characterized by low profile, light-weight weight and wide information measure. The self-similarity and house filling properties of pattern technology are wont to understand UWB antenna. A broadband antenna based on pattern technology for wireless communication applications like software package defined radio and UWB is planned by Cohen, et al (2003). A circular microstrip patch A circular microstrip patch antenna with triangular slot and a pentagon patch with pentagon seal Khoch is proposed by ring, et al (2006) and Naghshvarian, et al (2008) for UWB application.Two novel form antennas for each size reduction and band notch characteristics have been planned by Lui, et al (2005), (2006). These antennas aren't appropriate for time domain operation thanks to spurious current radiation.

2.2.4 PLANAR ANTENNAS

Planar Monopole (dipole) or disc antennas are characterised by tiny size and wide bandwidth of hour. The earliest form of flat aerial is that the tie antenna invented by Woodward [Krauss, et al (2010)]. The flat monopole antennas are fashioned by divergent metal patch over finite sized ground plane. The patch form may be rectangular, sq. [Ammann, (1999), Wong. et al (1997), Ammann, (2000), Thomas, (2011), Jung, et al (2005)], circular [Chen, et al (2003), Tong, et al (2005), Jinghui, et al (2006), Liang, et al (2006), Wang, et al (2007)], elliptical [Huang, et al (2005), Zhang, et al (2006), Ray, (2007), Schantz, (2002), Schantz, (2003), Paryani, et al (2011)], hexagonal or alternative form [Agarwall, et al (1997), Ray, et al (2006)]. The electrical phenomenon bandwidth of those antennas may be improved by 3 ways [Chen, et al (2006)]. First, the radiator form beveling leads to swish electrical phenomenon transition that successively results in sensible electrical phenomenon matching [Ammann, et al (2003), Chen, et al (2000)]. Second, etching a slot on the radiator amendments this distribution leading to change in current path additionally as electrical phenomenon [Rahayu, et al (2008), Liu, 2004), Lin, (2011), Desmukh, et al (2009)]. Finally, electrical phenomenon information measure is varied by optimizing the feed point location [Ammann, et al (2004), Ray, (2009)].

2.3 Broadband antenna requirements

The design of UWB antenna is completely different from that of its narrowband counterpart. Firstly, the antenna ought to have aliquot information measure of zero.2 or absolute information measure of five hundred megacycle. Secondly, the antenna ought to have consistent radiation characteristics throughout the band. Thirdly, the antenna ought to be low profile and flattened for simple integration into the mobile and moveable devices. The electrical characteristic of a MB-OFDM are: wide information measure and constant gain response. additionally to the same characteristics a periodical system needs linear section response. The mechanical characteristic needs like low profile, low value and straightforward integration are same for each the systems.

2.4 Broadband requirement methodology and its limitations

The first demand of antenna covering the whole operative information measure is achieved by completely different bandwidth sweetening techniques like-

- changing the form of the radiator by varied the roundedness quantitative relation or beveling the radiator to get smart resistivity matching
- Controlling electric resistance information measure by variable the feed gap between the partial ground plane and therefore the radiator.
- inserting slots or stubs within the radiator to vary this distribution that successively varies the current path length

- and overlapping of multiple resonance

The second demand will be achieved through the pure mathematics of the antenna. The third demand of low profile isn't solely to accommodate the antenna in miniaturized instrumentality however conjointly to appreciate uniform radiation. the elemental principle behind size reduction is increasing the electrical size of the antenna while not increasing the physical size. this is often achieved either through high medium loading or inductive/capacitive loading techniques [Lee, et al (2007), Kramer et al (2007)]. the most challenge in material loading is maintaining antenna weight whereas achieving desired miniaturization, because the density of high contrast medium and volume of fabric required becomes high once an oversized miniaturization issue is needed.

The performance of the tiny antenna is characterized by size, quality issue (Q-factor), halfway information measure and gain. The Q-factor is that the major limitation on little antenna [Chen, et al (2006)] wherever, letter of the alphabet of the antenna is reciprocally proportional to its information measure. the basic limitation on antenna was addressed an extended time past by Chu, Harrington, Wheeler, McLean, and Collin. [Abbosh, (2003)]. Chu explored the basic limits on antenna size, information measure, and potency. Harrington formalized Chu‟s ideas and named it the Chu-Harrington limit. This limit relates the dimensions to the Q-factor or inverse halfway information measure of a perfect high economical antenna. the dimensions is denoted by the radius „r‟ of the boundary sphere, the tiniest sphere that fully encloses the antenna. McLean got wind the error in determinative the wavelength in Chu-Harrington limit. The distinction happens in the process the wavelength of a narrowband and broadband antenna. The distinction becomes additional important because the antenna becomes really broadband [Schantz, (2003)].

Wheeler evaluated the radiation potency of the antenna by putting the antenna within a closed spherical shell referred to as Wheeler cap with radius $r = \lambda / 2\pi$ at the frequency of interest. But, this methodology isn't appropriate for UWB antenna [Schantz, (2003)]. a replacement methodology was developed by considering the massive spherical shell. a certain expression for radiation Q letter was investigated by Collin, that relies on temporary energy keep around associate degree antenna. the precise expression for letter Q is developed as

Q=(ka)^-3+(ka)?^-1 (2.3)

Where

k = wave number

a = smallest sphere radius (enclosed with the hypothetical radiator)

Bandwidth and q factor maintains the inverse relationship. Definition of q factor varies for narrowband and broadband antenna.

2.5 Applications of broadband communication

A broadband application area is printed here as a general grouping of applications designed for specific functions that will apply to different types of industries and shoppers. Some applications are designed for terribly specific audiences like the large–scale dataset analysis programs that Accelerated Parafit uses to match completely different biological process levels of trees (Stockinger, et al., 2011). Others have relevancy to a good form of skilled and industrial fields like Skype, a video–conferencing and vocalization web protocol (VoIP) application. this implies there are varied ways in which to categorize applications by kind as hostile categorizing by system needs. Applications generally about up quality of life, medical aid, education, and governance. These application areas are:

i.Video-based applications;

ii.Telehealth applications;

iii.Distance learning applications;

Iv.E–government applications; and,

v. Emergency management operations applications.

These application areas represent a tiny low range of doable applications of broadband. every of the areas includes various problems and neutral teams presenting distinctive challenges for the event and adoption of latest applications. the subsequent sections review a number of the outstanding current applications among every space.

Video–based applications

One of the explanations advanced and mid–range applications need massive amounts of information measure are the utilization of video and audio content. Video transfer could be a part in many alternative applications. the main target here is on two outstanding samples of entertainment-oriented applications, downloading media and on-line multiplayer games, and a business-oriented application, multi-point video conferencing.

Downloading media. Downloading movies and television shows is the business sector for firms like Netflix, Hulu, and Apple. However, all of those firms perform an equalization act between the standard of the video content provided and therefore the quantity of information measure consumed by the user (Moon, 2012). These firms are involved with information measure consumption because of some web service suppliers (ISPs) putting knowledge caps on customers that consume over an explicit data quantity every month. Application and software system developers dedicate sizeable time and resources to compression video file sizes whereas maintaining a high level of image quality (eyeIO, 2012). The implementation of information caps varies by ISP and could be a contentious issue (Fitchard, 2012). Apple provides customers with a general guide to file sizes and transfer times of various forms of media for the needs of managing knowledge usage (Apple, 2012). Table three provides these file sizes and their transfer times for various forms of media on networks with speeds of four, 10, 20, and fifty Mbps.

Online multiplayer video gaming: on-line multiplayer play is Associate in Nursing economic juggernaut price a calculable US$56 billion in 2011 alone (Economist, 2011). The demand for on-line play is arguably bigger than the other broadband application and needs an especially sturdy network to avoid interruption to players. large multiplayer on-line game (MMOG) communities will include many thousands of users and reach across international borders. World of Warcraft, the most important MMOG, has an Associate in Nursing calculable ten million active players across the world (Putzke, et al., 2010). MMOGs are the primary really productive virtual worlds, enjoying widespread adoption altogether styles of communities.he information measure needed for a user taking part in a game through a console, like PlayStation three, or through a computer online doesn't commonly want an association in far more than one Mbps. decision of Duty trendy Warfare three, one in all the newest and highest image resolution games, solely needs regarding 50–75 kbps (Xbox Forums, 2011). Several games currently use hosting to make a mini–user network that alleviates the strain on ISPs' and users' network connections. Rather than multiple users accessing the network promptly, one user “hosts” them on his network and provides a single association to the larger game network. The hosting user needs an association capable of sustaining speeds around 300–750 kbps.

Telehealth : Application of knowledge technologies to the tending field has been slow and comparatively haphazard compared to different major industries (American Telemedicine Association, 2006; Zanaboni and Lettieri, 2011). The size, complexity, and range of stakeholders concerned within the tending business build it tough to develop content and delivery standards for information (U.S. Department of Health and Human Services, 2010). Telehealth could be a general term used generally to explain the utilization of any info technologies for tending, like videoconferencing (Ackerman, et al., 2010). Telemedicine is often related to the utilization of technology to supply clinical services to patients (Hein, 2009).

The yankee Recovery and Reinvestment Act (ARRA) of 2009 amended the insurance movability and answerableness Act (HIPAA), the most law regulation health info technology, to want the Department of Health and Human Services (HHS) to develop standards, implementation specifications, and certification criteria for health info technologies to realize wider use of technology within the health care business, like through health info exchanges (HIEs) (U.S. Department of Health and Human Services, 2010).

Class room application through distance learning:

Much like within the attention business, the employment of technology in education is AN expansive field with a varied set of stakeholders and disagreement over the foremost effective due to incorporate technology

for instance, the state of Everglade State recently passed legislation requiring each administrative district within the state to adopt electronic textbooks by 2015, however the legislation includes no funding or pointers for a way this can be to be accomplished (Rockwell, 2011). Electronic textbooks are however one amongst several education technology applications that are accustomed (1) augment ancient teaching strategies within the classroom; or, (2) facilitate distance learning platforms, like synchronous interactive on-line instruction, wherever the training setting is made completely on-line.

There is some overlap between the 2 education technology application classes as some schoolroom applications are accessible solely on-line. A notable and widespread example is Second Life, that has several general applications outside education. However, the bulk historically are utilized in schoolroom settings and downloaded onto pc workstations (Wagner and scientific discipline, 2009; Webb, 2012). because the focus of education shifts from face–to–face or on-line lecture–based strategies to interactive methods higher suited to the fashionable, technology–driven society, synchronous interactive on-line instruction can increase in importance and use. This, in turn, can place larger strain on broadband networks and need users to upgrade their affiliation speeds to participate totally within the instructional expertise.

The yankee Recovery and Reinvestment Act (ARRA) of 2009 amended the insurance movability and answerableness Act (HIPAA), the most law regulation health info technology, to want the Department of Health and Human Services (HHS) to develop standards, implementation specifications, and certification criteria for health info technologies to realize wider use of technology within the health care business, like through health info exchanges (HIEs) (U.S. Department of Health and Human Services, 2010). AN example as an instance|parenthetically|let's say|maybe} the speed needs required for an race, Table five provides some samples of approximate transfer times to finish the transmission of various imaging pictures at different network speeds.

E-government : E–government could be a term loosely wont to describe on-line services or info provided by any federal agency (Evans and Yen, 2006). the bulk of e–government services usually involve downloading or uploading forms, permits, licenses, or alternative kinds of documents, still as alternative account management services. Examples embody invigorating a driver's license or paying a utility bill on-line. Most studies examine the effectiveness of e–government services supported user perceptions of the service as compared to user perceptions of e–commerce services. Affiliation speed is generally enclosed among the relevant variables (Steyaert, 2004; Morgeson and Mithas, 2009).

The variations in information measure needed for e–government services replicate the various service roles for the govt. agencies and departments. Most e–government services, like filing taxes, getting permits, or checking on criminal cases, don't involve giant amounts of knowledge transfer. affiliation speeds become a difficulty for these services solely within the case of establishments, like public libraries or force boards that have multiple users making an attempt to transfer files on constant network at the same time (Bishop, et al., 2011). These applications would be classified into the fundamental or mid–range level, though specific times it takes to accomplish totally different e–government tasks at different affiliation speeds aren't accessible. the foremost wide utilised advanced applications for e–government services are geographic info systems (GIS). GIS utilize multiple layers of high–resolution pictures associate degreed graphics and need an abounding quantity of knowledge storage for the network and a reference to a speed of a minimum of ten Mbps to avoid important latency whereas mistreatment the applying (Akamai, 2011).

Future applications : Bandwidth–heavy applications within the close to future, very similar to those accessible these days, can involve transferring high–resolution pictures and videos to multiple users. Application concepts from the antecedently mentioned, in progress project sponsored by Google make sure this trend. One application utilizes live streaming video of presidency workers' daily activities to extend transparency of native governments. Another proposes remote–controlled work robots that modify folks to scrub their living rooms whereas they're at work (Google Moderator, n.d.). this kind of application depends on the idea of pervasive computing or "the web of Things," a term initial coined by Mark Weiser (Mattern and Floerkemeier, 2010; Obaidat and Woungang, 2011). Pervasive computing refers to the introduction of the many embedded and mobile devices that are interconnected to produce improved quality of life through computing technologies. Pervasive computing will relate to any of the appliance areas represented higher than with explicit impact on the longer term of health care and education.

The development of wearable sensors at intervals consumer goods will give verdant physiological knowledge to assist physicians additional accurately diagnose and treat chronic diseases. From watching general important signals to motion analysis for stroke rehabilitation and treating Parkinson's illness, these wearable sensors are cited as health body space networks (HBANs) (Delmastro and Conti, 2011). Developers of HBANs get to limit power and information measure consumption of sensors for larger comfort and satisfactoriness. If a user were needed to recharge his shirt or alternative consumer goods enabled with HBAN technologies each hour approximately, for instance, then the utility of exploitation the HBAN on an everyday basis as supposed would be restricted.

3. Proposed Biconical Antenna Design

3.1 Introduction

Basically for the purpose of getting ideal omnidirectional radiation pattern and constant radiation pattern over a broad range of frequency spectrum [1][2] ; the concept of biconical antennas has been developed. However 2-D broadband antennas are suitable for their simple and convenient structure but they are not capable of applications which requires omnidirectional radiation patterns[3][4].

The roots of the first biconical antenna can be found back to the second half of the nineteenth century[5][6]. In 1898 the first patent of [7]implementation of biconical antenna was lodged by Sir Oliver Lodge[8]. There was no practical applications at that time as a result this type antenna invention was forgotten until the late 1930s. In the meantime Philip Carter rediscovered biconical antenna. The extensive theoretical basis can be known from [9][10][11] these ref in the following years

According to IEEE standard definition[12], “Biconical antenna is one kind of antenna which geometry consists of two conical conductors with a common axis and vertex. For the purpose of achieving broadband characteristics; biconical antenna has been arranged by placing two cones (two conical conductors) of infinite extent together. Two cones face in opposite directions which are driven by alternating magnetic field and the alternating electric current at the vertex [13]. In order to achieve the performance of the antenna as infinite case, it is suitable to define the length of the finite biconical antenna by a truncated distance.

3.1.1 Basic structure of the infinite biconical antenna

The following figure 3.1 illustrates the geometry of the infinite biconical antenna where the structure can be analyzed as a transmission line. Here voltage source produces a current distribution that flows radically outwards: when applied voltage V at the input terminals produce outgoing spherical waves. As a result between the cones voltage V and current I through the surface has been generated[14].

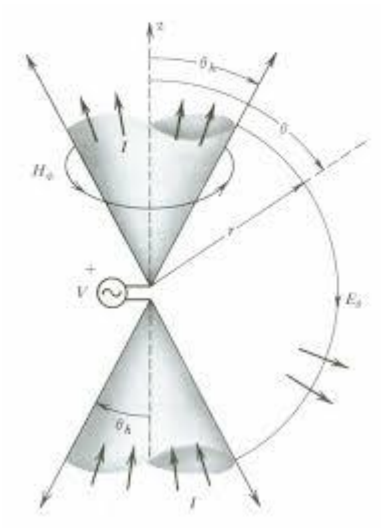


Figure 3.1 Geometry of the infinite biconical antenna (From Sutzman and Thiele [14])

According to Sutzman AND Thiele [14], the normalized field pattern of the antenna is

$$F(\theta) = \sin(\theta_h) / \sin(\theta) \qquad (3.1)$$

Where θ_h = The half angle of the cone

θ= the angle from the z axis.

From this equation the relationship between cone angle and the field strength in the available free space can be determined like this way- with the increasing cone angle, the field strength will be greater within the available free space[15].

3.1.2 Basic structure of the finite biconical antenna

Practically biconical antennas are made with consisting two cones of infinite bicone. As hown in figure 3.2 TEM waves exist together with high order modes inside an imaginary sphere of radius h which encloses the antenna [16]. The high order modes are the major contributors which

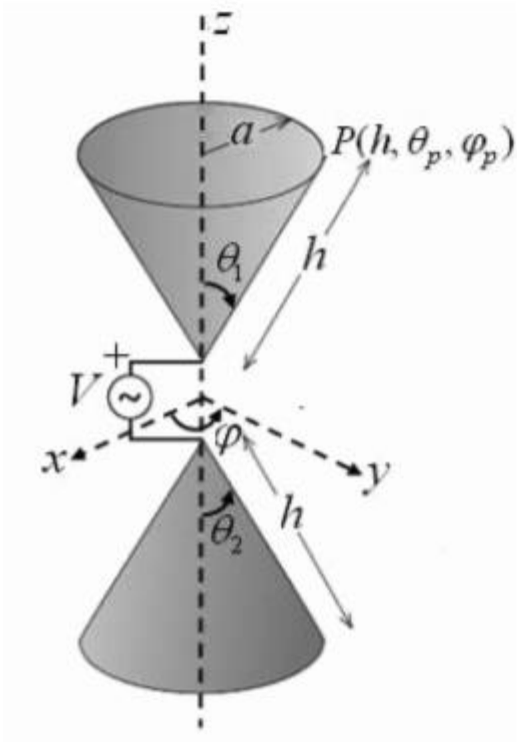


Fig.3.2 Geometry of the finite biconical antenna (From Sutzman and Thiele [14])

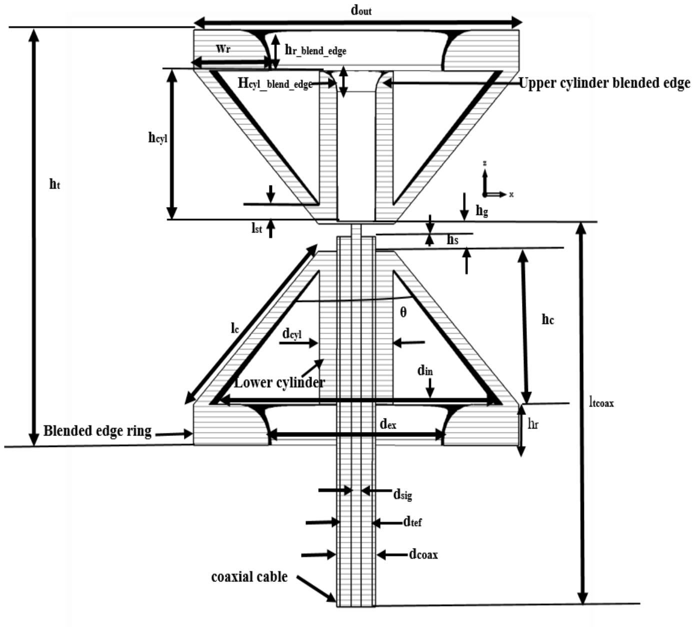
creates the antenna reactance. Standing waves are generated from the ending points of the cones which is the main reason for complex input impedance. By increasing the angle θ_1 over a progressively wider bandwidth , the reactive part belongs to the input impedance can be kept to minimum[17]. The real part of the input impedance shows less sensitivity when h or frequency has been changed.

3.2 Application of biconical antenna

Biconical antennas are used for emissions and immunity testing to satisfy numerous EMC standards specific dysfunction by FCC, CISPR, and nut. The broadband characteristics of the biconical antenna create it an honest selection for making sweep measurements and for automatic measurement systems. Normally, tuned dipole antennas are used for EMC website attenuation measurements for higher accuracy. However, the biconical antenna is less complicated to use for vertical site attenuation measurements, due to the long dipole part lengths at lower frequencies (5 meters at 30 MHz). in line with ANSI sixty three.4 specification, a calibrated biconical and a log periodic antenna will be used for website attenuation measurements. The standardization knowledge has given every antenna is used to calculate field strength measured for the chosen frequency. The antenna issue (dB/m) for the selected frequency is extra to the measured output (dBV) displayed by the EMI meter to get field strength (dBV/m).

3.3 Proposed biconical Antenna Design

Various configuration of a biconical antenna has been extensively studied by numerous researchers The design approach of this biconical antenna is based on which contains three parts: cone, ring and cylinder. In case of broadband biconical antennas with ring and cylinders, cone edges and cylinders inside each cone play very vital role as current flow from the cone edges and cylinders effects the whole radiation pattern most. In previous studies, analysis of spherically capped, asymmetric capped and edge terminated biconical antenna has been widely reported for getting good radiation pattern over wide range of frequencies. The most noticeable feature of this proposed biconical antenna is the introduction of blending shaped edge of ring and cylinder.


dout
Wr
hr_blend_edge
Hcyl_blend_edge
Upper cylinder blended edge
hcyl
ht
hg
lst
hs
lc
θ
hc
dcyl
din
Lower cylinder
ltcoax
Blended edge ring
dex
hr
dsig
dtef
dcoax
coaxial cable

(a)

(b)

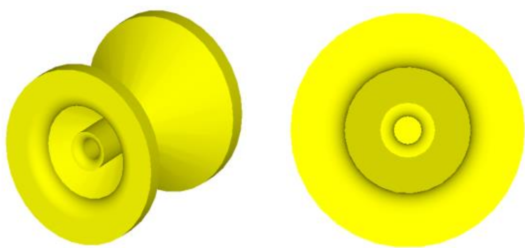
Figure 3.3. Proposed antenna (a) cut plane view (b) prototype of the antenna

Table 1: Design parameters for the proposed broadband antenna

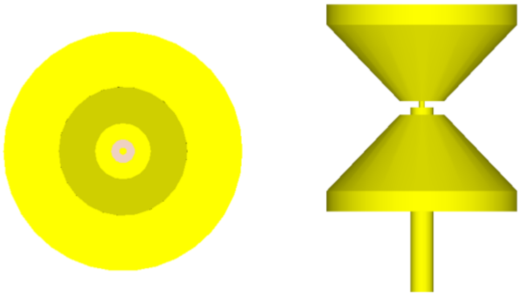
Symbol	**Value(mm)**	**Symbol**	**Value**	**Symbol**	**Value(mm)**
d_{out}	**30**	I_c	**12**	d_{sig}	**0.91**
w_r	**5.6**	d_{cyl}	**6.8**	d_{tef}	**2.98**
h_r	**16.62**	h_g	**2.14**	d_{coax}	**3.58**
h_{cyl}	**12**	h_s	**1.15**	h_c	**16.62**
H_{cyl} l_{blend_edge}	**2.25**	θ	**48.24**	h_r	**2.25**
h_t	**32.54**	d_{in}	**16.12**	l_{coax}	**30**

I_{st}	**1.5**	**d_{ex}**	**13.88**		

Both the cone has blended edge shape ring which are mirror to each other but only the upper cone has blended edge shape cylinder. For the purpose of improving good E-field radiation pattern with the increasing frequencies, these types of ring and cylinder are designed here. The proposed antenna structure has a total size of 30 mm X 30 mm X 32.54 mm (the electrical dimensions are $15\lambda_{max}$ X $15\lambda_{max}$ X $16.27\lambda_{max}$ at the lowest frequency of operation) and this optimized electrically small antenna provides strong current flow throughout the structure which results stable radiation pattern.



(a) (b)



(c)   (d)

Figure 3.4. Different views of the proposed antenna (a) perspective, (b) top, (c) bottom (d) upper

3.4 Important Design Consideration

- Here, in this thesis proposes an biconical antenna which far fields pattern resembles of an ideal dipole since frequency independent radiation characteristics is only possible with this type of structure
- For the purpose of mitigating any kind of pattern degradation two symmetrical cones are proposed here
- From the resonant length calculation the total length of the antenna is determined here which is shorter than a quarter wavelength.
- TEM mode is only excited in the standard coaxial cable which is fed with the radiator.
- In previous literature review it has been proved that without rings and cylinders radiation pattern shows distortion that's why ring and cylinder is introduced here.

- The blending edge: The smooth blending edges reduces the reflections from the sharp edges of the cone comparing with the conventional biconical antenna results minimized reflections and enhanced bandwidth
- Both the blending edges of ring and cylinder acts as a sink for the surface current providing a smooth transition for current flow throw the whole antenna structure which improves the radiation pattern.
- The blending edge of the lower cylinder of the lower cone effects the radiation pattern of the antenna, so the cylinder edge inside the cone is not blended here.
- The cone length of each side should be optimized such a way so that the current distribution remain equal through the whole structure as a result lower value of gain has been found.
- The gap between two cones also optimized such a way that it should not affect the impedance bandwidth of the antenna. The VSWR value varies too much for the very small 0.01 mm distance of gaping.
- Above all the cone length, cylinder height, ring height should be kept optimized for improving the impedance bandwidth.

4. Proposed Balun Design

4.1 Theory and Working Principle

In antenna designing technology transmission lines can be referred to as balanced and unbalanced. Wired antennas having symmetric structure require balanced signals for proper operation since many topologies of balanced transmission lines has been developed to feed these types of antenna.

Typically the fascinating antenna characteristic is that: the currents on the inner conductor and also the within the outer conductor ought to be equal in magnitude When an incident wave with balanced current is launched down on the parallel wire lines (which is inherently balanced), it excites balanced currents on a symmetrical antenna. On the contrary in a coaxial transmission line (which is not balanced; directly connected to a dipole antenna) when wave travelling down; [18]the currents will not necessary be equal. In actual scenario some of currents may flow back on the outside of the outer conductor of the coaxial cable- this situation is called the unbalanced phenomenon of the coaxial transmission line. For solving this type of unbalanced current problem “balun” concept has been developed[19]. e. The effects of imbalance are often reduced by extending the cable by many meters behind the antenna before permitting it to become parallel to the antenna parts, ,and conjointly by putting fell-ite clamps on the cable, to' this latter cannot eliminate the effect[20] This balanced and unbalanced phenomenon is shown in fig. 3.1.

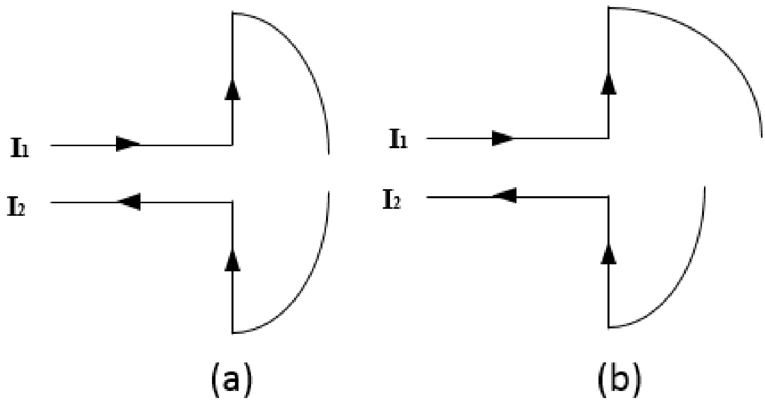


Fig. 4.1 (a) balanced currents I1=I2 (b) Unbalanced currents I1> I2 [21]

4.1.1 Balun definition

Balun is a one kind of impedance matching transformer which suppresses the outside surface current of the outer conductor of the coaxial transmission of the antenna for balancing purpose. The term also can be derived by using-“b

balanced to unbalanced transformer” or choking the current or chock[22][23]. Balun consists of two pair of terminals one is balanced which has equal currents in magnitude and opposite phase carries the signal and other pair is connected to the electrical ground[24]. Fig. 5.2 shows the combination of transmission line, Balun and Antenna configuration.

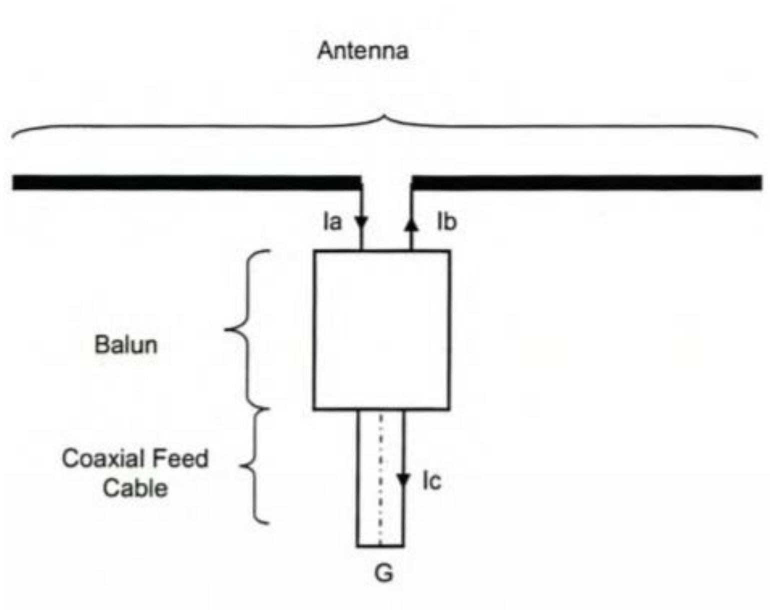


Fig 4.2. Transmission Line Balun and Antenna Configuration[25]

This Fig illustrates that a line is connected to Associate in Nursing antenna through a balun electrical device wherever American state, Ib, Ic are all attainable currents within the system and Ic is that the outer surface current of the concentrical line. If the outer surface currents are not properly suppressed it will cause unwanted radiation pattern in the antenna; that’s why balun plays very important role in antenna communication system.

4.2 Classification of balun

For the purpose of choking off the outer current and restoring balanced operation various kinds of baluns have been developed.

I. **Folded Balun:** It can be called the quarter wavelength balun as its distance from the coax is quarter wavelength long. This type of balun cancel out any current from the central arm of the coax so that no current can travel outer sleeve of the coaxial cable. In this way it maintains balanced condition[26].

II. **Tapered Balun**: Tapered baluns are sometimes broadband baluns which may be made by tapering a balanced cable to an unbalanced one over a minimum of Felis serval wavelengths of transmission length. during this form of balun style a linear tapering profile is employed for the breadth of the outer conductor of the concentric cable[19]. The shape is like: coaxial cable is gradually peeled so that it can convert coax to a balanced line.

III. **Infinite Balun**: The structure of this type of balun consists of one arm of the folded dipole as used as the outer conductor of the feeder. The center of the dipoles are drilled with the peeled cable (insulator and inner conductor remaining). The front arm of dipole is enlarged so that it can form a matching section[27]. This type of balun can also be used in spiral antennas. Advantage of using this type of balun is that: it lowers radiating impedance of the antenna and widening input impedance bandwidth.

IV. **Bazooka/ Sleeve Balun**: This type of balun geometry consists of quarter wavelength (λ/4) sleeves around the input signal of the coaxial transmission line. When the sleeve and outer conductor of the coaxial line form another coaxial line of characteristic impedance Z0′ which is actually shorted a quarter wavelength away from its input at the antenna terminals; it somewhat resembles like a bazooka shape[28].

There is a term outlined as “balancing ratio” [BR] that is taken into account during this kind balun for equalization current on the output line represents the fraction of power transmitted into the balanced twisted line.

$$BR=\frac{|S12b|}{|S12b|+|S12u|} \qquad (4.1)$$

Where

$S_{12u}=S_{12}$ for the unbalanced twin lead mode

$S_{12b}=S_{12}$ for the balanced twin lead mode.

4.3 Proposed Balun design for the broadband biconical antenna

While designing balun we considered the architecture from [21] . For pr oviding balanced feed between the coaxial cable and the antenna input po rt, sleeve balun should be designed. The cross section of the proposed sle eve is based on Fig. 2.[21], here the sleeve and the outer conductor of the coaxial line from another coaxial line has characteristic impedance Z0 ‘. It is shorted a quarter wavelength $(\frac{\lambda}{4})$ away from its input at the antenna terminals where the currents I1 and I2 became equal. With out eliminating any radiation, parallel conductor provides the desired current cancellation [Balanis].

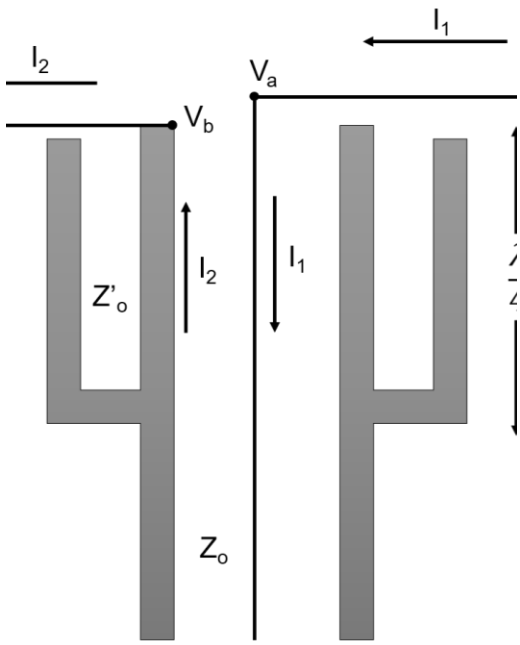


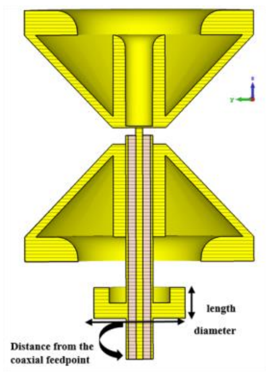
Figure 4.3 Cross section of a sleeve/Bazooka balun feeding a dipole at its center [21]

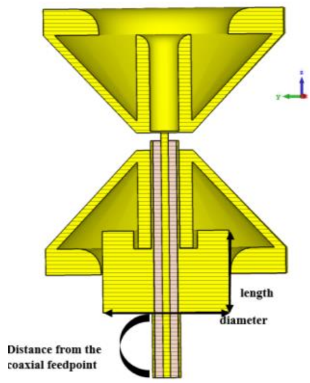
In this thesis "sleeve balun or bazooka balun" is chosen for its simplicity and for getting desired 3-dB angular beamwidth for some specific frequencies (3, 10, 15, 18, 24, 32 and 40 GHz). Baluns are individually designed here for single frequencies. For 6 GHz the antenna's 3 dB beamwidth has already shown good result so balun is not made for 6 GHz frequency. Variation of the diameter and length also distance from the feed point of the coaxial cable causes large changes in the matching. Additionally, during optimization of the balun's parameter: same balun is used for 18 GHz and 32 GHz

also another same balun is used for 24 GHz and 40GHz for getting desired 3 dB beamwidth. Therefore, total five baluns are individually designed here at specific frequencies as shown in Fig. 3. All dimensions of each balun for each frequencies are shown in table 2.

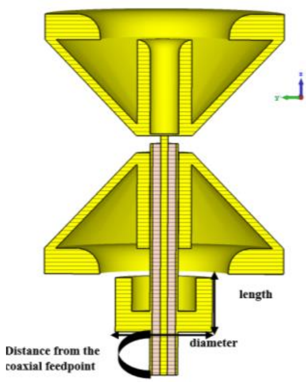
Table 4.1 . Design dimensions for different baluns at (3, 10, 15,18,24,32 and 40 GHz)

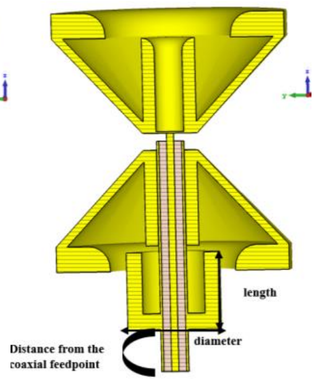
Frequency (GHz)	diameter (mm)	length (mm)	Distance from the coaxial feed point (mm)
3	12.00	4.00	5.30
10	15.80	10.00	8.00
15	12.20	6.80	5.41
18 and 32	12.00	9.70	5.30
24 and 40	16.00	4.00	3.30


length
diameter
Distance from the
coaxial feedpoint

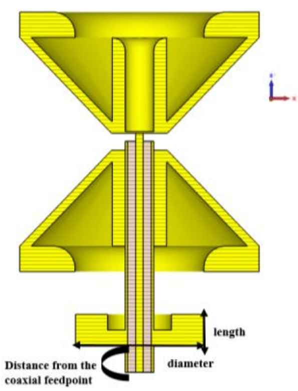

length
diameter
Distance from the
coaxial feedpoint

(a) (b)


length
diameter
Distance from the
coaxial feedpoint


length
diameter
Distance from the
coaxial feedpoint

(c) (d)


length
diameter
Distance from the
coaxial feedpoint

(e)

Figure 4.4. Cutting plane view of the antenna with individual sleeve baluns at (a) 3GHz, (b) 10 GHz, (c) 15 GHz, (d) 18GHz and 32 GHz, (e) 24 GHz and 40 GHz.

4.4 Important considerations of sleeve balun/ bazooka balun design:

- the balun is as effective as potential over a selected band by selecting as high a price for its Z0 as
- As its physical presence can modify the sphere distribution round the DUT, the coax cable is chosen to be strong in order that there ought to be no drawback throughout continuance association and disconnection
- For maintaining the best attainable worth of Z0 for a given outer radius R2 of the sleeve balun, the thickness of the sleeve is unbroken here little
- Fringing fields are working at the points of sleeves here. It has been observed during designing balun that as the sleeves diameter becomes wider, it effects the total current distribution in coaxial transmission line.

5. Simulation and measurement results

The antenna is designed on pure lossy Aluminum metal for getting convenient and rigid structure. For the optimization and simulation of the proposed antenna, a commercially available CST MICROWAVE STUDIO 2018 software was used. The simulated results have been carried out in CST simulator with the waveguide port using time domain solver.

(a). VSWR (VOLTAGE STANDING WAVE RATIO): The proposed antenna's simulation result has been shown in figure 5.1. The simulated VSWR of the antenna has broad impedance bandwidth starting at 3 GHz and continues upto 40 GHz with VSWR≤ 2.

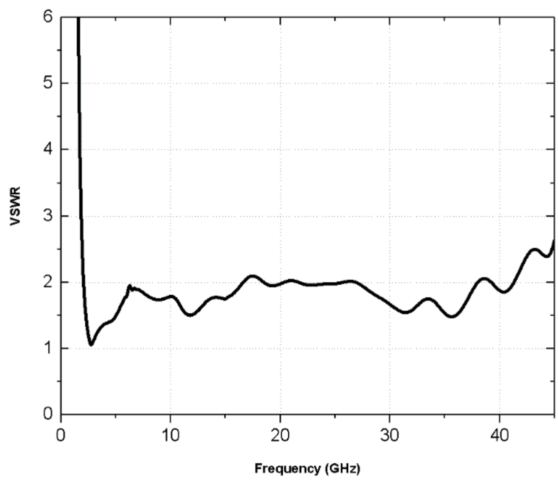


Figure 5.1. Simulated VSWR of the poposed broadband biconical antenna

Which depicts that this antenna is suitable for broadband communication. This result also demonstrates that this antenna exhibits low input reflection in the desired wide range of frequencies. The height of the blending edge shaped ring and cylinder of the antenna and the gaping distance between the cones are have been optimized in a perfect way for resulting this desired bandwidth of the proposed thesis work.

The prototype of the antenna was measured with Precision network analyzer(PNA) which range is from 10 MHz-67GHz. The measurement set up of the vswr of the proposd antenna has been shown in figure 5.2. The measured VSWR has been shown in figure 5.3. which illustrates that the fabricated proposed antenna works from 3 to 16 GHz with VSWR≤2.

Figure 5.2. Measurement set up of the prototype antenna

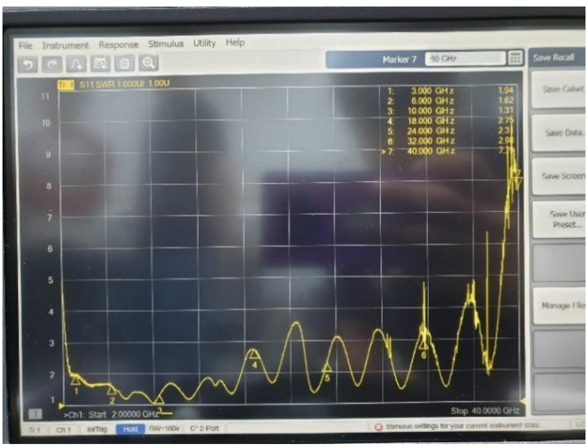


Figure 5.3 Measurement of VSWR of the propose antenna

The major differences between the simulated and measured VSWR happened due to the coaxial cable used in measurement purpose which was working upto 20 GHz.Additionaly the reason behind this discrepency between simulation and measurement result is that at higher frequencies the real cable has has higher losses than the simulated one.

(b). Radiation pattern:

An investigation of 3 dB angular beamwidth of the Elevation plane (E-plane) radiation patterns is shown here when antenna's coaxial feed line is attached with separate baluns for specific frequencies (3, 10, 15, 18, 24, 32, 40) GHz. The simulated radiation patterns figure 5.4 reveals that with increasing frequency the 3dB beamwidth varies from 101.1 to 83.3 degree.

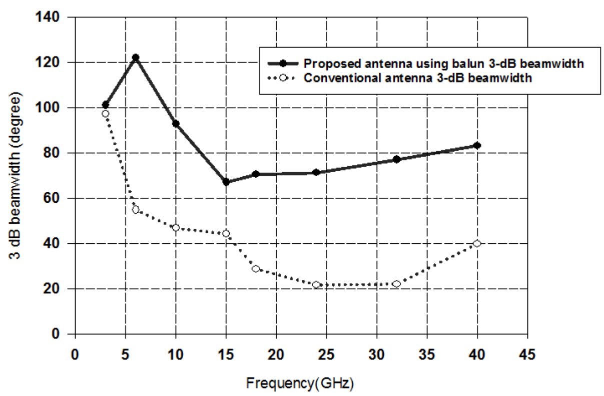


Figure 5.4 Comparison of 3 dB beamwidth between proposed and conventional biconical antenna

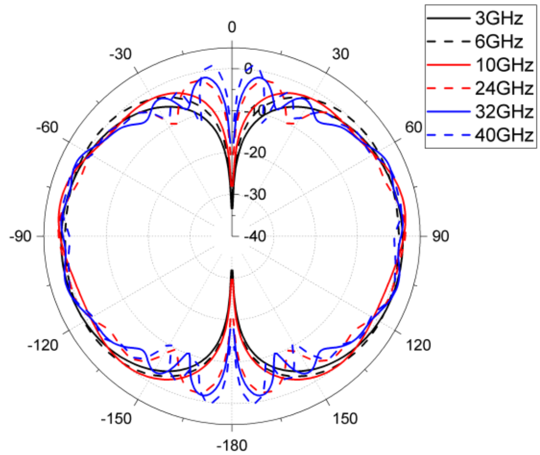
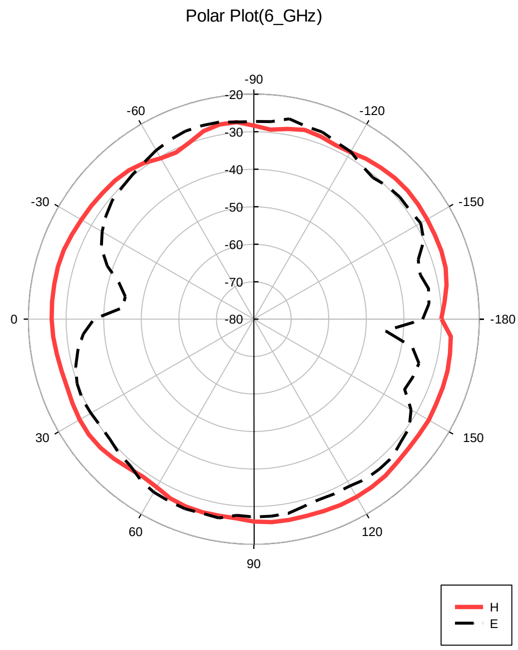


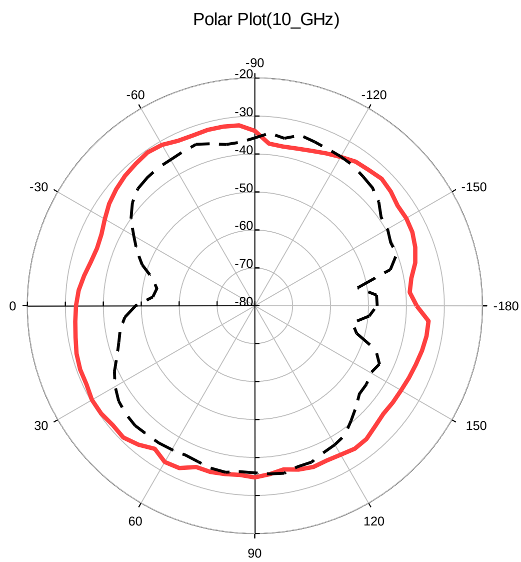
Figure 5.5 Simulated normalized E-plane radiation patterns (3, 6 , 10, 18, 24, 32, 40 GHz)

Figure 5.5 illustrates that while the side lobes in the radiation pattern are low compared to the main lobe over the covered spectrum. Simulated radiation pattern of a dipole-like radiation pattern in the E plane radiation pattern. As the frequency increases the sidelobes in the radiation pattern are low and minor lobes started occurring between +_30 degree along z axis. As this is omnidirectional it fulfils the criteria for E plane pattern which is appropriate for broadband.

The measurement results are shown from figure 5.6 to 5.8. Measurement has been observed for 6, 10,18,24,32 and 40GHz. The measurements were taken in an anechoic chamber covering different passbands of the UWB.

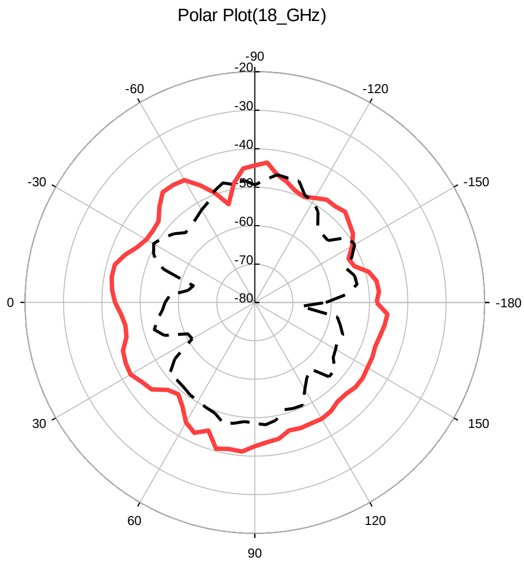


(a)

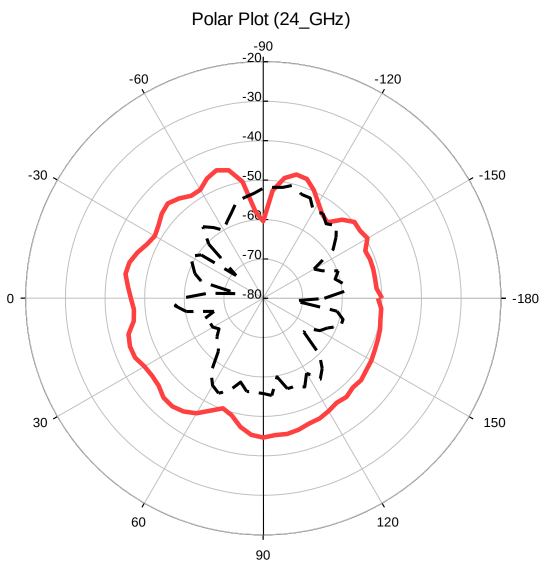


(b)

Figure 5.6 Measured radiation pattern E and H plane (a) 6, (b) 10 GHz

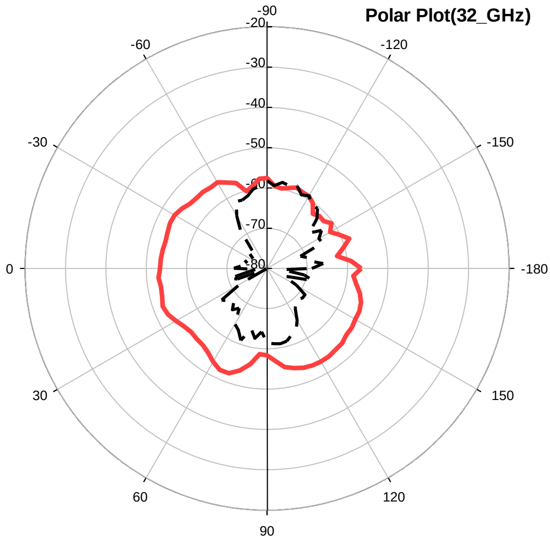


(c)

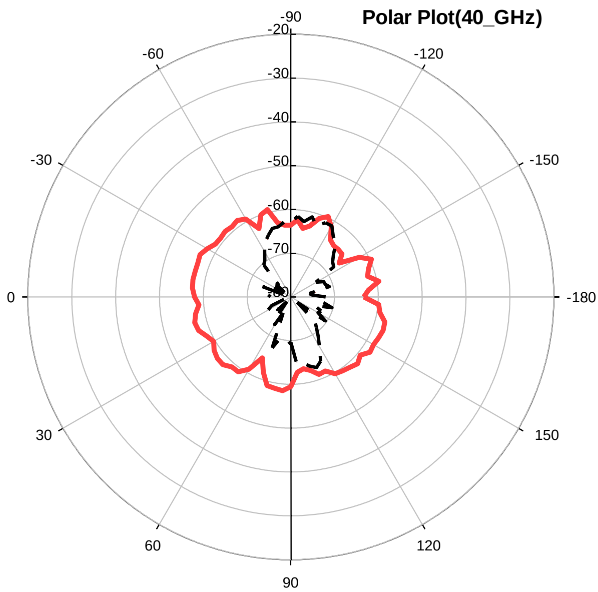


(d)

Figure 5.7 Measured radiation pattern E and H plane (c) 18, (d) 24 GHz



(e)



(f)

Figure 5.8 Measured radiation pattern E and H plane (e) 32, (f) 40 GHz

The cable with SMA connector works upto 26 GHz is used here with antenna for measurement purpose. The radiation pattern in the x–z plane (E plane) is dipole like shape and it is nearly omnidirectional in the y–z plane (H plane), which shows that the antenna radiates over a range of desired frequencies. Ripples started occurring but comparatively lower from the conventional biconical antenna with the increasing frequencies. As the E plane pattern are bidirectional towards the broadside direction and H plane is omnidirectional therefore these measurement result fulfils the criteria for radiation pattern. The bending cable and fabrication loss causes distortion in the measured radiation pattern of the antenna.

(c) Gain : For the purpose of broadband communication this thesis work aims for antenna with lower gain with increasing frequencies, as this simulated results gain value is lower comparing with increasing frequencies therefor it fulfils the requirement for broadband. The simulated and measured gain has major differences as the cable used for fabrication purpose was not upto 40 GHz. For simulated results over the frequency range from 3-40GHz the gain is upto 4dBi but for measurement purpose the gain varied upto 3.5dBi.

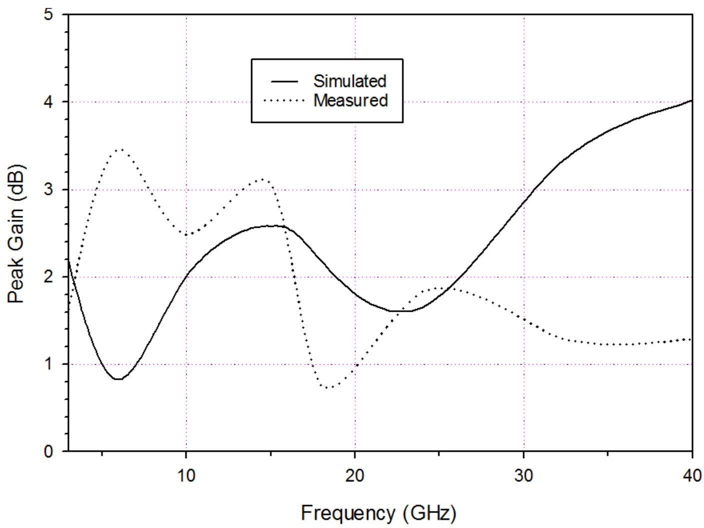


Figure 5.9 Measured and simulated gain plot

(d) Surface current distribution:. The current flowing on the outer surface of the cable protect causes radiation from the cable that successively corrupts the antenna radiation pattern-finest. Within the analysis of antennas we tend to have an interest primarily in the electrical and magnetic fields radiated by the currents flowing on the surface of the antenna. exaggerated the surface current and additional resonances.-The radiation diagram is decided by basically summation tiny sections of current (i.e., integrating), and this has an averaging/smoothing result.-with the increasing frequency the magnitude of the present flowing on the cable protect decreases and also the cable impact becomes insignificant.

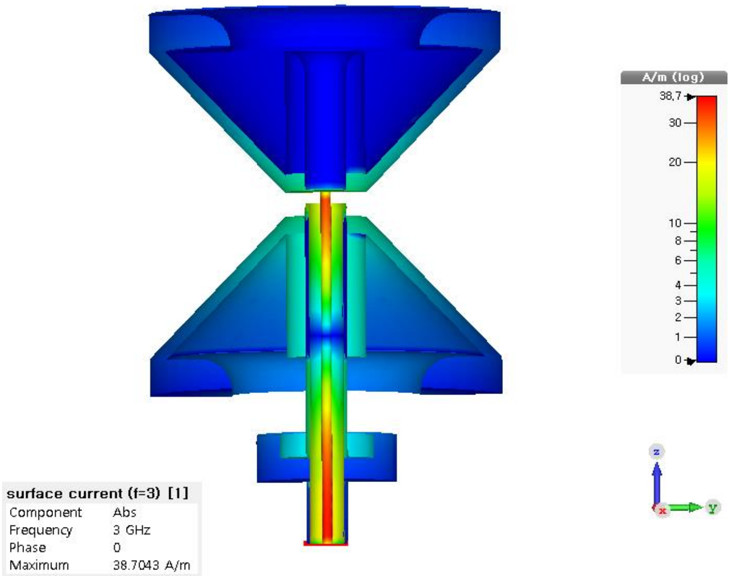


Figure 5.10: surface current distribution at 3 GHz

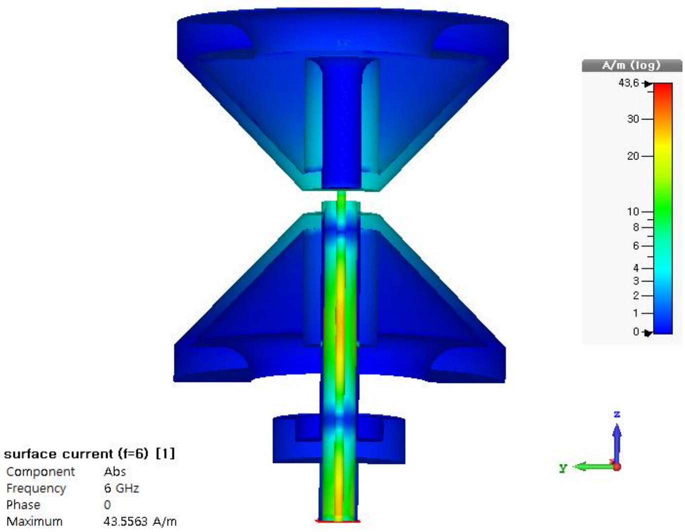


Figure 5.11: surface current distribution at 6 GHz

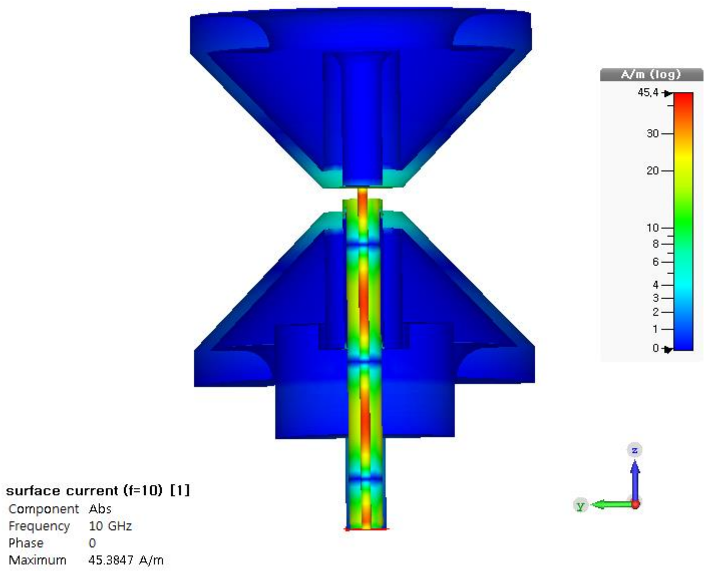


Figure 5.12 Surface current distribution at 10 GHz

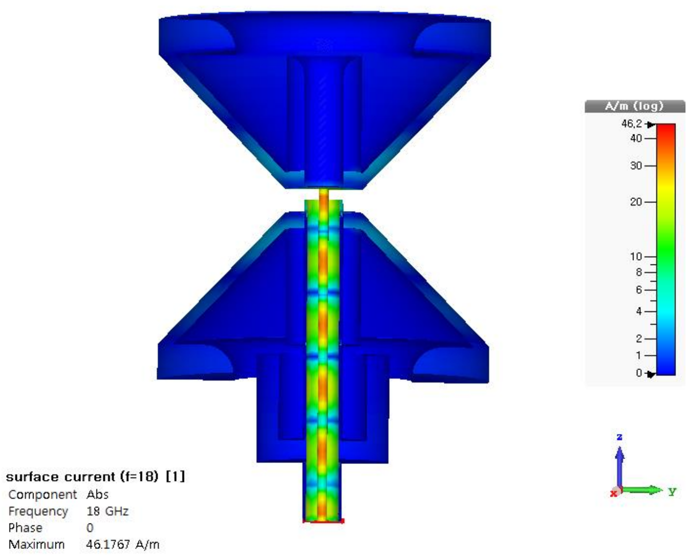


Figure 5.13 Surface current distribution at 18 GHz

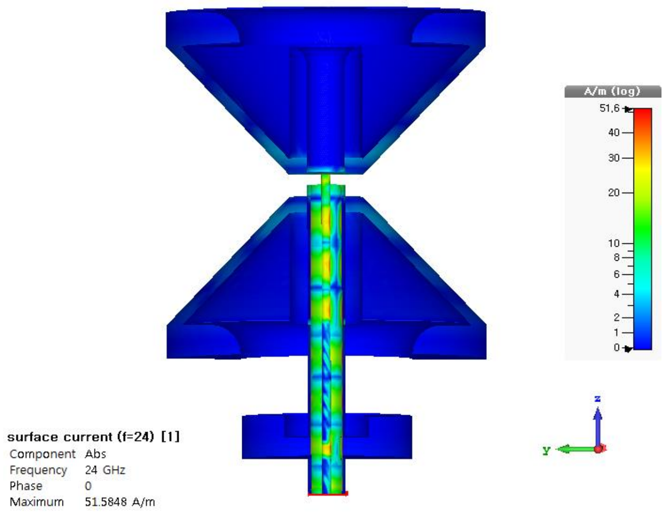


Figure 5.14 Surface current distribution at 24 GHz

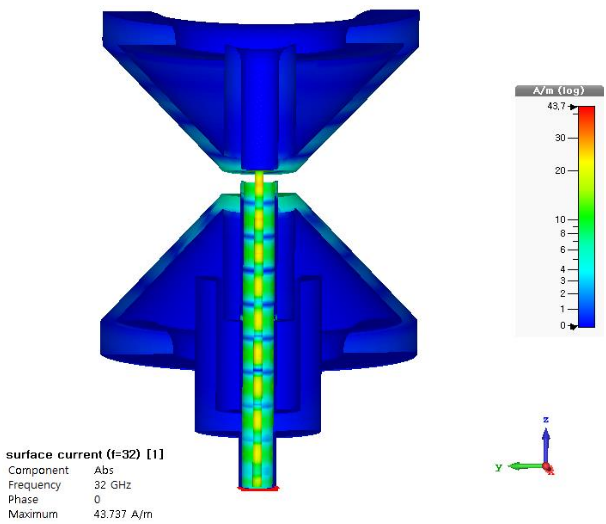


Figure 5.15 Surface current distribution at 32 GHz

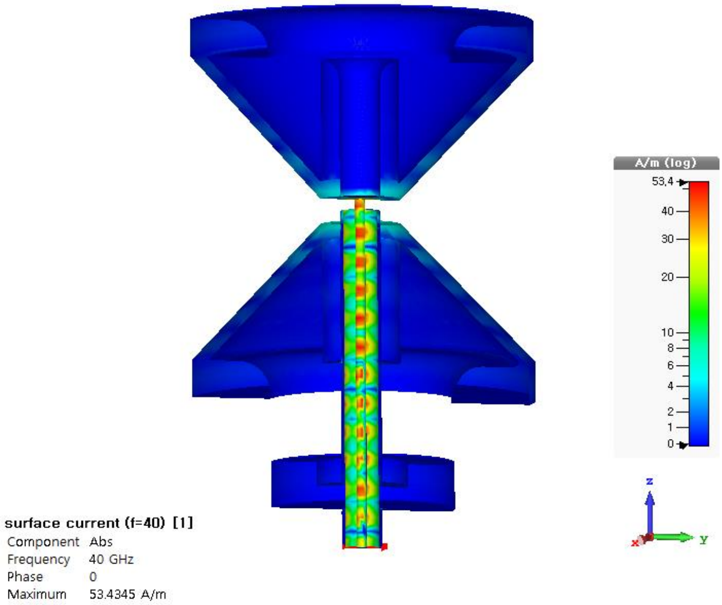
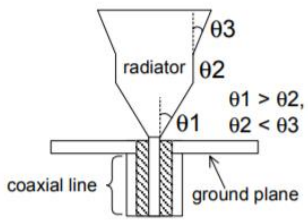
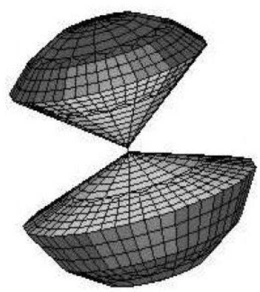
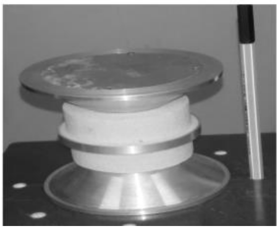
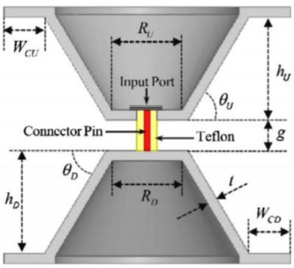
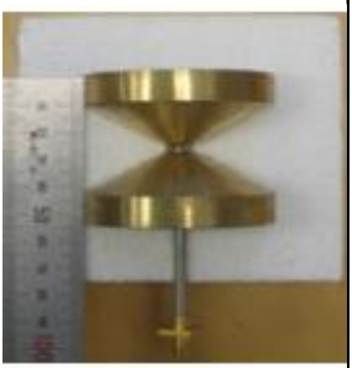


Figure 5.16 Surface current distribution at 40 GHz

From this figure five.10 it's been shown that current distribution is drum sander through the entire antenna with the increasing frequencies from 3GHz band. With the increasing frequencies current distribution is additional targeting the conductor of the coax. As we tend to used balun the present distribution results sensible simulated radiation diagram over the specified frequency spectrum. For 3 GHz the surface current distribution is stronger to the whole coaxial; cable and most parts of the lower arm which is lower cone of the antenna, with the increasing frequency current distribution on the cable shield getting lower through the cable. As for 40 GHz strongest electric field is getting lower but the while antenna stricture maintains smoother current distribution comparing with previous frequencies. As a result of smooth current distribution good radiation pattern can be achievable with this proposed design of balun and antenna.

Table 5. Comparison with the recently reported broadband biconical antenna

Reference	Radiation pattern E-plane(3-dB beamwidth in degree)	Frequency band	Relative gain (dB)
[46]small broadband antenna 	Varies 50-130	15-40GHz	varies≈(1-5)
[47] sphericallycappedbiconical antenna 	Varies 20-36.9 (considered for different cone angles)	0.3-26 GHz	Not considered
My proposed antenna	Varies≈ (67.1-101.1)	3-40GHz	varies≈(0.82-1.80)[simulated]

[48] canonical sleeve antenna 	Varies≈(35-66)	0.5-3.6GHz	varies≈(0.3-4.2)[simulated]
[49] Assymetric capped biconical antenna  (b) Cross section view	Varies≈(90-120)	0.5-3 GHz	Less than 5dB
[50] conventional biconical antenna with ring and cylinder 	Varies≈(30-65)	1.5-41 GHz	varies≈(1.8-4.5)

6. Conclusion

In this thesis work new compact wideband antenna designed with blended edge shape ring and cylinders also sleeve balun has been proposed and investigated for broadband applications. Due to symmetrical biconical section; this antenna shows characteristics of appropriate radiation pattern for wideband. In this research new design technique of blended edge and ring has been proposed for reducing the influence of the cable effect on the antenna radiation pattern. Also sleeve baluns are designed here for improving 3dB beamwidth of the radiation pattern over the frequency range 3-40 GHz. The simulated VSWR of the antenna has broad impedance bandwidth starting at 3 GHz and continues upto 40 GHz with VSWR≤ 2. The simulated radiation patterns reveals that with increasing frequency the 3dB beamwidth varies from 101.1 to 83.3 degree. The simulated gain of the antenna is maximum 4dB with the increasing frequency; which is lower comparing with previous literature. It fulfills the criteria for desired low gain for broadband antenna.

The simulated performance is verified by using the prototype of the antenna with connecting cable for 20GHz. the fabricated proposed antenna works from 3 to 16 GHz with VSWR≤2 also shows 8 shape Eplane and omnidirectional H plane over the frequency range. The stable radiation pattern over the broad frequency range has proved that this proppose d antenna is very suitable for broadband like emc measurement purpose. Future development of this research will be done by testing the fabricated antenna with appriopriate 40GHz cable.

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