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An investigation on installed performances of VHF and UHF turnstile antennas on 3U CubeSat platforms

3U küp uydu platformlarında VHF ve UHF turnike antenlerinin kurulu performansları üzerine bir inceleme

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Abstract

In this article, operational performance variations of VHF and UHF turnstile antennas widely utilized in Cube Satellites (CubeSats) are investigated according to their placement positions on 3U size platforms. Considering the utilizable space constraints in CubeSats and the volume of the orbital deployer case, a platform-integrated deployable turnstile antenna concept is applied for VHF and UHF antennas designed at 145 MHz and 435 MHz, respectively. The performances of conceptual deployable turnstile antenna designs are optimized by placing them separately in the central and edge regions of the 3U CubeSat platform. Then, their performances in the scenarios of joint use on the same platform are also investigated. The obtained results show that while the location of the antennas does not significantly affect the performances in individual placements, the performance of the UHF antenna is substantially increased in the central placement where VHF and UHF are installed on the same platform.

Keywords: CubeSat, Installed performance, Interaction analysis, Turnstile antenna, VHF antenna, UHF antenna

Öz

Bu makalede, küp uydularda yaygın olarak kullanılan VHF ve UHF turnike antenlerinin 3U boyutundaki platformlarına yerleşim konumlarına göre operasyonel performans değişimleri incelenmiştir. Küp uydulardaki kullanılabilir alan kısıtlamaları ve yörüngesel dağıtıcı kasasının hacmi göz önünde bulundurularak, sırasıyla 145 MHz ve 435 MHz'de tasarlanan VHF ve UHF antenler için platforma entegre konuşlandırılabilir turnike anten konsepti uygulanmıştır. Kavramsal dağıtılabilir turnike anten tasarımlarının performansları, 3U küp uydu platformunun merkez ve kenar bölgelerine ayrı ayrı yerleştirilerek optimize edilmiştir. Daha sonra, aynı platformda birlikte kullanım senaryosundaki performansları da incelenmiştir. Elde edilen sonuçlar, antenlerin yerleşiminin tek tek yerleşimlerde performansları önemli ölçüde etkilemediğini, ancak VHF ve UHF'nin aynı platforma yerleştirildiği merkezi yerleşimde UHF anteninin performansının önemli ölçüde arttığını göstermektedir.

Anahtar kelimeler: Küp uydu, Kurulu performans, Etkileşim analizi, Turnike anten, VHF anten, UHF anten

1 Introduction

Space technologies have grown tremendously over the last three decades by enabling the development of numerous artificial satellites placed in orbit around the Earth or other planets for military, commercial or scientific purposes. These satellites can be categorized as Low Earth Orbit (LEO), Medium Earth Orbit (MEO), Geosynchronous Earth Orbit (GEO) and High Elliptical Orbit (HEO) according to their orbital altitude, and can also be classified as communication, observation, remote sensing and navigation satellites according to their application areas. National space agencies and private companies have had to make long-term and large investments in this field since the average build-up time of a conventional bulky satellites is approximately four years and its cost is around 50-100 million US dollars [1]. In addition to the cost of building these huge satellites, the launch costs for placing it into the desired orbit are also quite high considering their high weight (over 500 kg) and increase depending on the total mass of the satellite. These high budget requirements severely limit space exploration activities, especially for non-commercial scientific purposes.

In 1999, a scientific small satellite project was proposed jointly by academics from California Polytechnic State University and Stanford University that would allow frequent launches to increase access to space and ensure continuous development in satellite technologies [2]. The main aim of the project is to reduce launch costs by producing comparatively lighter and compact satellites that can be placed on launch platforms as secondary payload or carried into orbit by International Space Station (ISS) crew. The success of this project has paved the way for the design of low-profile, low-weight, low-cost small satellites, called CubeSats, composed of stripped-down subsystems and modularly compatible with standard launch vehicles. Essentially, the operational subsystems required for control, command and communication activities and the payloads added for mission-specific purposes constitute the two basic parts of the modest subsystem architecture of a CubeSat. Also, this simplified subsystem architecture allows designers to focus on the development of critical payloads and provides

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the opportunity to use commercial off-the-shelf (COTS) products with space heritage for operational subsystems.

Following their success in research and education, CubeSats have attracted industry attention due to their cost-effective yet promising features that provide an affordable trial-and-error opportunity to validate new space technologies. Since the risk of failure is unacceptable in the conventional high-cost satellites, each subsystem utilized must be backed up with a hot or cold redundant subsystem whose operational capability has been previously verified in the space environment against possible malfunctions. In hot redundancy, the subsystem and its space-heritage redundant are energized simultaneously and the function of subsystem on satellite is maintained as long as at least one of them remains operational. On the other hand, in a cold backup system, only one of the subsystems is operational at the same time and continues to operate until a failure occurs, at which time its space-heritage redundant backup system is switched on and takes over its operation. While both types of redundancy ensure operational continuity, they dramatically increase the satellite's system complexity, weight, and volume.

Providing the space qualification for each subsystem can be achieved in a short time with an expendable, low-cost CubeSat that contains only the subsystem desired to gain space heritage as the payload and COTS operational subsystem products with space heritage, instead of high-cost satellites. In this way, dozens of different mission-oriented CubeSats are carried into orbit on just a single launcher as companions of the launcher's main payload (usually a fairly heavy satellite or spacecraft) without any negative impact on operational process of the main payload. These advantages have made CubeSats one of the most popular proof-of-concept prototyping platforms for space applications over the last two decades.

This high demand for CubeSats due to easy accessibility has also led to the need to standardize their masses and dimensions, which vary depending on implementation types. CubeSats are dimensionally standardized by a cube shape called a "U" unit, with dimensions of 100 x 100 x 113.5 mm^3, and their size varies between 0.25U and 27U [3]. On the other hand, the mass classifications of small satellites are standardized according to their total weight such as mini (100-180 kg), micro (10-100 kg), nano (1-10 kg), pico (0.1-1 kg) and femto (0.01-0.1 kg) satellites. CubeSats are categorized as the nanosatellite since the maximum allowed standard weight per unit (U) is 1.33 kg [4]. Another purpose of these standardizations is to reduce the proper placement complexity of CubeSats on launchers during transportation. Before the orbital deployment process, CubeSats are stored in a standard-sized deployer compartment case designed to have a compatible interface with launchers. Thus, the launcher can be used at maximum capacity during its each voyage into space, since the number of CubeSats that the launcher can carry during the transportation can be clearly determined and planned. When the launcher arrived to desired orbit, the hatch of deployer compartment system is opened and the loaded spring at the bottom of the case ejects CubeSats into the orbit. On the other hand, the deployer case volume strictly limits the size of any component on a CubeSat. Therefore, the folded dimensions of potentially deployable components such as solar panels, antennas, etc. must be within the dimensions that can be stored inside the compartment during launch. This limitation makes deployable antenna systems indispensable for CubeSat systems, especially for large-sized telemetry and telecommand antennas operating at lower frequencies due to longer wavelengths.

Antennas are one of the most important components for CubeSat platforms that transmit and receive radio waves for different purposes such as communication, telemetry, telecommand, positioning, etc. However, most of the antenna systems used on conventional satellites are not suitable for CubeSats due to the profile limitations of the deployer systems. In general, either single-antenna or multiple-antenna configurations can be implemented for uplink and downlink operations depending on mission requirements and mechanical constraints. The operational frequencies of CubeSat antennas are usually chosen from the Industrial Scientific Medical (ISM) and amateur radio frequency bands that are not require any frequency allocation obligations or usage fees due to reduce operating costs [5]. The downlink frequency used to send telemetry data to the ground station is generally higher than the uplink frequency used to receive telecommand data from the ground station. Since the telemetry, tracking and control subsystems are the first subsystems to establish communication with ground stations after orbital deployment, the reliability of this connection and all subsequent satellite operations depend on the success of this phase [6]. Therefore, the UHF band around 435 MHz and the VHF band around 145 MHz have been very popular frequency bands since the development of CubeSats for downlink and uplink operations, respectively [3-11]. CubeSat designers commonly choose these bands for some practical reasons, such as low-loss propagation characteristics and the large variety of COTS components operating at these frequencies. However, antenna lengths are increasing considerably since free-space wavelengths in the VHF and UHF radio bands range from 300 mm to several meters. This situation making the deployable wire-based antenna structures an excellent choice for volume-constrained structures such as CubeSats [10]. Deployable wire-based antennas are stowed in a coiled state on the CubeSat chassis during launch, in accordance with the profile limitations of the deployer case. Once the orbital placement of CubeSat is complete, the stowed antenna is released to achieve operational form, typically using a heated resistor as a release mechanism.

One of the most widely used solutions for VHF and UHF antenna subsystems of CubeSats are quite simple, very flexible and ultra-low-cost whip antennas that can be implemented in monopole, dipole and turnstile feed configurations. It is even possible to use a piece of metallic tape measure as the radiator for a single-band VHF or UHF antennas with a monopole or dipole configuration. A V-shaped dipole antenna made of a piece of steel tape measure that is implemented with a coaxial balun structure for use in CubeSat missions is presented in [11]. The tape measure peace is formed as V-shape in order to manipulate the radiation pattern of the designed VHF antenna to desired direction. Another tape-measure-based antenna in a deployable monopole antenna configuration in the UHF band is implemented on a CubeSat platform called PhoneSat that is built around an unmodified COTS smartphone by NASA [12]. In [13], CubeSat XI-IV developed by the University of Tokyo, successfully sent data obtained from its COTS camera to the ground station via a deployable UHF band linearly polarized dipole antenna. It is also possible to design dual-band antennas that can be operational in both VHF and UHF bands. In [14], the first and third harmonics of a monopole antenna are excited at 130 and 390 MHz, respectively. However, these antenna structures require additional RF circuits to separate the two bands in order to provide single-port dual-band performance.

The bottleneck of CubeSat communication, especially for high data rates, is the limited output power of satellites. Additional losses such as polarization loss, atmospheric loss, multipath interference, path loss, low antenna efficiency or gain, etc. require an extra link margin to maintain the operation in space applications. This can be accomplished by increasing antenna gains, which helps increase link margin, or by reducing losses that negatively impact the link budget. One of the most suitable solutions to reduce both atmospheric attenuation and polarization loss is to use circularly polarized antennas. While linearly polarized antennas are advantageous for communication links where the orientations of the transmit and receive antennas are well-aligned, the orientations of Cube-Sat antennas change continuously with respect to the ground station antenna due to its regular motion in orbit. These polarization-misalignment losses resulting from the operational conditions of space applications can be avoided by using circularly polarized antennas, which are inherently independent of orientation [15]. Circular polarization is also more suitable for trans-atmospheric communication since the rotating electric field according to direction of propagation making it more resistant to atmospheric attenuation caused by rain, fog, and ionospheric disturbances.

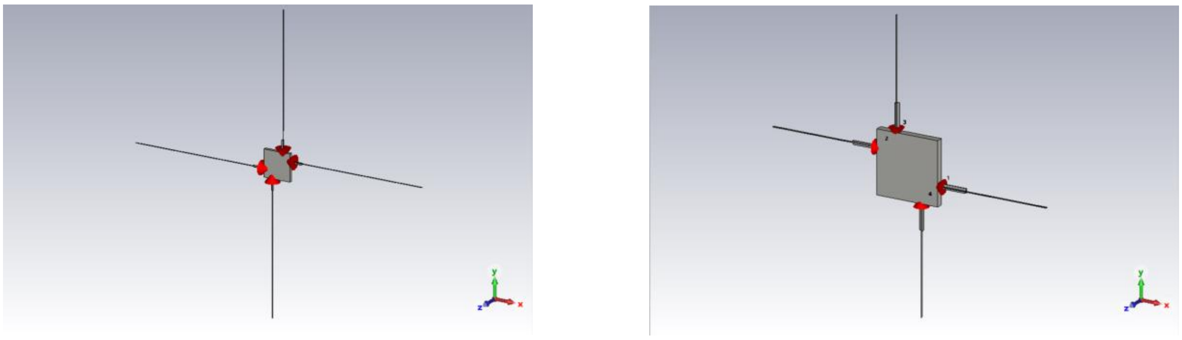
Benefiting from the advantage of circular polarization as well as the ability to be easily deployed, turnstile antennas have become a very popular solution option for reaching high data rates with their simple but effective antenna designs. Turnstile antennas consist of two dipole antennas placed perpendicular to each other and provide more directional circularly polarized radiation with higher gain compared to linearly polarized and omnidirectional monopole and dipole antennas. Circular polarization is achieved by creating a 90° phase difference between the dipoles at the operational frequency, either by adding a physical quarter wavelength path or by a 90° phase shifter between the feeds of the dipoles. [16-19]. It is also possible to obtain a turnstile antenna configuration by using four monopole antenna arms fed with a 90° phase difference placed on each side of a square [20-24]. Additionally, the monopole antenna arms can be optimized to provide high-gain radiation in the desired propagation direction, considering their positions relative to each other and the CubeSat platform [25]. On the other hand, the rapid increase in the variety of space-qualified deployable VHF and UHF commercial turnstile antenna products makes it more essential to optimize the installed performance of these COTS products on the platform used rather than optimization of the antenna design [26, 27]. Especially as the size of the CubeSat platform used increases, the placement options of COTS antenna products increase combinatorially. This situation forces CubeSat system designers to focus limited project time on the development of payload technology by minimizing operational risks in satellite communication with appropriate placement of COTS antennas on utilized platform. This situation directs CubeSat system designers to utilize functionally validated COTS antennas in space environment and to allocate limited project time to determining the most appropriate antenna and main payload placement positions on the platform in order to minimize operational risks in satellite communications.

In this study, the installed performances of deployable VHF and UHF turnstile antennas on 3U CubeSat platforms, which offer an optimum solution considering the cost and usable volumes for the on-board components, are investigated. Firstly, a circularly polarized deployable turnstile antenna concept is applied for VHF and UHF band antenna designs commonly used in realized CubeSats in literature. The 3U platform size, which is statistically the most preferred CubeSat size among CubeSats with 44.8%, is selected as the antenna placement platform on which the study to be conducted [5]. The performances of the designed conceptual VHF and UHF turnstile antennas are optimized by placing them separately in the central and edge regions of the determined CubeSat platform. The performance variations of these platform-specific optimized turnstile antennas are investigated for individual and tandem placement scenarios.

2 Material and method

2.1 Deployable VHF and UHF turnstile antenna design concepts

The space-qualified deployable COTS turnstile antenna products, especially in the VHF and UHF bands, have become very popular elements for CubeSat system designers as payload diversity increases and the need for high speed and high amount of data transmission for CubeSats becomes inevitable. In order to be compatible with all CubeSat applications of different U sizes, these COTS antenna products are generally designed by taking the unchanging aspect plane as reference (100mm x 100mm). Therefore, most of the deployable COTS antenna designs are built on a relatively thin square pedestal that can fit on the edge surfaces in the desired propagation direction axis of the 1U CubeSats or between any two U-cubes composing multi-U sized CubeSats. Accordingly, four deployable monopole antenna arms are placed perpendicular to each other on the four sides of the pedestal and excited with 90° phase difference successively. Depending on whether the excitation phase difference between the monopole arms is positive or negative in the clockwise direction, the turnstile



(a) (b)

Figure 1. The conceptual deployable turnstile antenna designs for (a) VHF band and (b) UHF band.

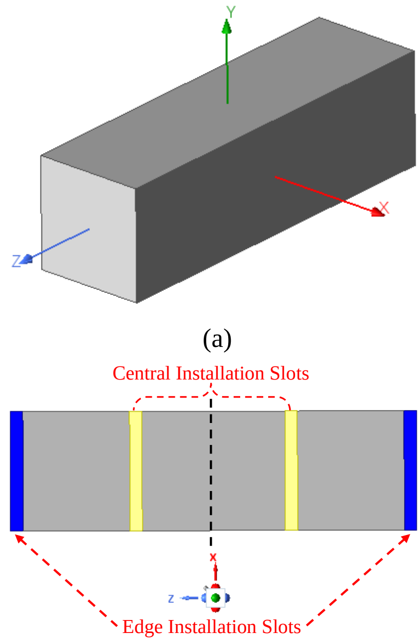
antenna performs right-hand circularly polarized (RHCP) or left-hand circularly polarized (LHCP) radiation patterns.

In order to be utilized in the platform installed performance analyses, which is the main objective of this study, two conceptual deployable antenna designs operating in VHF and UHF bands that mimic COTS CubeSat antennas are implemented by using CST Studio Suite as shown in Figure 1 (a) and Figure 1 (b), respectively. In the presented design concept, the z-axis is considered as the propagation direction and the pedestal is positioned in the x-y plane. The conceptual antenna designs are formed by placing a quarter wavelength (λ/4) monopole antenna arm on each of the four side-surfaces of the pedestal considering the lengths and maneuvering space of the deployment apparatus. Thus, the maximum dimensions of the designed deployable antennas do not exceed the size of the pedestal in the stowed state and can easily deployed when released by the mechanism apparatus. Ultimately, the proposed turnstile antenna designs are made as close as possible to COTS deployable CubeSat antennas considering their general characteristics and limitations.

Since the wavelength in the VHF band is larger than that in the UHF band, the length values of the monopole arms are expected to be longer for the VHF band turnstile antennas unless a special design technique is applied. Also, the monopole arm lengths should be optimized according to the utilized platform in both frequency bands to obtain efficient radiation patterns. On the other hand, the monopole arm length on each surface can be optimized individually in order to improve the axial ratio (AR) of circular polarization. However, the monopole arm lengths are kept equal in order to preserve the simplicity of the conceptual antenna designs in all analyses in this platform installment effect-based performance investigation study. Moreover, in order to make the scenario of jointly use on the same CubeSat platform more realistic, the monopole arms of the VHF and UHF antenna designs are excited to provide their most commonly used polarizations in literature, RHCP and LCHP, respectively. In this way, the possibility of the radiation patterns of the antennas affecting each other and compromising data transmission is aimed to be reduced. Thus, the performances of both antenna designs are individually optimized according to the placement locations on the utilized 3U CubeSat platform and the performance changes of the optimized sized antenna designs in tandem installation (co-use) scenarios are clearly examined.

2.2 3U CubeSat platform

The 3U platform size is selected for the antenna installation platform, as the most cost-effective CubeSat size with dimensions of 100 x 100 x 340.5 mm^3. Although it is known in the literature that dielectric materials on the platform surface may affect the antenna performance according to operating frequency in real applications, this effect is negligible for relatively low frequencies VHF and UHF [28-30]. Therefore, the platform structure is simplified and assumed as a perfect electrical conductor (PEC) as shown in Figure 2 (a). Since the platform structure is mirror image symmetric with respect to the black-dashed line as seen in Figure 2 (b), it can be said that there are only two different possible placement slot positions (blue and yellow) for each antenna design.



(a)

(b)

Figure 2. Simplified model of 3U CubeSat: (a) perspective-view and (b) side-view.

3 Results and discussion

The free-space radiation performances of monopole antennas, which are also utilized in this study, vary depending on the size of the installation platform. On fixed-size platforms, such as 3U CubeSat, optimizing the performance of antenna designs according to their position on the platform is still an efficient method, since the antennas are ultimately intended to operate on these platforms.

3.1 Individual installations

Firstly, the performances of the designed conceptual VHF and UHF turnstile antennas are optimized individually according to their installation positions on the platform.

3.1.1 Installed performance optimizations of the VHF antenna design

The conceptual turnstile VHF antenna design is individually placed in the side and central slots and its four identical monopole antenna arm lengths (L_{arm}) are optimized for both different installation case as given in Figure 3 (a) and (b). It is observed that the optimized L_{arm} value is 490 mm at 145 MHz operating frequency to obtain maximum RHCP gain in both placement scenarios. As can be seen from Figure 4 (a)-(d), for a turnstile antenna design in the VHF band, the installation position variations on a 3U CubeSat platform do not cause any significant change in terms of S_{11}, AR and RHCP gain patterns. Even so, it can be said that the results of the central slot placement are slightly better and relatively preferable to the edge slot placement.

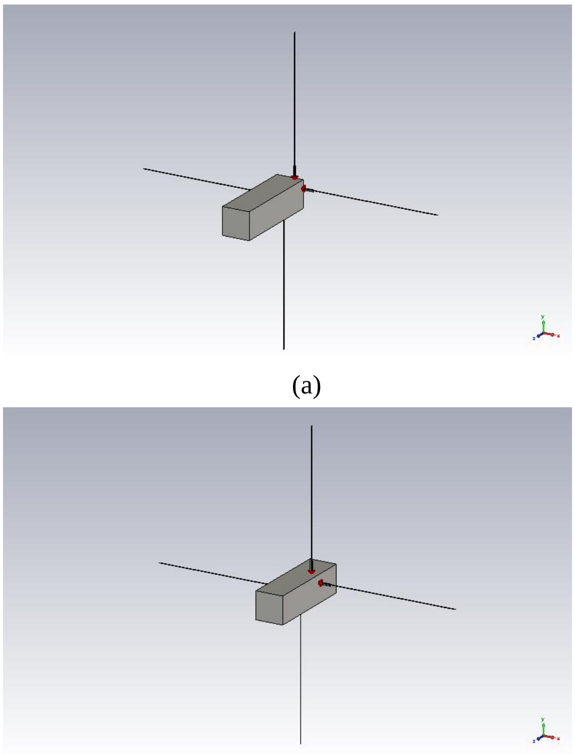


Figure 3. Individual installation scenarios for VHF antenna design: (a) edge slots and (b) central slots.

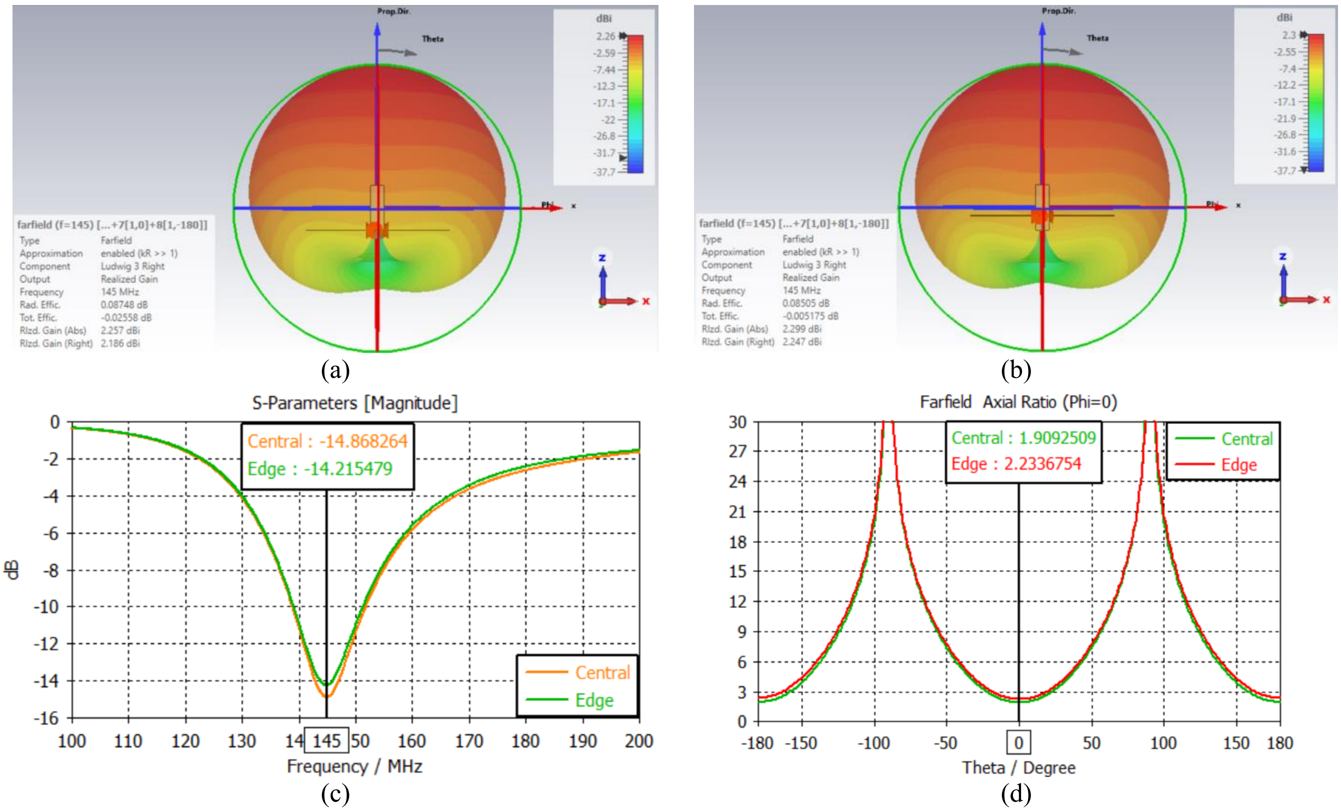
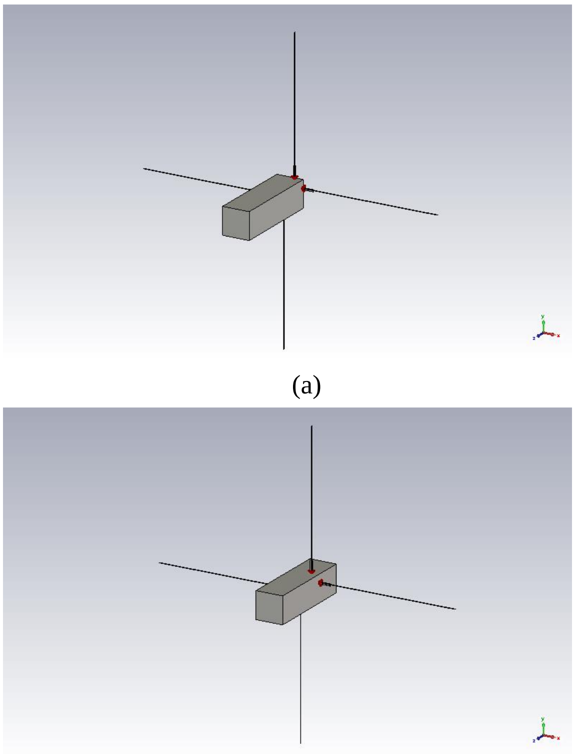


Figure 4. The optimized VHF antenna: RHCP gain performances for the placement of (a) edge slots, (b) central slots, and performance comparison of (c) S_{11} and (d) axial ratio.

3.1.2 Installed performance optimizations of the UHF antenna design

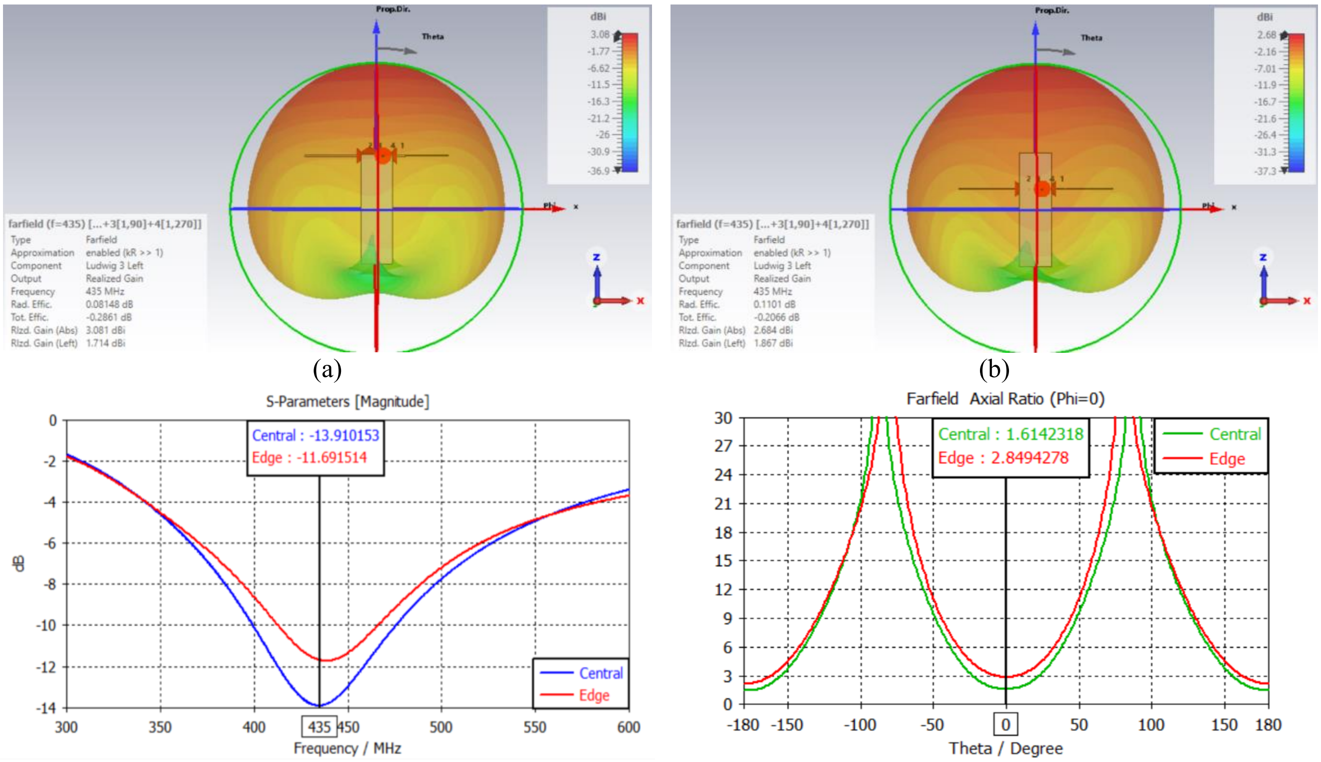
The individual placement performance optimizations of the conceptual turnstile UHF antenna design are realized for the side and central slots as shown in Figure 5 (a) and (b). Considering that the UHF frequency band is relatively higher and the wavelength is smaller, the fixed dimension 3U platform size is also larger then compare to VHF band in terms of electrical length. Therefore, the installation position has more impact on the antenna performance, and maximum LHCP gains are achieved with two different L_{arm} values, 174 mm and 182 mm, at 435 MHz operating frequency for edge and central installation options, respectively. The high similarity in the LHCP gain radiation pattern results of both placement options presented in Figure 6 (a) and (b) indicates that the optimization quality of the antenna designs is sufficiently high. On the other hand, when the results in Figure 6 (c) and (d) are examined, it is observed that the central slot placement provides better performance results not only for S_{11} and but also in terms of AR. Since even small improvements in these terms are of vital importance for the applications requiring long-distance communication with limited power, such as CubeSats, the central slot placement can be recommended for UHF turnstile antennas. Thus, the communication link budget can be used more efficiently by reducing the return loss and polarization loss factors increasing proportionally with the S_{11} and AR values, respectively.



(a)

(b)

Figure 5. Individual installation scenarios for UHF antenna design: (a) edge slots and (b) central slots.



(a) (b)

(c) (d)

Figure 6. The optimized UHF antenna: LHCP gain performances for the placement of (a) edge slots, (b) central slots, and performance comparison of (c) S_{11} and (d) axial ratio.

3.2 Tandem installations

The effects of placement positions on the antenna performances are also analyzed in the case of installing these optimized VHF and UHF turnstile antennas together on the same platform, called tandem installation.

3.2.1 Installed performance analyses of placement in edge slots

The antenna designs optimized specifically for the edge slots are simultaneously applied on the edge placement slots of the same 3U CubeSat platform, as shown in Figure 7, in order to analyze the effect of the antenna positions relative to each other and the platform on the co-operational performance of the antennas. In the previous sections of the study, the optimized L_{arm} values for the individual edge slot installations of the antenna designs operational at 145 MHz and 435 MHz are determined as 490 mm and 174 mm, respectively. Furthermore, these dimensions are also kept the same in the case of tandem installation of the antennas on edge placement slots of the same platform. The circularly polarized (CP) gain radiation pattern results obtained from the simulation of tandem placement of VHF and UHF turnstile antenna designs on the edge slots are shown in Figure 8 (a) and (b), respectively. When the results are examined, it can be said that using both antennas together in the edge slots of the platform adversely affects the performance of the CP gain patterns comparing their individual installation performance. AR results of the same antennas are also given in Figure 8 (c) and (d).

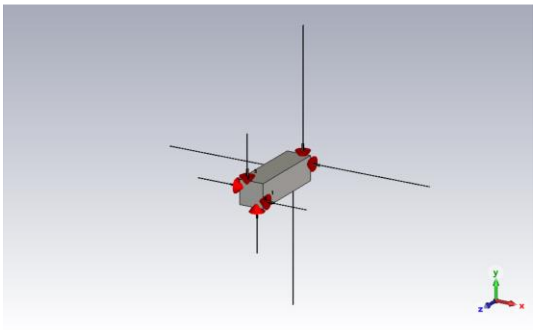
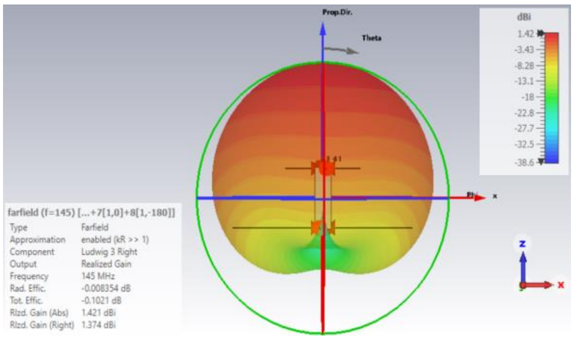
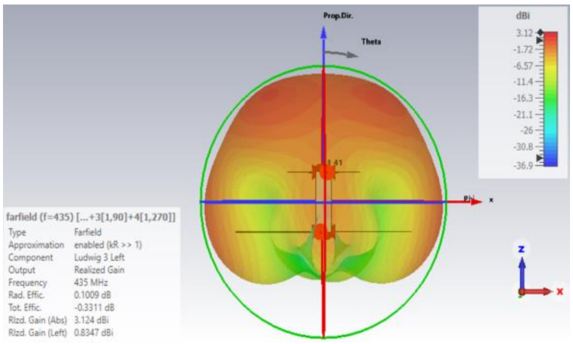


Figure 7. Tandem installation of the optimized VHF and UHF antenna designs in edge slots.

According to these results, the AR of the VHF antenna is improved in the tandem installation compared to its counterpart results for individual placement. On the other hand, the AR performance of the UHF antenna in tandem installation is dramatically deteriorated compared to the individual installation performance. In light of all these results, it can be said that tandem installation on edge slots is not efficient enough for 3U CubeSat platforms. Nevertheless, the decrease in antenna CP gains and the increase in polarization losses resulting from adversely affected axial ratios must be considered in the communication link budgets for uplink and downlink operations separately, in case edge slot placement is utilized in tandem installation by CubeSat system designers due to project constraints, accessibility etc.



(a)



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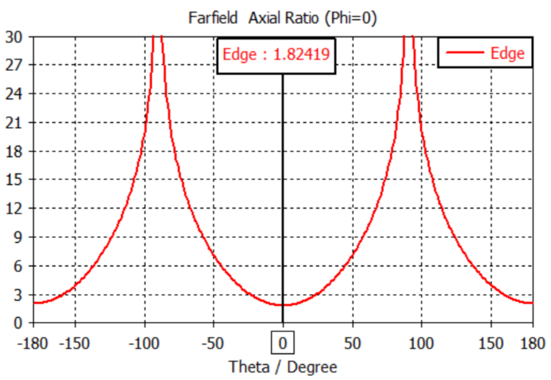
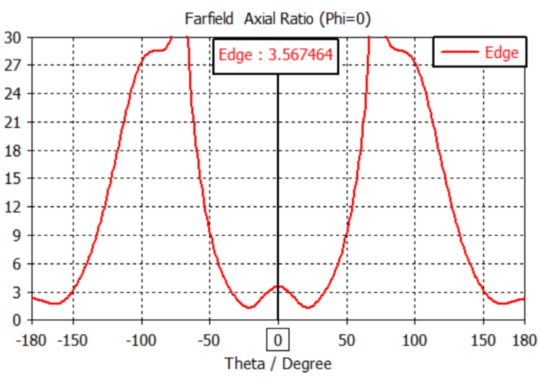


(c)



(d)

Figure 8. The edge placement performance results for antenna CP gains of a) VHF, and b) UHF, and axial ratio results for c) VHF, and d) UHF antennas.

3.2.2 Installed performance analyses of placement in central slots

To examine the effect of the central slot installations on the joint use performance of both antennas, the optimized VHF and UHF antenna designs specifically for central slot placements are implemented simultaneously to the same platform as seen in Figure 9. The dimensions of these antenna designs, optimized for operating frequencies of 145 MHz and 435 MHz and with Larm values determined as 490 mm and 182 mm, respectively, are also kept the same in this tandem installation performance analysis based on central slot placement. The CP gain pattern results obtained from the simulation of tandem placement in the central slots of VHF and UHF turnstile antenna designs are shown in Figure 10 (a) and (b), respectively. According to the results, it can be said that using both antennas together in the central slots of the platform negatively affects the CP gain performance of the VHF antenna design compared to the individual installation performances, but still provides better results compared to the tandem installation results in the edge slots. On the other hand, while the CP gain performance of the UHF antenna design is 1.973 dBi for individual placement for boresight direction (θ=0° & φ=0°) and 0.8347 dBi for tandem installation for edge slots, it is surprisingly improved to 4.926 dBi when both antennas are used together in the central slots of the 3U CubeSat platform. Similarly, the AR results for both antennas are significantly improved with tandem installation in the central slots, as can be seen in Figure 11 (a) and (b). The simulation results obtained for all placement scenarios are given comparatively in Table 1 in terms of S_{11}, CP gain and AR.

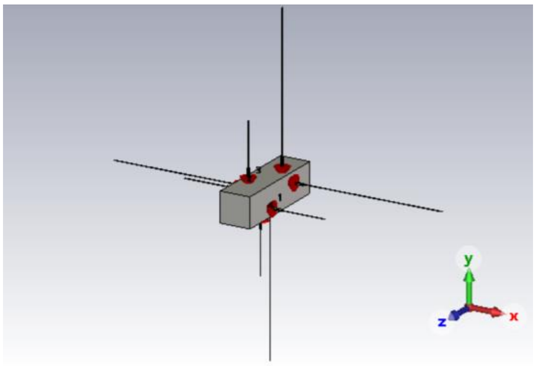


Figure 9. Tandem installation of the optimized VHF and UHF antenna designs in central slots.

In light of these results, it is observed that VHF turnstile antennas are less affected by the platform and more effective in individual central slot placement in terms of CP gain. On the other hand, it has been obtained from the results that UHF turnstile antennas are more effective in central slot placement in both individual and tandem installation conditions, but provide a significant CP gain advantage in central slot tandem installation. Moreover, tandem installation in central slots is the most prominent installation type in all the layout scenarios examined with its relatively lower AR, lower S_{11} and higher CP gain.

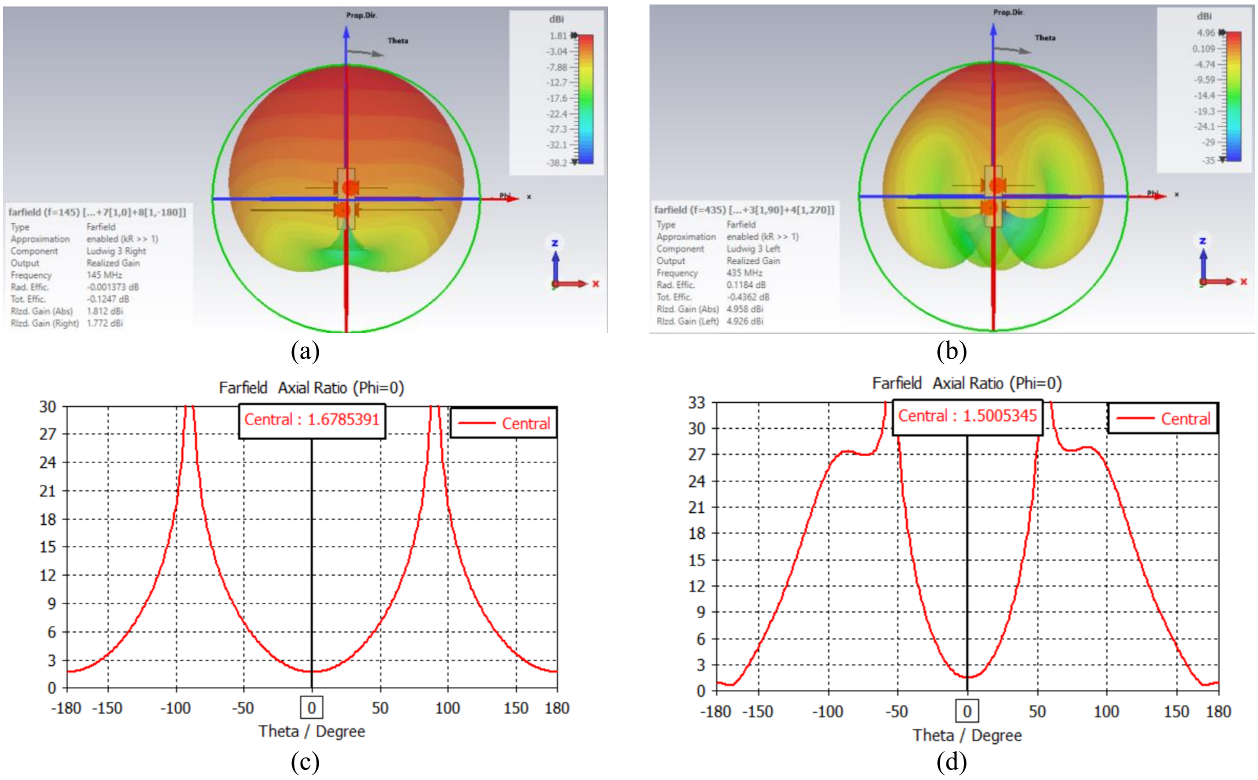


Figure 10. The central placement performance results for antenna gains of a) VHF, and b) UHF, and axial ratio results for c) VHF, and d) UHF antennas.

Tablo 1. Comparison of the obtained simulation results for all placement scenarios

		S_{11} (dB)		Axial Ratio (dB) (θ=0° & φ=0°)		CP Gain (dBi) (θ=0° & φ=0°)	
		VHF (145 MHz)	UHF (435 MHz)	VHF (145 MHz)	UHF (435 MHz)	VHF (145 MHz)	UHF (435 MHz)
Individual Installation	Edge Slot	-14.21	-11.69	2.23	2.85	2.186	1.714
	Central Slot	-14.86	-13.91	1.90	1.61	2.247	1.867
Tandem Installation	Edge Slots	-25.12	-12.33	1.82	3.56	1.374	0.8347
	Central Slots	-17.89	**-15.26**	**1.67**	**1.50**	1.772	**4.926**

4 Conclusions

In this study, the performances of VHF and UHF turnstile antennas, which are very popular in CubeSats and have a wide range of COTS products, are comparatively investigated in terms of S_{11}, AR and CP gain parameters according to their placement positions on 3U platforms. Considering the volumetric constraints in CubeSat applications, a platform-integrated deployable turnstile antenna concept is implemented and CP gain performances under ideal feeding conditions are optimized with respect to individual installation position on platform for VHF and UHF antennas designed at 145 MHz and 435 MHz, respectively. Furthermore, the effects of a nadir pointing 3U CubeSat platform on the performance results in individual and joint use scenarios for the central and edge slots placements are examined. According to the results obtained, although the position of the antennas does not significantly affect the performances in individual placements, the central slot placement is still more preferable for both VHF and UHF antennas. However, it is observed that there is a significant increase in the CP gain performance of the UHF antenna, along with the improvement in S_{11} and AR values in case of the central slot placement in tandem installation scenario of VHF and UHF antennas. It is understood that in case of tandem installation in central slots, physically larger VHF antenna contributes to CP gain performance of UHF antenna whereas relatively smaller UHF antenna causes congestion and CP performance of VHF antenna decreases compared to single installation scenario. The learnings from this investigation have critical importance to increase the communication link budget efficiency, especially for the satellite system designers developing CubeSat applications while utilizing COTS products. This study also aims to facilitate the antenna placement issue for CubeSat system designers even if they do not have sufficient antenna expertise. In light of this study, future studies can also be conducted using the exact dimensions and feeding network performances of COTS deployable turnstile antenna products implemented on various CubeSat platforms sizes.

Conflict of interest

The author declares that there is no conflict of interest.

Similarity rate (iThenticate): %12

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