Analysis and Design Of Polygonal Antenna for Ka-band Applications

Abstract The technological development of wireless communication requires finding a new techniques and optimizing them to meet the socio-economic demands, where currently a great competition in the field of invention and design of antenna that presents a key element to ensure a very reliable wireless communication. This short communication presents a new design of polygonal planar antenna for Ka-band applications using Momentum Agilent, where the effectiveness of this planar antenna determined by a numerical simulation with 10.14 dB of antenna gain at 24.5 GHz and return loss less than -10 dB at a frequency band [24.05-24.8 GHz] which we can be exploited such an antenna in a wireless communication system works in Ka-band.

KeywordsGain.Ka-band. The polygonal planar antenna. Method of Moments.

The micro-strip antenna can be used for wireless applications as it has the particular characteristic such as lightweight, easy to mount and it is easy to mass produce [1]which is good for the micro-strip antenna to be deployed in different fields, on the other hand the micro-strip antenna in its simplest form cannot meet the bandwidth requirements and gain for most wireless communication systems, overcoming these limitations, the micro-strip antenna can be used to its full potential.

To meet these requirements; several techniques have been developed which have proved their efficiency for planar antennas.This article focuses on the development of new antenna structures for Ka-band applications; Reducing the weight while ensuring the rigidity of the structure.

Based on [3-4]; we propose a new Ka-band application for the polygonal antenna where we propose to present the reflection coefficient, the VSWR and the gain of this polygonal antenna element.

Although the width of a patch antenna in its simplest form is one of the factors that affect the bandwidth width; but it is not practical to increase it to obtain satisfactory results.

Polygonal patch antenna shapes are currently considered very promising, especially for the design of compact antennas. It's designed by patch deformation to improve the performance of these types of antennas such as bandwidth, multi-frequency resonance, and gain.

Basing on the theoretical analysis in [3-4] ; from antenna theory, the unknown current density excited to calculate patch-radiating features and input impedance is given by[3]:

(1)

Where

G is the dyadic Green's function [8] of the dielectric

: are the observation and source vectors associated with the points on the metallic surfaces,

is the union of the patch surface and the finite ground plane surface,

is the incident field produced by the feed.

To simplify the calculations, the Fourier transforms of the entire domain basis functions is[3]:

(2)

The solution of equation (2) is generated by the method developed in [3]; and the results of measurements in [9]

The proposed polygonal antenna element was designed using Taconic RF-41, where are recommended as a low loss alternative to FR-4 materials and desirable to manufacture of satellite antennas.

This substrate has dielectric permittivity εr = 4.1, a dielectric thickness *h* = 0.787 *mm* and 0.05 *mm* conductor thickness and a loss tangent tan = 0.003.

The proposed antenna has a regular polygonal shape will be presented in Figure .1.

Fig.1 The inputs return loss (S11)

Figure.1 shows the return loss results by Momentum, where we notice that we get less reflection at resonance frequencies around 22 GHz, 24.5 and 25 GHz.

Fig.2 Radiation Pattern for Electric magnitude for Theta

Figure.2 shows the radiation pattern of the proposed polygon antenna around 24.5 GHz for variation in the Theta angle withTheta= 45° and it is clear that the energy is concentrated in a direction of an aperture 44° at -3 dB.

Fig.3 Gain variation

It is shown that for 24.5 GHz, the gain has reached a maximum value which makes the possibility of using this antenna for Ka-band applications.

Table 1polygonal antenna VSWR variations

Frequency [GHz]	VSWR
22.10	3.70618247003201070E0
22.25	2.61263576082948920E0
22.39	1.48964810389584890E0
22.54	1.81210960012063650E0
22.70	2.61301052903382750E0
24.19	1.60596577293616210E0
24.35	1.18579119109142140E0
24.50	1.17092306311432190E0
24.64	1.53907456046851230E0
24.80	1.86495256134741320E0
28.25	2.59694747670860340E0
28.39	2.20677316815588800E0
28.55	1.77828578085861300E0
28.70	1.18168659005946600E0
28.85	1.15595669417653530E0

28.99	1.34920746368853050E0
29.15	1.34676232940189620E0
29.30	1.34372504306339890E0
29.44	1.37985481805581700E0
29.60	1.34514732406433660E0
29.75	1.28473262368045460E0

It is clearly shown in Table 1 that in the resonated frequency exploited for this antenna, the VSWR value is significantly lower than 1.5 not only around 22 GHz but also around 24.5 GHz and 28.85GHz where the VSWR value is 1.17 and 1.16 respectively.

Based on the patch antenna theory, specific design for polygonal antenna working in Ka-band is presented. The multi-frequency resonances of the Ka-band were has been noticed. The analysis by method of moments shows the effectiveness of using a polygonal antenna to respond to specific needs, .For transition from micro-strip to antenna, micro-strip feed line was calculated in order to decide the matched resonance frequency, and then simulations with commercial software were followed up to verify the matching condition.

References

[1] C. A. Balanis (1997) Antenna theory analysis and design. New York: JohnWiley& Sons

[2] R. Garg, P. Bhartia, I. Bahl, A.Ittipiboon (2001)Microstrip antenna design Handbook. Artech house publishers

[3] M. Manzani, A. Alù, F. Bilotti, and L. Vegni (2004) Polygonal Patch Antenna for Wireless Communication. IEEE transactions on vehicular technology 53: 1434 – 1440

[4] M. Manzani, A. Alù, F. Bilotti, and L. Vegni (2003) Design of Polygonal Antennas with a Broad-Band Behavior via a Proper Perturbation of Conventional Rectangular Radiators. IEEE Antennas and Propagation Society International Symposium. https://doi.org/10.1109/APS.2003.1219229

[5] www.cst.com.

[6] www.keysight.com

[7] A. Harrabi, T. Razban , Y. Mahe , L. Osman , and A. Gharsallah (2005) Theoretical Approach for the Design of a New Wideband Ku-band Printed Antenna. ACES JOURNAL30:1200-1208

[8] F. Bilotti(2002)Progetto di componenti a microonde realizzati su substrati non convenzionali. Ph.D. dissertation, Univ. Roma Tre, Rome, Italy

[9] C. Vegni and F. Bilotti(2002)Parametric analysis of slot-loaded trapezoidal patch antennas. IEEE Trans. Antennas Propagat50: 1291–1298

[10] R.Yahya, T.A.Debidni (2011) Compact CPW-fed antenna with ultrawideband and dual polarization. Mediterranean Microwave Symposium 110–112

[11] J-H.KIL,J-Kwan.Kim, Y-Jin Kim,H-M.Lee (2007) High Gain Antenna using Parasitic Shorted Annular Patch Structure. Asia-Pacific Microwave Conference 1–4

[12] H.Verrikalladi, O.Lafond,M.Himdi (2009) High-Efficient and High-Gain Superstrate Antenna for 60-GHz Indoor Communication. Antennas and Wireless Propagation Letters 8:1422–1425