RESEARCH ARTICLE OPEN ACCESS

Analytic Study about Slotted Waveguide Antenna to Enhance Radiation Pattern of These Antenna

Mayass Nassour [1], Moeen Younes [2]
Master Student [1], Assistant Professor [2]
Faculty of Mechanical and Electrical Engineering
Tishreen University
Lattakia - Syria

ABSTRACT

In this study, analysis of circular and Hexa shape-slot array located on the broad wall of rectangular waveguide antenna with reflectors is presented. For broad wall of the rectangular waveguide, the slot displacements from the wall centerline determine the antenna's sidelobe level (SLL) and the radiations pattern shape. For broad wall SWAs, the slot displacements. This paper presents a simple inventive procedure for the design of broad wall SWAs with good SLLs. For a specified number of identical circular and Hexa slots and given the required SLL and operating frequency, this procedure finds the slots length, width, locations along the length of the waveguide, and displacements from the centerline and compare the sidelobe and radiation pattern in two cases.

Keywords :- *Rectangular Waveguide, Slot, Gain, Sidelobes.*

I. INTRODUCTION

Slotted waveguide antenna is a type of antenna wich use in microwave and radar applications and on the Aircraft Suites so they should have some of properties fits this applications like:

Concentrate the radiated energy towards the target

Collect the reflected and scattered energy from the target

Operates as a spatial filter to receive radiated energy from the target only.

These advantages that made it suitable for use in remote communications, in radar navigation systems and also in spacecraft and aircraft. It also offers many features and characteristics but we will focus on our research to improve the characteristics mentioned earlier.

An antenna would be suitable if it exhibits high gain in one direction, while suppressing the sidelobes in all other directions. High gain serves to concentrate energy toward a target as well as collecting scattered energy from a target. Low sidelobes serve to act as a spatial filter that will help in resolving targets and determining their position

Rectangular Slotted Waveguide Antennas (SWAs) [1] radiate energy through slots cut in a broad wall of a rectangular waveguide. This means the radiating elements are an integral part of the feed system, which is the waveguide itself. The resulting sidelobe for antenna arrays is related to the excitations of the individual elements. In our study two types of slot displacement will investigated and studied which is uniform and nonuniform displacement and the sidelobe and the radiation pattern will be discussed with and without reflectors.

For rectangular slots, the slot length is about half the free-space wavelength. However, for circular and Hexa slots, as the ones used in this work, the exact length is to be optimized. For a desired SLL, the conductance's of the slots are obtained from a certain distribution, Chebyshev, Taylor, or Binomial; then an equation that relates these conductance's to the displacements from the centerline is used to deduce these displacements.

A prototype SWA with 6 circular and hexa slots, operating at a frequency of 3.4045 GHz, has been designed, fabricated, and measured using HFSS simulator, and the results show good analogy with the simulated ones.

II. CONFIGURATION AND GENERAL GUIDELINES

We will use WR-284 waveguide with dimensions a = 2.84 inch and b = 1.37inch. The design is done for the 3GHz frequency. Ten circular and hexa slots are made to one broadwall. The waveguide is shorted at one end and fed at the other.

A. Slot Positions

There are general rules for the longitudinal positions of the slots on the broad wall:

• The center of the first slot, Slot 1, is placed at a distance of quarter guide wavelength $\lambda g/4$, or $3\lambda g/4$, from the waveguide feed.

• The center of the last slot, Slot 10, is placed at $\lambda g/4$, or $3\lambda g/4$, from the waveguide short-circuited side.

• The distance between the centers of two consecutive slots is λg/2.

The guide wavelength is defined as the distance between two equal phase planes along the waveguide.

It is a function of the operating wavelength (or frequency) and the lower cutoff wavelength, and is calculated according to the following equation:

$$\lambda g = \frac{\lambda 0}{\sqrt{1-(\frac{\lambda o}{\lambda cutoff})}} = \frac{c}{f} * \frac{1}{\sqrt{1-(\frac{c}{2a*f})}}$$

where:
λ0 is the free-space wavelength calculated at 3 GHz.
c is the speed of light.
So:
λg=138.5mm.
and the total length of the waveguide will be 5λg as shown in Fig.1.

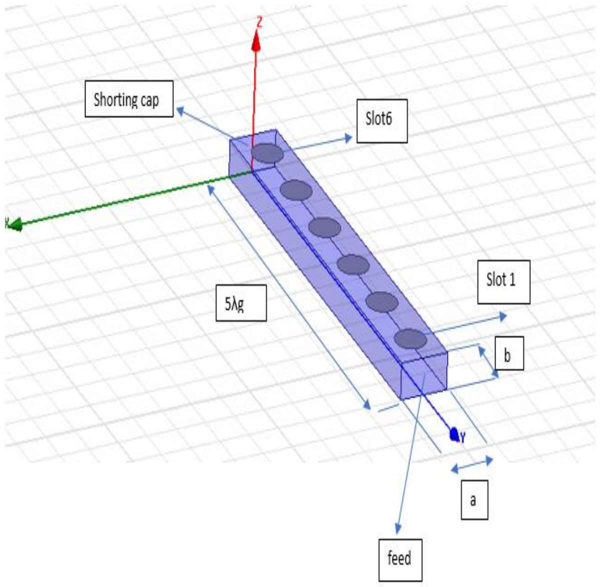

Fig. 1 Slotted waveguide dimensions

B. Slot Displacement

Slot displacement refers to the distance between the center of a slot and the centerline of the waveguide broadface, as illustrated in Fig. 2.

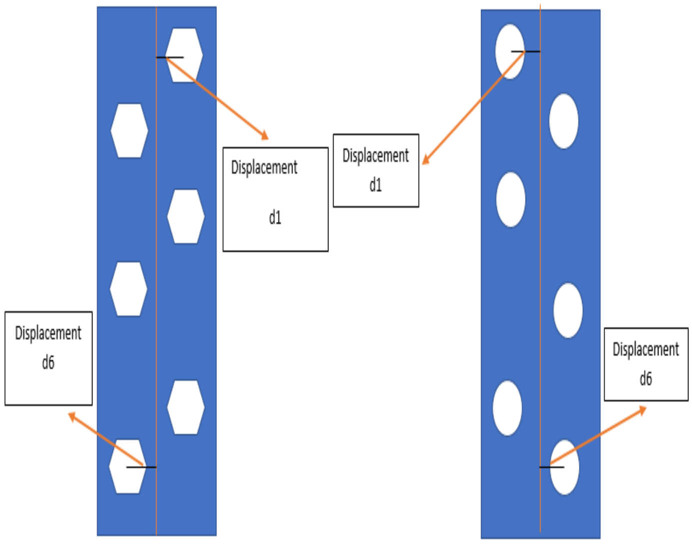

Fig. 2 Slot Displacement

Here we have Two cases:

B.1 Uniform Slot Displacements

The value of the uniform slot displacement that leads to a good reflection coefficient is given by [15, 16]:

$$d_u = \frac{a}{\pi}\sqrt{\arcsin\left[\frac{1}{N \times G}\right]}$$

$$G = 2.09 \times \frac{a}{b} \times \frac{\lambda_g}{\lambda_0} \times \left[\cos\left(0.464\pi \times \frac{\lambda_0}{\lambda_g}\right) - \cos(0.464\pi)\right]^2$$

Where:
N is the Number of slots which equal to 6.
λ0 = 100mm at 3GHZ.
So du wil equal to be 7.7mm.
C-Antennas was designed using HFSS Program as shown in fig:

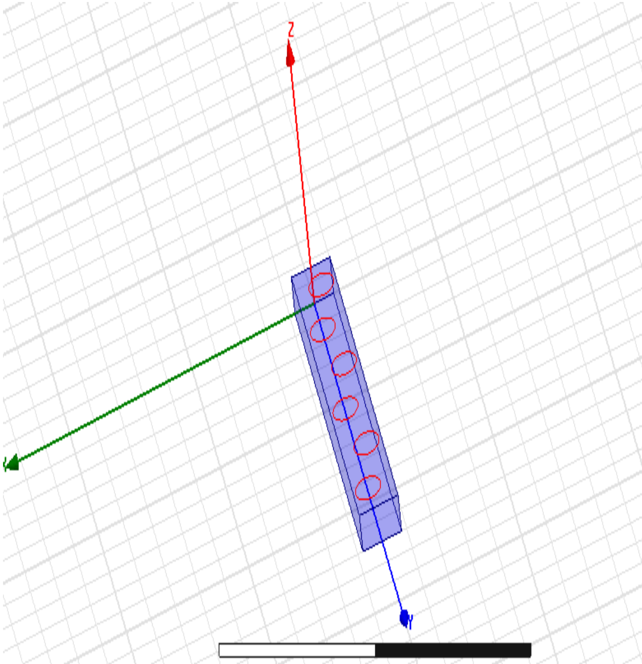

Fig. 3 Slotted waveguide antenna with circular shape

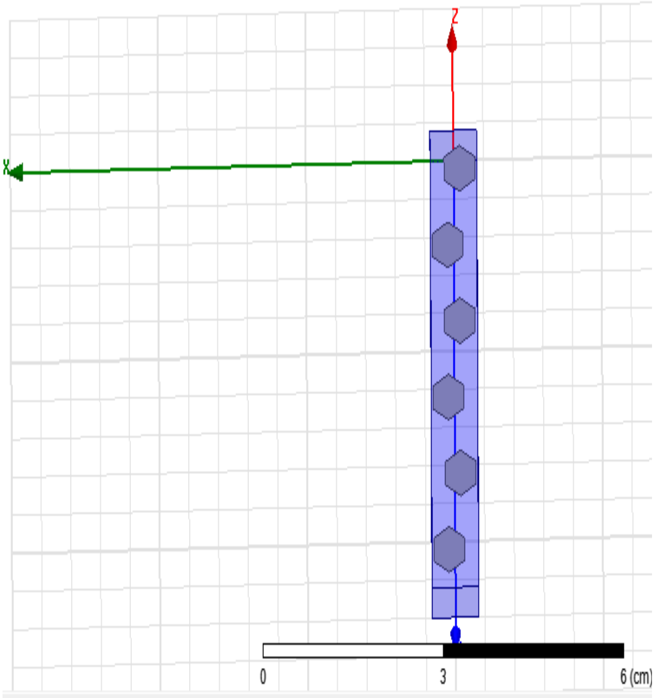

Fig.4 slotted waveguide antenna with hexa shape

Two metal sheets are then attached symmetrically, These 2 sheets act as reflectors, thus leading to beam focusing in the azimuth plane and as a result to a gain increase. The width of each metal sheet, L, is 4inch.as show in fig:

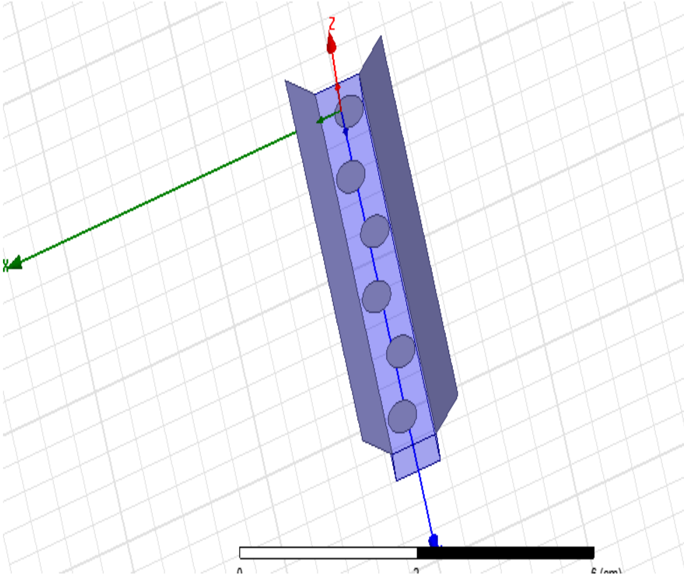

Fig.5 slotted waveguide antenna with circular shape and reflectors

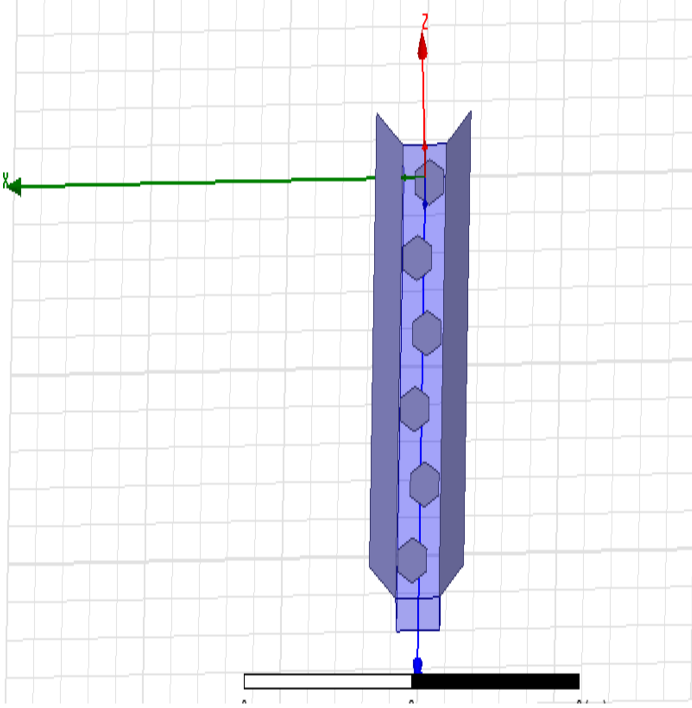

Fig. 6 slotted waveguide antenna with hexa shape and reflectors

B.2 Non-Uniform Slots Displacement

Here the slots made on the broad wall in random areas as show in figure

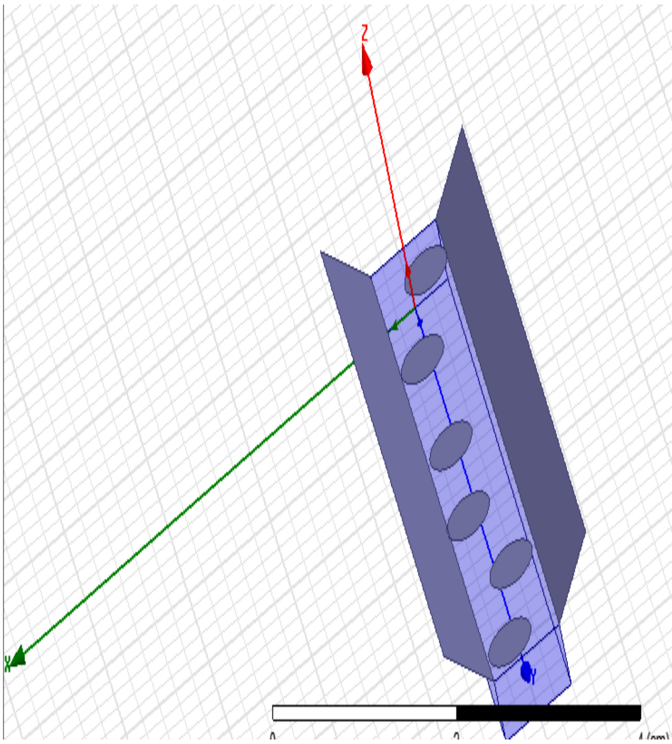

Fig. 7 slotted waveguide antenna with non-uniform circular slots

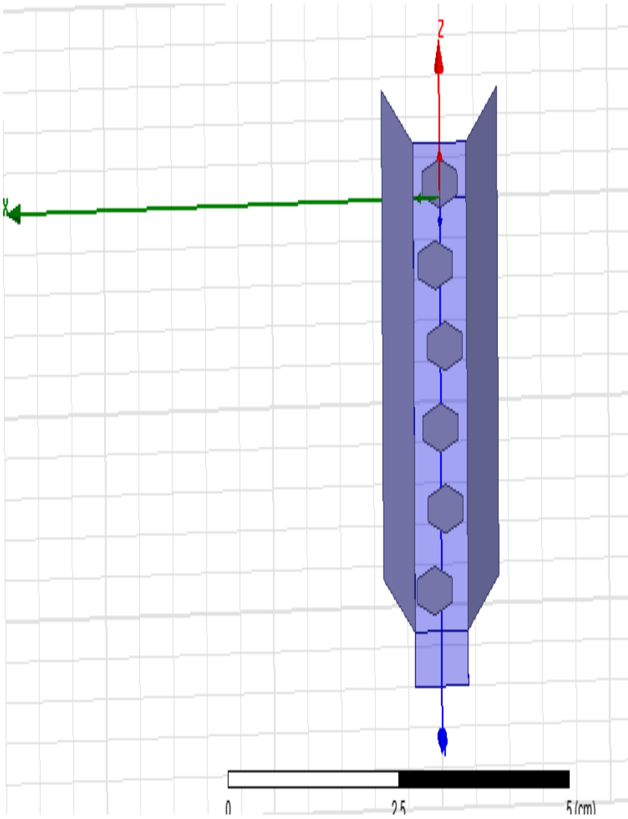

Fig. 8 Slotted waveguide antenna with non-uniform hexa slots

III. SIMULATION RESULTS

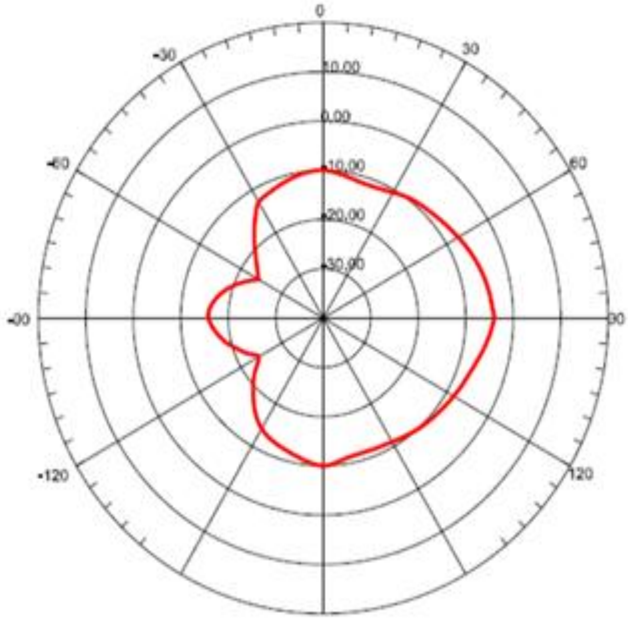

Fig. 9 Radiation pattern for slotted waveguide antenna with uniform circular slot.

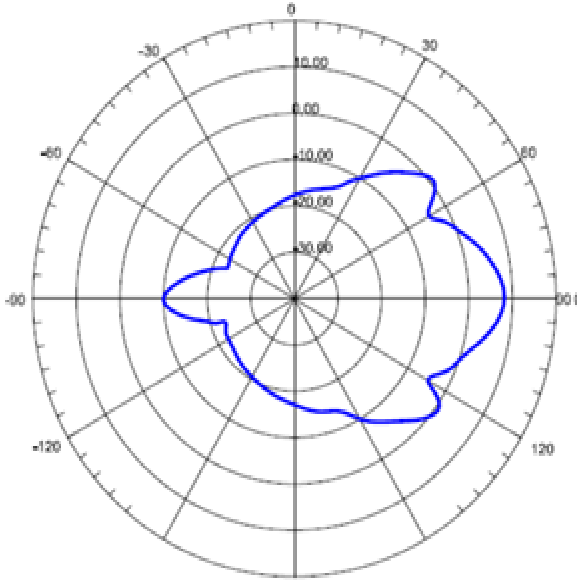

Fig. 10 Radiation pattern for slotted waveguide antenna with uniform circular slot and reflectors

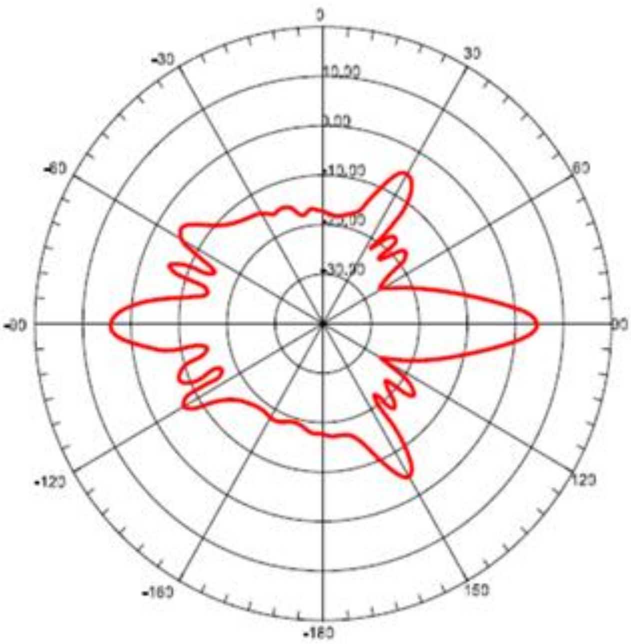

Fig. 1 1 Radiation pattern for slotted waveguide antenna with uniform hexa slot

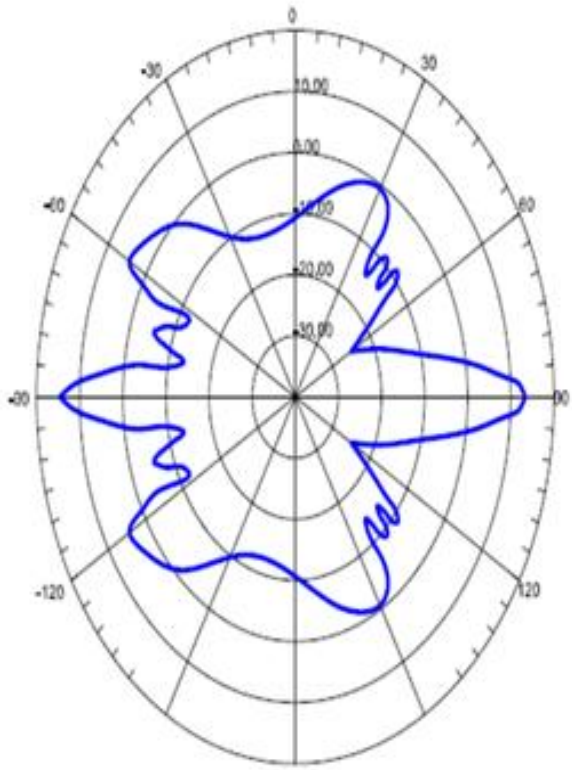

Fig. 12 Radiation pattern for slotted waveguide antenna with uniform hexa slot and reflectors

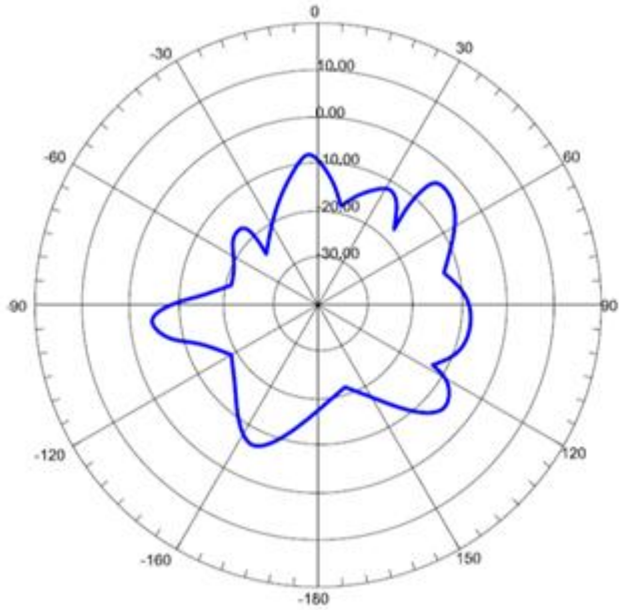

Fig. 13 Radiation pattern for slotted waveguide antenna with non- uniform circular slot and reflectors

IV. CONCLUSIONS

A 3 GHz slotted waveguide antenna was presented. It has 10 elliptical slots, with optimized dimen-sions, made to one broadwall and displaced around its centerline so as to obtain a 20 dB sidelobe level ratio. The antenna has a very broad azimuth plane beam and a peak gain of about 17 dB.Upon adding two reflectors to the antenna's edges, the beam is focused and the gain is increased
to about 20 dB.

REFERENCES

[1] D. Pozar, Microwave Engineering, 3rd ed. JohnWiley & Sons, 2005.

[2] John D.Kraus ,Ronald J.Marhefka“Antennas for all applications”,3rd ed.McGraw Hill,pp.304-308,2004.

[3] D. Howard, Ed., Dictionary of Electronics, 4th ed. Penguin Reference,2005.

[4] Andries Johannes Nicolaas Maritz,” Investigation and Design of a Slotted Waveguide Antenna with Low 3D Sidelobes” Stellenbosch University,2010.

[5] A. F. Stevenson, “Theory of Slots in a Rectangular Waveguide,” J. Appl. Phys., vol. 19 (1948): 24–38.

[6] M. Skolnik, Introduction to Radar Systems, 3rd ed. McGraw Hill, 2001.

[7] C. Balanis, Antenna Theory, 3rd ed. JohnWiley & Sons, 2005.

[8] J. Volakis, Antenna Engineering Handbook, 4th ed. McGraw Hill, 2007.

[9] Al-Husseini, M., A. El-Hajj, and K. Y. Kabalan, “High-gain S-band slotted waveguide antenna arrays with

elliptical slots and low sidelobe levels," PIERS Proceedings, Stockholm, Sweden, August 12–15, 2013.

[10] Mailloux, R. J., Phased Array Antenna Handbook, Artech House, 2005.

[11] Gilbert, R. A., Antenna Engineering Handbook, Chapter: Waveguide Slot Antenna Arrays, McGraw-Hill, 2007.

[12] Hilal M. El Misilmani, Mohammed Al-Husseini, and Karim Y. Kabalan" Design of Slotted Waveguide Antennas with Low Sidelobes for High Power Microwave Applications" Vol. 56, 15–28, 2015.

[13] Hilal M. El Misilmani, Mohammed Al-Husseini, and Karim Y. Kabalan" High-gain S-band Slotted Waveguide Antenna Arrays with Elliptical Slots and Low Sidelobe Levels" Progress In Electromagnetics Research Symposium Proceedings, Stockholm, Sweden, Aug. 12-15, 2013.

[14] Andries Johannes Nicolaas Maritz" Investigation and Design of a Slotted Waveguide Antenna with Low 3D Sidelobes" Master of Science in Engineering at Stellenbosch University March 2010.

[15] Venus Research and Development Site, \Deep space network, new beam-waveguide antenna, "Goldstone,California,

[16] Venus Research and Development Site, \Deep space network, new beam-waveguide antenna,"Goldstone, California, http://deepspace.jpl.nasa.gov/dsn/antennas/arrays.html.