Faculty of Electronic and Computer Engineering

DESIGN OF HIGH GAIN ANTENNA WITH HARMONIC SUPPRESSION USING T-SHAPE DGS AND SPURLINE

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DECLARATION

I declare that this thesis entitle "Design of High Gain Antenna with Harmonic Suppression using T-Shape DGS and Spurline" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : .....

Name : NURZAIMAH BINTI ZAINOL

Date : 31/10/2016

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering.

Signature : .....

Name : ASS0C. PROF. DR. ZAHRILADHA BIN ZAKARIA

Date : 31/10/2016

DEDICATION

I dedicate this thesis to ALLAH S.W.T, my loving family, my lover, and my beloved friends for their constant support and unconditional love.

I love you all dearly.

ABSTRACT

The use of novel antenna with harmonic suppression is an attractive idea. There are many applications that could benefit from this such as cellular mobile radio, factory monitoring and biomedical applications. The potential for highly efficient of harmonic suppression at harmonic frequency is offered by antenna itself. Conventionally, defected ground structure (DGS), electromagnetic band gap (EBG) and stub have been used for stop band characteristics. However, there are also challenges that arise from these antenna with harmonic suppression. One of them is the problem of fabricating the antenna which increase the cost and the other one they require large amount of circuit size and consequently require similar stop band characteristics which restrict their use in many important applications. The resulting antenna with harmonic suppression was ordinary one and have low gain at resonant frequency. Thus, a high gain antenna with harmonic suppression have gained a considerable interest over the past few years due to their advantages such as low cost, ease of fabrication and not complex. Therefore, this thesis presents a high gain antenna with harmonic suppression which produce broadband harmonic suppression with capability to suppress undesired harmonic signals from 3 GHz up to 8 GHz. These antenna with harmonic suppression are based on microstrip structure of T-shape DGS and spur line low pass filters by employing the perturbation theory, in which the dielectric properties of the substrate used affect the radiation characteristics of antenna. The antenna are designed at operating frequency of 2.45 GHz with harmonic suppression entirely second and third order. As a results, the final design of antenna has achieved a very good return loss which peaked up to -33.44 dB at 2.45 GHz operating frequency. In addition, it has an extremely high gain which achieved a 14.20 dB with a strong directional radiation pattern; and total efficiency achievement of the 2x2 antenna array is up to 98.86%. Besides that, the harmonic signals have been suppressed effectively from -29.19 dB to -7.77 dB at frequency of 3.24 GHz and achieved a broadband harmonic suppression. Experimentally, the measured and simulated results are found in an excellent agreement and achieved high gain compared to those in literatures whic has an average gain of 1 dB to 6 dB for the same applications. The antenna is designed and simulated by using Computer Simulation Technology (CST) Studio Suite. The presented work in this thesis consists of defining the characterizations for all subsystems which are preceded with optimized design process. It is believed that these high gain antenna with harmonic suppression would lead for a promising solution for RF/Microwave energy transfer particularly in suppressing the harmonic that degrade the system performance.

ABSTRAK

Penggunaan antena novel dengan penindasan harmonik adalah satu idea yang menarik. Terdapat banyak aplikasi yang boleh mendapat manfaat daripada ini seperti radio mudah alih selular, pemantauan kilang dan aplikasi bioperubatan. Potensi yang sangat berkesan penindasan harmonik pada frekuensi harmonik ditawarkan oleh antena sendiri. Konvensional, berpaling tadah struktur tanah (DGS), jurang elektromagnet band (EBG) dan puntung telah digunakan untuk ciri-ciri stop band. Walau bagaimanapun, terdapat juga cabaran yang timbul daripada antena ini dengan penindasan harmonik. Salah seorang daripada mereka adalah masalah-reka antena yang meningkatkan kos dan satu lagi mereka memerlukan sejumlah besar saiz litar dan seterusnya memerlukan sama ciri-ciri stop band yang mengehadkan penggunaan mereka dalam banyak aplikasi penting. Antena terhasil dengan penindasan harmonik adalah biasa dan mempunyai keuntungan rendah pada frekuensi salunan. Oleh itu, keuntungan antena tinggi dengan penindasan harmonik telah mendapat minat yang besar sejak beberapa tahun kebelakangan ini kerana kelebihan seperti kos rendah, kemudahan fabrikasi dan tidak kompleks. Oleh itu, tesis ini membentangkan keuntungan antena tinggi dengan penindasan harmonik yang menghasilkan penindasan harmonik jalur lebar dengan keupayaan untuk menyekat isyarat harmonik yang tidak diingini dari 3 GHz sehingga 8 GHz. Antena ini dengan penindasan harmonik adalah berdasarkan kepada struktur mikrostrip daripada T-bentuk DGS dan merangsang penapis lulus garis rendah dengan menggunakan teori usikan, di mana sifat-sifat dielektrik substrat yang digunakan memberi kesan kepada ciri-ciri sinaran antena. antena direka pada frekuensi operasi 2.45 GHz dengan penindasan harmonik sepenuhnya kedua dan ketiga. Dengan itu, reka bentuk muktamad antena telah mencapai kehilangan pulangan yang sangat baik yang memuncak sehingga -33.44 dB pada 2.45 GHz kekerapan operasi. Di samping itu, ia mempunyai keuntungan yang sangat tinggi yang mencapai 14.20 dB dengan corak sinaran arah yang kuat; dan jumlah pencapaian kecekapan pelbagai 2x2 antena sehingga 98.86%. Selain itu, isyarat harmonik telah ditindas berkesan dari -29.19 dB untuk -7.77 dB pada frekuensi 3.24 GHz dan mencapai penindasan harmonik jalur lebar. Uji kaji, hasil yang diukur dan simulasi terdapat dalam perjanjian yang sangat baik dan mencapai keuntungan tinggi berbanding dalam kesusasteraan yang mempunyai keuntungan purata 1 dB hingga 6 dB untuk aplikasi yang sama. Antena direka dan simulasi dengan menggunakan Computer Simulation Technology Suite (CST) Studio. Kerja-kerja yang dibentangkan di dalam tesis ini terdiri daripada mendefinisikan pencirian untuk semua subsistem yang didahului dengan proses reka bentuk dioptimumkan. Adalah dipercayai bahawa keuntungan antena tinggi dengan penindasan harmonik akan membawa untuk penyelesaian menjanjikan untuk pemindahan tenaga RF / Microwave terutamanya dalam membenteras harmonik yang menjejaskan prestasi sistem.

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LIST OF ABBREVIATIONS

AIA	-	Active Integrated Antenna
AR	-	Axial Ratio
AUT	-	Antenna Under Test
CMA	-	Circular Microstrip Antenna
CP	-	Circular Polarization
DGS	-	Defected Ground Structure
EM	-	Electromagnetic
ISM	-	Industrial, Scientific and Medical
LHCP	-	Left Hand Circular Polarization
RF	-	Radio Frequency
RHCP	-	Right Hand Circular Polarization
WPT	-	Wireless Power Transfer

LIST OF SYMBOLS

$\cong$	-	Approximation
α	-	Bandwidth scaling factor
C	-	Capacitance
f_o	-	Centre frequency
λ_o	-	Centre frequency wavelength
f_c	-	Cut-off frequency
ε_r	-	Dielectric constant
K	-	Impedance inverter
L	-	Inductance
δ	-	Loss tangent
N	-	Number of order(s)
R	-	Resistance
f_r	-	Resonant frequency
c	-	Speed of light
h	-	Substrate thickness
λ	-	Wavelength

LIST OF PUBLICATIONS

The research papers produced and published during the course of this research are as follows:

Journals:

Zainol, N., Zakaria, Z., Abu, M., and Mohamed Yunus, M., 2016. Harmonic Suppression Rectangular Patch Antenna with Circularly Polarized. *TELKOMNIKA (Telcommunication. Computing, Electronics and Control)*, 14(2). *(Scopus)*

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