MULTIFUNCTIONAL RECONFIGURABLE WILKINSON POWER DIVIDER WITH SINGLE POLE DOUBLE THROW SWITCH FOR RF FRONT-END COMMUNICATIONS

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A thesis submitted
in fulfillment of the requirements for the degree of Doctor of Philosophy

Faculty of Electronic and Computer Engineering

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DECLARATION

I declare that this thesis entitled "Multifunctional Reconfigurable Wilkinson Power Divider with Single Pole Double Throw Switch for RF Front-End Communications" 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 candidature of any other degree.

Signature : ……………………………………………….

Name : Nurhasniza binti Edward

Date : 30 August 2022

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 Doctor of Philosophy.

Signature : ……………………………………………

Supervisor Name : Professor Dr. Zahriladha bin Zakaria

Date : 30 August 2022

DEDICATION

The name of ALLAH Almighty creator,

My beloved father, Edward Basir and mother, Nina Triana Asril,

My supportive family members for your encouragement and undying supports.

And to everyone.

ABSTRACT

Current and future communication systems necessitate reconfigurable structures and extended features, which are taken into account in the development of microwave devices such as: filters, antennas, and amplifiers. Reconfigurability refers to the ability to adjust or control a power divider's features dynamically while still maintaining acceptable overall performance. Power divider with adjustable power division ratio, center frequency, and transmission mode or function selectivity are the key features targeted by reconfigurable power dividers. Commonly, PIN diodes and varactors are used to achieve reconfigurability. One type of reconfigurable power divider that has recently gained popularity is switchable power dividers, in which the structure of the power divider can be adjusted to achieve different functionality. There are many techniques have been developed to achieve reconfigurable power divider, but majorities of the reconfigurable designs are focused on a single element, either on a power divider or single pole double throw (SPDT) switch. Therefore, the aim of this research is to design novel structure of reconfigurable modified Wilkinson power divider with SPDT switch function which promises a new potential functionality of the microwave devices. Two designs approaches were introduced, which are reconfigurable modified WPD and reconfigurable function modified WPD using Roger Duroid RO4350B with a dielectric constant of 3.48. To realize the concept, the techniques used in designing the reconfigurable modified WPD and reconfigurable function modified WPD have been combined to form a single structure of a novel reconfigurable modified WPD with SPDT switch function. To validate the design technique, mathematical analysis of the reconfigurable modified WPD as a SPDT switch is presented to prove the switchable mechanism. The commercial software program that has been used in the design and development of the main designs is the Advanced Design System (ADS) software. All designs were simulated, manufactured, and measured. The proposed design's total layout is 48.1 mm x 80.9 mm. The simulation results showed good agreement for both functions and frequencies, with S_{11} less than -15 dB, S_{21} more than -4.2 dB, and S_{23} less than -10 dB. The experimental results show good agreement with the simulated results. Even though there was a frequency shift in the measurement, the measurement results still correlated with the simulation results. The benefits of the reconfigurable integrated design are potentially reducing the entire structure's size, easy to fabricate and cost effective. The outcomes of the proposed reconfigurable integrated design may facilitate improvements in an integrated technique for RF front end systems.

PEMBAHAGI KUASA WILKINSON BERBILANG FUNGSI YANG BOLEH DIKONFIGURASI SEMULA DENGAN SUIS SATU KUTUB DUA LONTAR BAGI KOMUNIKASI FREKUENSI RADIO BAHAGIAN DEPAN

ABSTRAK

Sistem komunikasi semasa dan pada masa hadapan memerlukan struktur yang boleh dikonfigurasi semula dan ciri-ciri lanjutan untuk diambil kira dalam pembangunan peranti gelombang mikro seperti: penapis, antena, dan penguat. Konfigurasi semula merujuk kepada keupayaan untuk melaras atau mengawal ciri pembahagi kuasa secara dinamik sementara mengekalkan prestasi keseluruhan. Pembahagi kuasa dengan keupayaan boleh laras bagi nisbah pembahagian kuasa, frekuensi, dan mod penghantaran atau selektiviti fungsi adalah ciri-ciri utama yang disasarkan oleh pembahagi kuasa boleh dikonfigurasi semula. Kebiasaannya, diod PIN dan varaktor digunakan untuk mencapai konfigurasi semula. Satu jenis pembahagi kuasa boleh dikonfigurasi semula yang mendapat populariti baru-baru ini adalah pembahagi kuasa boleh-suis, di mana struktur pembahagi kuasa boleh diselaraskan untuk mencapai fungsi yang berbeza. Terdapat banyak teknik yang telah dibangunkan untuk mencapai pembahagi kuasa yang boleh dikonfigurasi semula, tetapi majoriti reka bentuk yang boleh dikonfigurasi semula difokuskan pada elemen tunggal, sama ada pada pembahagi kuasa atau suis satu kutub dua lontar (SPDT) sahaja. Oleh itu, tujuan penyelidikan ini adalah untuk mereka bentuk struktur baru pembahagi kuasa Wilkinson yang boleh dikonfigurasi semula dengan fungsi suis SPDT yang menjanjikan fungsi potensi baru peranti gelombang mikro. Dua pendekatan reka bentuk diperkenalkan, WPD yang diubahsuai boleh dikonfigurasi semula dan fungsi WPD yang diubahsuai boleh dikonfigurasi semula menggunakan Roger Duroid RO4350B dengan pemalar dielektrik 3.48. Untuk merealisasikan konsep ini, teknik yang digunakan dalam mereka bentuk WPD yang diubahsuai boleh dikonfigurasi semula dan fungsi WPD yang diubahsuai boleh dikonfigurasi semula telah digabungkan untuk membentuk struktur tunggal baru yang dinamakan WPD diubahsuai boleh dikonfigurasi semula dengan fungsi suis SPDT. Untuk mengesahkan teknik reka bentuk tersebut, analisis matematik bagi WPD diubahsuai boleh dikonfigurasi semula sebagai suis SPDT telah dibentangkan untuk membuktikan mekanisme boleh-suis. Program perisian komersial yang telah digunakan dalam mereka bentuk dan pembangunan reka bentuk utama adalah perisian Advanced Design System (ADS). Semua reka bentuk telah disimulasikan, dihasilkan, dan diukur. Susun atur keseluruhan reka bentuk yang dicadangkan ialah 48.1 mm x 80.9 mm. Hasil simulasi menunjukkan persetujuan yang baik untuk kedua-dua fungsi dan frekuensi, dengan S_{11} *kurang daripada -15 dB,* S_{21} *lebih daripada -4.2 dB, dan* S_{23} *kurang daripada -10 db. Hasil eksperimen menunjukkan persetujuan yang baik dengan hasil simulasi. Walaupun terdapat peralihan frekuensi dalam pengukuran, hasil ukuran masih berkaitan dengan keputusan simulasi. Manfaat konfigurasi semula integrasi reka bentuk berpotensi untuk membentuk struktur yang kecil, mudah dan kos efektif. Hasil daripada reka bentuk konfigurasi semula integrasi yang dicadangkan boleh menaik taraf peningkatan dalam teknik integrasi untuk sistem RF bahagian hadapan.*

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ADS	-	Advanced Design System
DC	-	Direct Current
EM	-	Electromagnetic
LNA	-	Low noise amplifier
MCMC	-	Malaysian Communications and Multimedia Commission
PIN	-	Positive-intrinsic-negative
RF	-	Radio Frequency
SPDT	-	Single pole double throw
TEM	-	Transverse-electromagnetic
UV	-	Ultraviolet
VNA	-	Vector network analyzer
WPD	-	Wilkinson power divider
WLAN	-	Wireless Local Area Network

LIST OF SYMBOLS

c	-	Speed of Light
ε_o	-	Permittivity of Free Space
ε_r	-	Dielectric Constant of Material
ε_{reff}	-	Effective Dielectric Constant
F	-	Operating Frequency
k_0	-	Free Space Propagation Constant
λ_m	-	Microstrip Wavelength
Z_o	-	Characteristic Impedance

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