WIFI-UHF TRANSCEIVER DESIGN FOR 650-680 MHZ TELEVISION WHITE SPACE (TVWS) SPECTRUM APPLICATION

by

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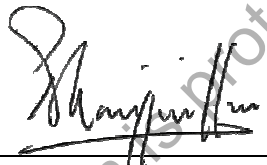

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LIST OF ABBREVIATIONS

ADS	Advanced Design System
BPF	Band Pass Filter
BW	Bandwidth
CAD	Computer-aided Design
CR	Cognitive Radio
dB	Decibel
dBm	Decibel of Measured power referenced to 1 milliwatt (mW)
DUT	Device Under Test
EF	Error Function
FCC	Federal Communications Commission
HPF	High Pass Filter
IEEE	Institute of Electrical and Electronics Engineering
IF	Intermediate Frequency
ISM	Industrial, Scientific and Medical
LNA	Low Noise Amplifier
LO	Local Oscillators
LOS	Line of Sight
LPF	Low Pass Filter
NF	Noise Figure
PA	Power Amplifier
PCB	Printed Circuit Board
PLL	Phase-locked Loop
PN	Part Number
RF	Radio Frequency
RX	Receiver
SAW	Surface Acoustic Wave
SNR	Signal-to-noise Ratio
TX	Transmitter
TVWS	TV White Space Spectrum
UHF	Ultra High Frequency
VBPF	Variable Band Pass Filter
VCO	Voltage Control Oscillator
VNA	Vector Network Analyzer
Vctrl	Voltage Control
WB	Wide-Band
WLAN	Wireless Local Area Network

Wi-Fi	Wireless Fidelity
WUT	WIFI UHF Transceiver

LIST OF SYMBOLS

Ω	Ohm
ϵ_r	Relative Permittivity
η	Efficiency
ε	Permittivity
σ	Conductivity
c	Speed of light ($3 \times 10^8\ ms^{-1}$)
λ	Free space wavelength
C	Capacitance
R	Resistance
L	Inductance
ε_{eff}	Effective permittivity
λ_g	Guided Wavelength
Y	Admittance
f_c	Resonance frequency

Rekabentuk WiFi UHF Transceiver Untuk Aplikasi Spektrum Ruang Putih Televisyen 650-680 MHz

ABSTRAK

Penyelidikan telah mencetuskan minat untuk mengkaji secara lebih mendalam sekiranya wujud kemungkinan untuk memanfaatkan frekuensi daripada ruang putih telivisyen yang jarang digunakan dalam lingkungan band 470-770 MHz supaya dapat menggantikan Wi-fi frekuensi 2.4 GHz yang spectrum frekuensinya hampir habis digunakan. Reka bentuk, simulasi, fabrikasi, pembuktian secara eksperimen dan pengoptimuman terhadap litar didalam Wi-fi-UHF transceiver untuk mencapai kebolehan bagi membuat penukaran frekuensi secara menaikkan dan menurunkan frekuensi diantara 2.4 GHz dan band UHF adalah dipersembahkan didalam tesis ini. WUT yang mempunyai beberapa bahagian seperti penapis, pengadun, penguat dan pelemah direka secara menyeluruh melalui satu seni bina yang hanya menggunakan satu VCO-PLL untuk merealisasikan penaikkan dan penurunan signal RF diantara 2.4 GHz dan 650-680 MHz. Penurunan frekuensi diantara 2.4 GHz dan 650-680 MHz dilakukan semasa pemancaran signal RF manakala penurunan frekuensi berlaku sebaliknya. Dengan memprogramkan VCO-PLL kepada frekuensi tertentu sebagai pengayun setempat (LO) signal RF pada 2.4 GHz dapat diturunkan kepada mana mana frekuensi didalam lingkungan 650-680 MHz yang mana frekuensi tersebut akan dipancarkan menerusi antena ke udara. Pada laluan atau bahagian penerimaan frekuensi pula, penyelarasan keatas VBPF melalui potensiometer dapat membolehkan WUT menerima apa sahaja frekuensi didalam lingkungan 650-680 MHz yang akan bercampur dengan frekuensi LO tertentu daripada VCO-PLL yang sama untuk menghasilkan signal 2.4 GHz. Reka bentuk yang mempunyai mekanisma yang sebegini unik dapat membuka jalan agar WUT dapat berfungsi sebagai transceiver yang tidak memerlukan langsung pengubahsuaian keatas Wi-Fi modem yang sedia ada. ADS digunakan sebagai alat untuk membuat rekaan dan simulisasi terhadap bahagian-bahagian litar secara individu menurut speifikasi masing-masing sebelum kesemua bahagian-bahagian ini diintegrasikan menjadi satu sistem yang lengkap. Hasil simulasi membuktikan WUT berjaya menurunkan frekuensi daripada 2.4 GHz kepada 650-680 MHz dengan kenaikan 9.5dB manakala penaikan frekuensi daripada 650-680 MHz kepada 2.4 GHz juga berjaya dicapai. Begitu juga WUT yang sebenar dapat melakukan fungsi yang sama tetapi dengan penurunan 42.7dB untuk penaikan frekuensi dan 22.6dB untuk penaikan frekuensi.

WiFi UHF Transceiver Design For Television White Space (TVWS) Spectrum Application

ABSTRACT

Studies have sparked an interest to look further into the possibility of research to make beneficial of underutilized Television White Space (TVWS) frequency band of 470 MHz-770 MHz to substitute the 2.4 GHz Wi-Fi which has been running out of frequency spectrum. The design, simulation, fabrication, experimental validation and optimization of a Wi-Fi-UHF Transceiver (WUT) circuit to achieve a capability of up and down-conversion between frequency of 2.4 GHz and UHF band are presented in this thesis. The WUT which is consisted of subsections like filters, mixers, amplifiers and attenuators are comprehensively designed with an architecture of utilizing a single VCO-PLL to perform up-conversion and down-conversion of RF signals between 2.4 GHz and 650-680 MHz correspondingly. The down-conversion from 2.4 GHz to 650-680 MHz is performed during the RF transmission while up-conversion is the other way around. By programming VCO-PLL to certain frequency as local oscillator (LO), the 2.4 GHz RF signal can be down-converted to any frequency within 650-680 MHz which will be transmitted out from the antenna into the air. On the receiver path, pre-adjustment of the VBPF through potentiometer enabled WUT to receive any frequency within 650-680 MHz which will be mixed-up with certain LO frequency from the same VCO-PLL to generate the 2.4 GHz. Such unique design mechanism has paved the way for WUT to work as a transceiver without any change or modification required to the existing Wi-Fi modem. ADS is used as a tool to design and simulate the subsection circuits separately towards specific design goals prior to integration as complete WUT system. The simulation results shows that WUT is able to down-convert 2.4 GHz to 650-680 MHz with gain of 9.8 dB meanwhile the up-convert of 650-680 MHz to 2.4 GHz managed to have gain of 5.6 dB. Also the physical WUT is able to perform similarly, but with up-conversion gain of -42.7dB and down-conversion gain of -22.6dB.