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FACULTY OF ENGINEERING
Electronics and Communications Engineering Department

A Compact Planar Filtenna for Wireless Communications Applications

A Thesis

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STATEMENT

This dissertation is submitted to Ain Shams University in partial fulfillment for the degree of Doctor of Philosophy in Electrical Engineering (Electronics and Communications Engineering), 2019.

The work included in this dissertation was carried out by the author at the Electronics and Communications Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

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ABSTRACT

A Compact Planar Filtenna for Wireless Communications Applications

by

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**DOCTOR OF PHILOSOPHY IN ELECTRICAL ENGINEERING THESIS
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With the current scenario of emerging services of the wireless communication systems, in addition to the predictable transition from the current wireless communication standards to the new generation with higher operating frequency bands, the need for compact multiband antenna with the ability of covering the current standards at the microwave band and the next generation standards at the millimeter-wave band simultaneously is raising.

On the other side, the operation of cognitive radios and self-adaptive systems need to dynamically monitor the frequency spectrum in search of the unused licensed channels and then altering its radiation characteristics for transmission and reception within these spectrum holes as a second user for better exploit the existing spectrum. Such system constraints have forced the researchers to design reconfigurable antennas with ultrawideband mode for spectrum monitoring operation and also have the ability of altering their radiation operating frequency to access the selected unequipped communication channels.

Three different types of filtennas are presented in this thesis: fixed, switchable and tunable. In the fixed filtenna a Franklin strip monopole antenna is designed to cover 4G, and wireless applications (WLAN and WiMAX), and a rectangular patch antenna that is designed to cover 5G band. Furthermore, a modified CMRC (compact microstrip resonant cell) low pass filter is printed between the antenna parts to allow feeding the Franklin antenna at low-frequency bands (2.4/5.5 GHz center frequency) while isolating the Franklin antenna from the rectangular patch antenna at the 5G band (28 GHz center frequency). In the switchable filtenna design (second type), the antenna consists of circularly polarized monopole antenna for the UWB mode with two bandpass filters integrated in the feeding network for the two 3.5/5.5 GHz center frequencies narrow band modes to cover UWB/WiMAX applications.

The switching between the wideband mode and the two narrowband modes is achieved by sending the RF signal directly to the monopole antenna or through one of the two bandpass filters using switching matrix equipment. In addition to this, ultrawideband monopole antenna with tunable dual band-notch characteristic is proposed (third type). The tunable filtenna consists of a circular ring monopole antenna as a main radiator with two unequally sized semi-circular stubs added near the inner edge of circular ring to achieve dual band-notching. The band-notching tuning achieved by connecting the larger stub to the main radiator through varactor diode.

The contributions of this thesis in the three filtenna designs are: 1) design, analysis and fabrication of fixed filtenna with predefined operating bands over the microwave band and millimetre-wave band simultaneously, 2) design and fabrication of switchable filtenna that is circularly polarized at the ultrawideband mode and also at the narrowband modes, and 3) the design of tunable filtenna with ultrawideband operation and the tuning of the two notched bands was achieved by using single varactor diode.

The three filtennas were designed and analysed using different ready-made software simulators and fabricated using photolithographic technique. The designs have been verified through comparison between the simulated and measured results.

Key Words: *Filtenna, Reconfigurable antenna, Switchable antenna, Tunable antenna, Cognitive Radio (CR), Multiband, Wideband-to-Narrowband, Band-Notch.*

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Table of Contents

ACKNOWLEDGMENT.....	V
ABSTRACT	VI
Table of Contents.....	VIII
List of Figures	X
List of Tables	XIV
List of Abbreviations	XV
List of Symbols	XVI
Publications.....	IX
1 Chapter 1: INTRODUCTION.....	1
1.1 Motivations and challenges of the thesis	1
1.2 Main objectives	2
1.3 Filtenna applications in modern communication systems.....	2
1.4 Achievements.....	4
1.5 Software packages used.....	4
1.6 Thesis organization.....	4
2 Chapter 2: LITERATURE SURVEY	6
2.1 Introduction	6
2.2 Fixed filtennas	7
2.3 Switchable filtennas	10
2.4 Continuous tuning reconfigurable antenna	15
2.5 Conclusion	20
3 Chapter 3: Single Fed 4G/5G Multiband 2.4/5.5/28 GHz Filtenna	21
3.1 Introduction	21
3.2 Design and structure.....	21
3.2.1 Rectangular patch antenna	22
3.2.2 Modified CMRC LPF	26
3.2.3 Franklin monopole antenna.....	32
3.3 Simulation and measurement results.....	39
3.4 Conclusions	44

4 Chapter 4: Circularly Polarized Ultrawideband-to-Narrowband Switchable Filtenna.....	45
4.1 Introduction.....	45
4.2 Design and structure.....	45
4.2.1 UWB circularly polarized antenna.....	46
4.2.2 Modified three-line coupled resonator BPF.....	52
4.2.3 Wideband BPF using two resonators.....	57
4.3. Simulation and measurement results.....	61
4.4. Conclusion	68
5 Chapter 5 UWB Monopole Filtenna with Tunable Dual Band-Notch Characteristics	69
5.1 Introduction.....	69
5.2 Design and structure.....	69
5.2.1 UWB Circular disk monopole antenna	69
5.2.2 Notch-band antenna characteristic.....	72
5.2.3 UWB antenna with tunable rejected dual-band characteristics	75
5.3 Simulation and measurement results.....	82
5.4 Conclusion	86
6 Chapter 6: Conclusions and Suggestions for Further Work.....	87
6.1 Conclusions	87
6.2 Suggestions for Further Work.....	88
REFERENCES	90
Appendix A.....	98
Appendix A.I: Mat-lab program of rectangular patch antenna design	98
Appendix A.II: Mat-lab program of TLCR equivalent circuit	99
Appendix B	100
B.I: Data Sheet of RC-8SPDT-A18 RF Switch Matrix	100
B.II: Data Sheet of SMV1405 Varactor Diode.....	104
B.III: Data Sheet ZX85-12G+ Bias Tee	107

List of Figures

Figure 1-1: Cognitive radio mechanism chain [4].....	3
Figure 2-1: Geometry of proposed multiband rectangular patch antenna with two folded slots (all dimensions in mm) [13].	7
Figure 2-2: Geometry of the proposed mm-Wave patch antenna [14].	8
Figure 2-3: The geometry of the three layers filtering antenna [15].	9
Figure 2-4: (a) Two 4G MIMO antennas, (b) the slot antenna array, (c) the feed network of the 5G antenna array, and (d) the slot antenna with feeding network (all dimensions in mm) [16].	10
Figure 2-5: (a) the top view of the proposed two port antenna, and (b) meander line resonator of the narrowband antenna [33].	11
Figure 2-6: The structure of the proposed wideband-to-narrowband antenna (all dimensions in mm) [34].	12
Figure 2-7: The proposed annular ring reconfigurable antenna geometry (a) Top view, (b) Side view, and (c) Bottom view [35].	13
Figure 2-8: The geometry of the proposed CPW wideband-to-narrowband antenna for WLAN application [36].	13
Figure 2-9: The geometry of the proposed multiband to wideband antenna (all dimensions in mm) [37].	14
Figure 2-10: The structure of the proposed CPW spiral wideband-to-narrowband antenna (all dimensions in mm) [38].	15
Figure 2-11: The configuration of the proposed circular-shaped monopole antenna with two SIRs [46].	16
Figure 2-12: The simulated and measured gain of the proposed circular-shaped monopole antenna with two SIRs [46].	17
Figure 2-13: The geometry of the proposed reconfigurable band rejection antenna (a) the front view of the elliptical broadband antenna, (b) the back view, (c) the antenna with two OLRs, and (d) the geometry of the OLR loaded with varactor diode [47].	17
Figure 2-14: The measured gain at different biasing voltage of the varactor diodes for (a) the antenna with OLR at the left, and (b) the antenna with OLR at the right [47].	18
Figure 2-15: The configuration of the reconfigurable band-notched UWB antenna (a) the front and the side views, and (b) the detailed band-notch structure [48].	18
Figure 2-16: The configuration of the reconfigurable dual band-notched UWB circular monopole antenna (a) front view, and (b) back view [49].	19
Figure 2-17: The measured gain of the reconfigurable dual band-notched UWB circular monopole antenna when $V_1=30\text{ V}$ and $V_2=0\text{ V}$ [49].	19
Figure 3-1: The proposed multiband filtenna (a) Front view, and (b) back view.	22
Figure 3-2: The design of 5G rectangular patch antenna (a) top view, (b) bottom view, and (c) The dimensions of the CSRR.....	22
Figure 3-3: The simulated input reflection coefficient of the 5G antenna with and without the CSRRs.....	23
Figure 3-4: The simulated realized gains of the 5G antenna with and without the CSRRs.	24
Figure 3-5: The simulated efficiency of the 5G antenna with and without the CSRRs.	24
Figure 3-6: The simulated E-plane and H-plane radiation patterns for the 5G antenna (a) without CSRRs, and (b) with CSRRs.....	25

Figure 3-7: (a)The equivalent LC circuit of the proposed 5G rectangular patch antenna, and (b) The comparison between the reflection coefficient results of the antenna simulated by CST simulator and its equivalent circuit simulated by ADS simulator.....	26
Figure 3-8: The design of CMRC lowpass filter (a) the original CMRC [55], and (b) the modified CMRC.	27
Figure 3-9: The design procedures of the proposed filter (a) step 1, (b) step2, (c) step3, and (d) step 4.	28
Figure 3-10: The comparison between the $ S_{21} $ simulation results of the filter design steps.	29
Figure 3-11: The simulation results of the traditional CMRC filter and the proposed modified one (a) $ S_{11} $, and (b) $ S_{21} $	30
Figure 3-12: The equivalent LC circuit of the proposed modified CMRC filter.	30
Figure 3-13: The comparison between the return loss and insertion loss results of the filter simulated by CST simulator and its equivalent circuit simulated by ADS simulator (a) $ S_{11} $, and (b) $ S_{21} $	31
Figure 3-14: The design of the Franklin strip monopole antenna (a) top view, and (b) bottom view.	33
Figure 3-15: The simulated reflection coefficients of the antenna, (a) with and without the stub, and (b) with and without the curved ground.	34
Figure 3-16: (a)The equivalent LC circuit of the proposed 4G Franklin monopole antenna, and (b) The comparison between the reflection coefficient results of the antenna simulated by CST simulator and its equivalent circuit simulated by ADS simulator.....	35
Figure 3-17: Photograph of fabricated antenna. (a) Front view, and (b) Back view.	36
Figure 3-18: The measured and simulated reflection coefficient of Franklin antenna.	36
Figure 3-19: Simulated and measured realized gains at: (a) lower band (2.15-2.83 GHz), and (b) upper band (5.05-6.07 GHz).	37
Figure 3-20: Simulated the efficiency at: (a) lower band (2.15-2.83 GHz), and (b) upper band (5.05-6.07 GHz).	37
Figure 3-21: Simulated current distribution at: (a) 2.37 GHz, (b)5.31 GHz.	37
Figure 3-22: The simulation electric and magnetic radiation patterns (a) Lower band resonance (2.37 GHz), and (b) Upper band resonance (5.31 GHz).	38
Figure 3-23: The comparison between the reflection coefficient of the multiband filter antenna system simulated by CST simulator and its equivalent circuit simulated by ADS simulator.	40
Figure 3-24: Photograph of fabricated multiband antenna. (a) Front view, (b) Back view.	40
Figure 3-25: The measured and simulated reflection coefficient.	41
Figure 3-26: Simulated current distribution at (a) 2.4 GHz, (b)5.5 GHz, and (c) 28 GHz..	42
Figure 3-27: Simulated and measured gain at: (a) First band, (b) second band, and (c) simulated gain using CST and HFSS simulators for the third band.	43
Figure 3-28: The simulated and measured E-plane and H-plane radiation patterns at: (a) First band (2.4 GHz), (b) Second band (5.5 GHz), and (c) The Simulated E-plane and H-plane radiation patterns of the third band (28 GHz) using CST and HFSS simulators.	44
Figure 4-1: The design of ultrawideband-to-narrowband antenna (a) Front view, and (b) back view.	46
Figure 4-2: The design of quasi C-shaped monopole antenna (a) Front view, and (b) back view.	47

Figure 4-3: The design procedure of the proposed antenna (a) step 1, (b) step 2, (c) step3 and (d) step 4.	49
Figure 4-4: The simulated results for Ant. 1-4 (a) return loss, and (b) axial ratio.	49
Figure 4-5: Simulated surface current distributions of the proposed antenna at 5.5 GHz at four different phases (a) 0°, (b) 90°, (c) 180°, (d) 270°.....	50
Figure 4-6: The simulated realized gain of the proposed circularly polarized monopole antenna.....	51
Figure 4-7: The simulated realized gain of the proposed circularly polarized monopole antenna.....	51
Figure 4-8: The simulated E-plane and H-plane radiation patterns at 7 GHz.	51
Figure 4-9: The design of the proposed TLCR bandpass filter.	53
Figure 4-10: The simulation results of the TLCR bandpass filters (a) Traditional U-shaped TLCR, and (b) Modified TLCR.	54
Figure 4-11: The equivalent circuit of the proposed TLCR bandpass filter.....	54
Figure 4-12: The simulated and numerical results for the proposed TLCR filter (a) $ S_{11} $, and (b) $ S_{21} $	57
Figure 4-13: (a) The design of the proposed two resonators wideband BPF and (b) Odd-mode equivalent circuit of the resonator R_1	58
Figure 4-14: The simulation results of the two resonators wideband bandpass filter.	59
Figure 4-15: The equivalent LC circuit of the proposed BPF with two open loop resonators.	60
Figure 4-16: The comparison between the reflection coefficient and transmission coefficient results of the filter simulated by CST simulator and its equivalent circuit simulated by ADS simulator (a) $ S_{11} $, and (b) $ S_{21} $	61
Figure 4-17: Photograph of fabricated antenna. (a) front view, and (b) back view.	62
Figure 4-18: The simulated and measured reflection coefficient of the different modes of the antenna (a) UWB mode, and (b) NB modes.	63
Figure 4-19: The simulated axial ratio of the different modes of the antenna.	63
Figure 4-20: The simulated and measured realized gain of the different modes of the antenna (a) UWB mode, and (b) NB modes.	64
Figure 4-21: Simulated current distribution for (a) the UWB mode at 7 GHz, (b) the first NB mode at 3.5 GHz, and (c) the second NB mode at 5.5 GHz.....	65
Figure 4-22: The simulated and measured radiation patterns in XZ and YZ planes for (a) the first NB mode at 3.5 GHz, (b) the second NB mode 5.5 GHz, and (c) the UWB mode at 7 GHz.	66
Figure 4-23: Simulated Normalized co-polar and cross-polar patterns of the proposed antenna in XZ and YZ planes for (a) the first NB mode at 3.5 GHz, (b) the second NB mode 5.5 GHz, and (c) the UWB mode at 7.3 GHz.	67
Figure 5-1: The design procedure of the proposed UWB antenna (a) Step 1, (b) Step 2, and (c) Step 3.	70
Figure 5-2: The simulated reflection coefficient of the UWB antenna procedures.	71
Figure 5-3: The simulated realized gain of the UWB antenna procedures.	71
Figure 5-4: The simulated efficiency of the UWB antenna procedures.....	71
Figure 5-5: The simulated radiation patterns of the UWB antenna procedures.	72
Figure 5-6: The design procedure of the proposed dual band-notch antenna (a) step 1, (b) step 2, (c) step 3, and (d) step 4.	73

<i>Figure 5-7: The simulated reflection coefficient of the dual band-notch antenna design procedures (Ant.1-4).</i>	74
<i>Figure 5-8: The simulated realized gain of the dual band-notch antenna design procedures (Ant.1-4).</i>	74
<i>Figure 5-9: The simulated efficiency of the dual band-notch antenna design procedures (Ant.1-4).</i>	75
<i>Figure 5-10: The simulated E-plane and H-plane radiation patterns of the dual band-notch antenna design procedures (Ant.1-4).</i>	75
<i>Figure 5-11: The first design of tunable dual band-notch antenna (a) Front view, and (b) back view.</i>	76
<i>Figure 5-12: The simulated results of the first design at different varactor diode capacitances (a) reflection coefficient, and (b) realized gain.</i>	77
<i>Figure 5-13: The second design of tunable dual band-notch antenna (a) Front view, and (b) back view.</i>	78
<i>Figure 5-14: The simulated results of the second design at different capacitances of first varactor diode ($C_2=2.67$ pF) (a) reflection coefficient, and (b) realized gain.</i>	79
<i>Figure 5-15: Simulated results of the proposed design for different value of varactor C_2 and varactor C_1 unbiased (a) reflection coefficient, and (b) realized gain.</i>	80
<i>Figure 5-16: Simulated results of the proposed design for different value of the two varactors capacitance using the same biasing voltage (a) reflection coefficient, and (b) realized gain.</i>	81
<i>Figure 5-17: (a) The equivalent LC circuit of the proposed UWB antenna with dual band-notched characteristic, and (b) The comparison between the reflection coefficient results of the antenna simulated by CST simulator and its equivalent circuit simulated by ADS simulator.</i>	82
<i>Figure 5-18: Photograph of fabricated antenna. (a) front view, and (b) back view.</i>	83
<i>Figure 5-19: The reflection coefficients at different values of the varactor diode capacitance (a) simulations, and (b) measurements.</i>	84
<i>Figure 5-20: Simulated and measured realized gain when the varactor diode is unbiased.</i>	84
<i>Figure 5-21: Simulated current distribution for (a) the radiating frequency at 12.9 GHz, (b) the first notch band at 3.7 GHz, and (c) the second notch band at 6.8 GHz.</i>	85
<i>Figure 5-22: The simulated E-plane and H-plane of the proposed antenna at the center frequency of the operating band (13.25 GHz).</i>	86

List of Tables

<i>Table 3-1: 5G antenna dimensional parameters.</i>	<i>23</i>
<i>Table 3-2: 5G antenna equivalent circuit parameters.</i>	<i>25</i>
<i>Table 3-3: The modified CMRC filter dimensional parameters.</i>	<i>27</i>
<i>Table 3-4: Modified CMRC filter equivalent circuit parameters.</i>	<i>31</i>
<i>Table 3-5: Dimensions of the proposed Franklin antenna.</i>	<i>33</i>
<i>Table 3-6: Franklin monopole antenna equivalent circuit parameters.</i>	<i>35</i>
<i>Table 3-7: Performance comparison of the proposed Franklin antenna and others in literature.</i>	<i>39</i>
<i>Table 4-1: Monopole antenna dimensional parameters.</i>	<i>47</i>
<i>Table 4-2: The modified TLCR filter dimensional parameters.</i>	<i>52</i>
<i>Table 4-3: Dimensions of the proposed filter.</i>	<i>58</i>
<i>Table 4-4: Two resonators filter equivalent circuit parameters.</i>	<i>60</i>
<i>Table 4-5: Comparison of proposed wideband-to-narrowband switchable antenna with those existing in the literature.</i>	<i>68</i>
<i>Table 5-1: The proposed first antenna design dimensional parameters.</i>	<i>76</i>
<i>Table 5-2: UWB antenna with dual band-notching equivalent circuit parameters.</i>	<i>82</i>

List of Abbreviations

4G	Fourth Generation
5G	Fifth Generation
ADS	Advanced Design System
AMC	Artificial Magnetic Conductor
AR-BW	Axial Ratio Bandwidth
CMRC	Compact Microstrip Resonant Cell
CP	Circular Polarization
CR	Cognitive Radio
CSRR	Complementary Split Ring Resonators
CST	Computer System Technology
CPW	Coplanar Waveguide
HFSS	High Frequency Structure Simulator
IBW	Impedance Bandwidth
LPF	Low Pass Filter
LTE	Long-Term evolution
MEMS	Micro Electro Mechanical System
MIMO	Multi Input Multi Output
NB	Narrow-Band
OLR	Open Loop Resonator
PE	Printed Electronic
PIN	P junction Intrinsic N junction
RF	Radio Frequency
RHCP	Right-Hand Circular Polarization
SIR	Stepped Impedance Resonator
TLCR	Three-Line Coupled Resonator
UMTS	Universal Mobile Telecommunications System
UWB	Ultra-Wide-Bandwidth
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network