AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electronics and Communications Engineering Department

A Compact Planar Filtenna for Wireless Communications Applications

A Thesis

Submitted in partial fulfillment of the requirements of the degree of Doctor of Philosophy in Electrical Engineering

(Electronics and Communications Engineering)

Submitted by:

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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.

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

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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

AIN SHAMS UNIVERSITY

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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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 volution**
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**