Preface

Today, mechanical and electrical engineering are two research domains which attract many researches due to highly potential to improve the human life. The Mechanical Engineering field is covered by many areas as heat transfer, manufacturing, mechanical design, system dynamics and control, thermodynamics, energy Systems, and the study on the fundamentals of fluid mechanics. Hence, to understand the engineering phenomenon is required a certain knowledge in mathematics, physics, chemistry. Further, the Electrical Engineering field numerous applications as well. For examples, electrical engineers work in several fields including aeronautics, biomedical, energy, computer, electrical and electronic systems, as well as telecommunications. They participate to the industrial design and implementation of projects. The contents of Handbook of Research on Recent Developments in Electrical and Mechanical Engineering represents the efforts of many researchers working in electrical and mechanical field. The objective of this handbook is to share experiences and research studies in different attractive areas of electrical and mechanical engineering.

The state of art of the investigated research field was presented briefly in each chapter. It makes this manuscript an ideal handbook for university that focus in mechanical courses, microwave active and passive circuit courses, training courses, engineers, PhD students, and researchers. The themes covered in this book are divided into fourth sections:

The first section is about “Microwave Passive & Active circuits” that presents some studies on computer aided design of planar circuits; the introduction to electromagnetic metamaterials and their applications; some research work on measurement technique, and microwave passive and active circuits design as filters, antennas, power amplifier and RF-DC rectifiers.

The second one is “Information Technology and Signal Processing” that contains chapters around Autoencoders in Deep Neural Network. There we reported a chapter which presents wireless sensor networks (WSNs) with a comparative study of clustering-based routing protocols in terms of their energy efficiency, network lifetime, throughput and stability performances. The aim of the third chapter were to describe the dictionary learning by factorization techniques in Non negative matrices (NMF) for the separation of signals.

The third section describes the research studies focused on “Solid-state lighting technology & Renewable Energy”. This section deals with solid-state lighting technology particularly LEDs, and other works on renewable energy.

The fourth section is about mechanical engineering, particularly a chapter on Lamb waves which are an attractive tool used to control long distances such as pipes. Another study presents propagation characteristics of anti-plane shear horizontal surface wave in a homogeneous micro-polar layered structure by introducing interfacial complexity. We reported as well as a research works on the antilock braking

system, performance improvement of mechanical components by precision coating, 3D printers and Thermal improvement of curing in resin transfer molding process.

The book is organized into 18 chapters. A brief description of each chapter were made in order to easy accommodate the reader with the content of this manuscript:

In chapter 1, the planar branch-line coupler circuits were reviewed and analyzed comprehensively in terms of analytical modeling development, numerical simulation using commercial software, the recent trend of modified structures of the branch-line coupler, and its applications in microwave devices. The analytical analysis is the easiest method in simple branch-line coupler design. The analytical equations are explicit and capable of determining the characteristic impedance of each branch line for the coupler at the desired coupling level as well as the suitability of broadband S-parameters analysis. However, nowadays most planar branch-line couplers have been modified to miniature size, better bandwidth, thus a lot of modified structures of circuit's branch line have been proposed, such as slow wave structure, meandering line, cascading circuit, and proximity feed gap-coupled. To modify the branch-line coupler circuit, the numerical method usually takes over from the analytical method in design work due to analytical analysis is unable to solve the complicated modified branch-line circuit. Typically, microwave office software (AWR), Advanced Design System (ADS), and Computer Simulation Technology (CST) are used in modified branch-line coupler design. In fact, the branch line coupler circuit has many applications in microwave devices, such as complex ratio measuring unit, 2-way 90-degree power splitter, 3-dB coupler, and double balanced mixer. In this chapter, the branch-line applications will also be briefly reviewed.

Chapter 2 deals with Metamaterials which are artificial engineered materials that possess unique properties not found in natural materials. The properties are derived from the structural designs of metamaterials and they allow the structure to manipulate electromagnetic waves and achieve desired responses in certain frequency range. This chapter reviews past achievements, recent development and future trend on electromagnetic metamaterials in microwave regime. The chapter first briefly introduces electromagnetic metamaterials from a general prospect including the definition, historical overview and classification of metamaterials. Furthermore, five selected applications of metamaterials which are microwave absorbers, filters, sensors, antennas and energy harvesters will be discussed in details based on their designs, characteristics and operation theories.

Chapter 3 discusses various types of Microwave complex ratio measurement (MCRM) circuits. They have been described in detail that includes previous studies, basic theory, and general calibration methods for MCRM circuits. This chapter attempts to provide concise and comprehensive information to researchers who are involved in the construction of MCRM circuit. MCRM is usually used to construct RF reflectometer. The advantages of the MCRM circuit are simple, inexpensive, not easy to damage, do not need to use many electronic components in the construction of the reflectometer. In addition, MCRM allows the signal through it steadily and insensitive to operating temperature. Normally, the temperature of MCRM circuit does not increase significantly when the circuit is operated for a long period.

Chapter 4 introduces Wireless power transmission (WPT) which has become a novel alternative technology to solve all these power supply problems. A wireless power transmission system consists of a block that converts continuous energy into microwave energy capable of transmitting in free space through a transmitting antenna. Reception is provided by a receiving antenna followed by an RF-DC rectification system. Each element of the WPT system can be characterized by its efficiency. The key element of a WPT system is called Rectenna (for rectifying antenna), a conventional rectenna circuit consists of a receiving antenna followed by an RF-DC conversion circuit with a non-linear characteristic. This circuit usually contains one or more Schottky diodes, an HF input filter, a DC output filter and

a resistive load that models the consumption of the powered system. The challenge is to optimize the entire rectenna, with the objective of maximizing the DC output and efficiency of RF-DC conversion. Optimization must be carried out over the entire circuit, hence the need to use global analysis methods combining electromagnetic simulation and circuit. Numerical modeling presented is a fundamental and decisive tool throughout this work. The main aim being to take into account all possible couplings between the different parts of the circuit. Further, the objective of this chapter was to present experimentally an innovative, compact and high-efficiency rectifier circuit at 2.45 GHz for the power supply of low consumption devices. This rectifier has been designed by using Advanced Design System. The bridge topology was employed on an FR4 substrate with dielectric constant er=4.4, substrate thickness h=1.6 mm and the loss tangent is 0.025. A good matching input impedance was observed and high conversion efficiency was obtained. Simulation results have been validated through realization and measurements.

Chapter 5 introduces the design of new structures of broadband power amplifiers which span a wide range of areas, among which microwave crop drying and quarantine in agriculture, medical diathermy, medical imaging, heating, electronic warfare, telecommunications, tracking and navigation systems. The design of BPAs, as that for any other power amplifier circuit, is basically subdivided in a chain of methodical steps, from the identification of BPA specifications up to the concluding characterization and measurements of the fabricated circuit, to prove fulfilment of the design requirements. Throughout the design of BPAs, essential and commonly contrasting specifications have to be at the same time fulfilled. On the one hand, wide bandwidth, high output power as well as high power gain are typically needed to minimize the number of PA stages, and consequently reduce the size of the whole unit. Furthermore, in order to ensure adequate signal amplification unaccompanied by affecting the data content, as well as preserve the suitable quality for the transmitted signal, high linearity must be assured. There are several techniques and circuit topologies deployed to realize broadband power amplifiers. In this chapter, the broadband power amplifier considerations will be briefly presented and described. Then, the broadband impedance matching techniques will be described. Finally, the proposed broadband power amplifier circuit design as well as the simulated results will be presented.

In chapter 6, an overview of coplanar waveguide technology is presented. Varieties of defected ground structure with the recent DGS units which developed to replace the Electromagnetic Band Gap (EBG) circuits in the goal to improve response and characteristics of microwave components such as filters are introduced. In this chapter, a circular defected ground structure (DGS) with shaped coplanar line is investigated for compact stopband filter (SBF) for microwave and millimeter wave applications. With this structure, the first proposed response of resonant element in 20 GHz exhibits the bandstop function. The proposed DGS is also modified by introducing four symmetrical slots with L-configuration in conductor line of a coplanar circuit to improve separately the stopband and passband performances. The insertion loss can be reduced by introducing four symmetrical slots with L-configuration in conductor line of a coplanar circuit to improve separately the stopband and passband performances. Additionally, the operating frequency ranges are extended to millimeter-waves with little increase in radius of circular defected ground. It combined between those requirements: simple structure and design, easy fabrication and good performance.

In chapter 7 we have reported some studies on “Blind Audio source Separation (BASS)”. In this way, this chapter is dedicated to study the BSS as a solution for human machine interaction. The objective consists in recovering one or several source signals from a given mixture signal. Mixtures can be classified according to the nature of the environment (instantaneous or convolutive), the number of sources compared with the number of acoustical sensors which determines the nature of the mixture

(over-determined, determined and underdetermined) and time-varying or time-invariant conditions. The purpose of BSS still remains the same, which is to recover the signals sources, without knowledge of the mixture, using only the observations. There are a lot of methods that can solve this kind of problem, like the Independent Component Analysis (ICA) and the FAST-ICA algorithm.

Chapter 8 deals with wireless sensor networks (WSN) which became an emerging technology since its increasing usage in various domains and different applications such medical systems, environment monitoring, military applications, surveillance and recently they are induced to respond to several Internet of Things applications requirements. That is all because of their advantages which are principally reflected in the absence of infrastructure, the ease deployment of the network, low maintenance and faster communication. This chapter presents a list of comparative studies of certain clustering-based routing protocols in terms of their energy efficiency, network lifetime, throughput and stability performances. In one hand, it will focus mainly in the recent based routing algorithms belonging to two different clustered routing protocols families dedicated for heterogeneous WSNs namely respectively Selected Election Protocol (SEP) and Distributed Energy Efficient Clustering Protocol (DEEC). It is about eight protocols named SEP, E-SEP, T-SEP, Z-SEP, DEEC, E-DEEC, D-DEEC and T-DEEC. In other hand, a new approach inspired by the SEP protocol family is presented.

Chapter 9 is focus on the NMF methods. The aim is to factorize a non-negative observation matrix X as the product X =G.F between two non-negative matrices G and F, respectively the matrix of contributions and profiles. Although, these approaches are studied with great interest by the scientific community, they often suffer from a lack of robustness with regard to data and initial conditions and can present multiple solutions. The work of this chapter aims to examine the different approaches of NMF, thus introducing the constraint of sparsity in order to avoid local minima. The NMF can be informed by introducing desired constraints on the matrix F (resp G) such as the sum of 1 of each of its lines. Applications on images made it possible to test the interest of many algorithms in terms of precision and speed.

Chapter 10 focuses on the Solar energy, which is the one of the major reliable renewable sources. Solar photovoltaic system is used to convert the light energy (photons) into electrical energy from the sunlight. A simple solar PV system consists of solar PV panel and inverter to convert the sunlight into electricity. Solar panel is a device that used to convert the photons in the sun light into DC electricity and inverter is used to convert the DC electricity into AC electricity. This chapter will introduce some standards in this field and an introduction of solar micro inverter which is designed for single solar PV module instead of group of solar PV modules. Each module shall be equipped with a micro inverter to convert the DC electricity into AC electricity and the micro inverter is placed/installed below the module.

Chapter 11 presents some of the recent technological developments in the field of LED lighting technology and challenges that limit their performance. Solid-state lighting technology is rapidly gaining acceptance in lighting industry with a growing list of applications, such as, street lighting, traffic lighting, decorative lighting, projection displays, display backlighting, automotive lighting and so on. It differs from conventional light sources that use tungsten filament, plasma or gases to generate light, solid-state lighting is based on organic or inorganic light emitting diodes (LEDs), and has the potential to generate light with almost 100% efficiency. LED lighting fixtures have long lifetime and are environmental friendly with no toxic mercury contained. However, the success of these fixtures depends on the system design, which comprises an understanding of electrical and photometrical characteristics under temperature effect on device performance.

Chapter 12 is focused on the study of Lamb waves' propagation. In this chapter Finite Element Method (FEM) is used to study the Lamb waves' propagation and their interactions with symmetric

and asymmetric delamination in sandwich skin. Firstly, a theoretical model is established to obtain the equation of lamb modes propagation. Secondly dispersion curves are plotted using Matlab program for the laminate. The simulations were then carried out using ABAQUS CAE by exciting the fundamental A0 Lamb mode in the frequency 300 kHz. The delamination was after that estimated by analyzing the signal picked up at two sensors using two technics: Two Dimensional Fast Fourier Transform (2D-FFT) to identify the propagating and converted modes and Wavelet Transform (WT) to measure the arrival times. The results confirmed that the mode A0 is sensible to symmetric and asymmetric delamination. Besides, based on the signal that changes with the delamination edges, a localization method is proposed to estimate the position and the length of the delamination. In the last section of this chapter, an experimental FEM verification is provided to validate the proposed method.

In chapter 13 is presented the concept of Microgrid. From which the main resources of these systems are transformed in renewable energy resources. On the other hand, the use of DC-based systems potentially has significant efficiency and cost advantages to a range of power system applications. One of the systems which are used from DC power is DC Microgrids. In the Microgrids, the loads are supplied from the local Distributed Generations (DGs) sources; also, the majority of loads and DGs in Microgrids are DC, hence, using DC power in Microgrids is more suitable. Besides, the main problems of these systems are modeling and protection of DC Microgrids. This chapter study different modeling techniques of DC Microgrid components such as Photovoltaic (PV), Wind Turbine (WT), lines and converters. Therefore, the challenges and different methods for identifying the location of fault and methods for reliable and secure operation of the system is introduced. Moreover, one of the challenging problems of DC Microgrids is locating the fault location. Therefore, different fault location method is proposed in this chapter.

Chapter 14 includes the theoretical investigation of the propagation characteristics of SH-type wave and a new type of dispersive surface wave in an irregular layer overlying a half-space, both constituted by distinct homogeneous micropolar isotropic elastic materials. At the common interface of the layered structure, two types of irregularities viz. rectangular and parabolic shaped, are studied in two distinct cases. Existence of new type of dispersive surface wave along with its dispersion relation has been deduced in the closed-form by adopting a distinct mathematical treatment for various cases concerned with the presence and absence of microrotational components in the composite structure. It is also examined that the dispersion equation of new type of dispersive surface wave vanishes identically in classical elastic case.

Chapter 15 is focused on the Antilock Braking System (ABS). It is an active safety system that aims to reduce the number of road accidents. The ABS investigated is an electronically controlled system that allows the driver to keep up control of the vehicle amid crisis braking while at the same time keeping the wheels under control. Besides, by keeping brake weight just underneath the point of making a wheel lock up. The ABS guarantee that the most extreme braking power is utilized to stop the vehicle while ensuring the minimum possible braking distance. The formal methods are mathematically based techniques that allows to specify and verify the systems. The use of those methods can greatly increase our understanding of a system by revealing inconsistencies, ambiguities, and incompleteness that might otherwise go undetected. The formal method used in this paper is Event-B, which is based on set theory as a modeling notation.

Chapter 16 presents the summary of latest performance for Improvement of Mechanical Components by Precision Coating. Here, we present the main coating technologies and their practical applications. Furthermore, the quality and precision aspects, as well as the applicable standards are discussed. Some practical examples regarding the performance improvement of different mechanical components by ap-

plying precision coatings are additionally presented. The final goal of this chapter is to enable the readers to choose the proper system for their application, by providing all the relevant information regarding various coating types.

Chapter 17 presents the Additive Manufacturing process. It is a three dimensional printing methods that permits to manufacture lighter, stronger three-dimensional parts by using so calling manufactured layer by layers of material deposition. The Additive Manufacturing uses a computer and CAD software's which passes the program to the printer to build the desired shape. Metals, thermoplastic polymers, ceramics are the preferred material used for additive manufacturing. Fused deposition modeling is one the additive manufacturing technique that involves the use of thermoplastic polymer for creating desired shape. Carbon fibers can be added into polymer to strengthen the composite without adding additional weight. The present chapter deals with the manufacturing of Carbon fiber reinforced Polylactic Acid composites prepared using fused deposition modeling. Mechanical and thermo-mechanical properties of composites are studied as per ASTM standards and using sophisticated instruments. It is observed that there is enhancement in thermo-mechanical properties of composites due to addition reinforcement which is discussed in detail.

Chapter 18 is focused on the Resin Transfer Molding (RTM) method which has become one of the most efficient processes to manufacture medium size reinforced composite parts. Among the main steps in processing the composite parts is the curing reaction. In the majority of cases this reaction is of exothermic nature and accompanied by a rise in temperature in the center of the laminate, this leads to the appearance of a thermal gradient. This chapter presents a study on the effect of increasing temperature on the optimization of the curing cycle, furthermore, and another study on the effect of thickness variation on temperature distribution in the composite. Further, this research work aims also to elucidate the thermal gradient phenomenon generated as a result of a cross linking reaction. The objective is to minimize the temperature excess in the composite laminate.

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