Preface

Ultra wide band (UWB) has received a great amount of interest since the decision by the US Federal Communications Commission (FCC) in February 2002 authorizing the emission of very low power spectral density in a bandwidth going from 3.1 to 10.6 GHz. This technique of radio transmission consists of using signals whose spectrum is spread out over a wideband of frequencies, typically from about 500 MHz to several GHz. It was formerly used for military and radar applications, then transposed a few years ago to telecommunications, thus causing a growing interest within the scientific community and industry. This spectral availability makes it possible to consider the wideband communications and also leads to a fine space resolution for the radars. However, the current restrictions of the regulatory agencies on the emission power level limit the range of the UWB communications to a few meters for high data rates and up to a few hundred meters for low data rates. UWB technology thus seems naturally well positioned for short range communications (WLAN, WPAN), offering an alternative at the same time of low cost and low consumption to the existing standards in these networks.

The acronym UWB gathers two standardized but distinct technologies today. The first is founded on the emission of impulses of very short duration; this is the mono-band or impulse radio approach. The second approach is based on the use of multiple simultaneous carriers where the bandwidth is subdivided into several sub-bands (multi-band approach).The modulation used in each sub-band is the OFDM (Orthogonal Frequency Division Multiplexing).

The advantages and disadvantages of the mono- and multi-band approaches are delicate questions and have been the subject of debate by many regulatory agencies. A particularly important question is the minimization of the interference to the emission and reception of the UWB system.

The multiple band approach is particularly interesting because the carrier frequencies can be suitably selected to avoid interferences with narrow band-based systems. This offers more flexibility but requires an additional layer of control in the physical layer.

UWB signals in the impulse technique require very good RF components (very short switching time) and a greater accuracy of synchronization. UWB systems can then be developed at a relatively low cost. Contrary to the multi-band approach which is based on techniques which are tested and available already, the architecture of a telecommunication system in impulse mode has involved many developments and in particular has required the installation of new definitions. The antenna does not escape these changes and we will show that this interface between the propagation channel and the architecture of the transmitters/receivers must add other time-domain radiation characteristics to optimize the transmission and the reception of impulses. These characteristics naturally come to complement and not replace the conventional ones, making it possible to qualify the antennas.

This is the method which we retained in this work; starting from the usual parameters necessary for characterization of the antennas in the spectral domain, we added to these the suitable definitions in the time domain. We will not consider the radiation characteristics which will not be used during the antenna design in time domain. We will thus look at the frequency and time-domain characteristics, by specifying each time the joint and specific definitions. This book, dedicated specifically to UWB antennas, provides the electromagnetic foundations to students and presents state of arts for engineers and researchers. The reader will notice some absences: the IRA (Impulse Radiating Antenna) and specialized UWB smart antennas which could not be detailed within the scope of this book.

This book is one of the fruits of the autumn school, GDR[1] Ondes, on UWB organized in October 2006 in Valence (France). Its role was to present the fundamental aspects, measurement, processing and architectures of UWB systems. The large majority of the authors of this book were already "on board" and took an active part in the GDR Ondes Working group "Ultra Large-Bande, Communications Hauts-Débits, Contrôle et Commande" (Ultra Wide Band, High Data Rates Communications, Remote and Control).

Finally, the book is a summary of French work recognized at an international level on a subject which, still today, produces several hundred scientific articles

1. GDR ONDES 2451, created on 1st January 2002 by the CNRS, has the role of being an indispensible center for all specialists in electromagnetism, optics and photonics and acoustics.

every year. The chapters were written by academic and institutional researchers and industrial specialists in the field.

This book is composed of six chapters.

Chapter 1 presents the definitions and the regulatory aspects of the UWB. A classification then a comparison of UWB approaches is proposed. The chapter is closed by a presentation of UWB target applications on fields as varied as broadband communications in multiple environments and geolocalization.

Chapter 2 defines the radiation characteristics of the antennas usually used in the frequency domain. It is a restricted, rather than an exhaustive, presentation of the characteristics which will be then used throughout the book. Special attention has been brought to the validity of the definitions in the time and frequency domains. An example of a directive UWB antenna is then proposed to illustrate the characteristics defined in the chapter.

Chapter 3 enriches the conventional characterization of the antennas. Through a functional approach, we define concepts, objects of reference and indicators appropriate for the analysis of time domain behavior of UWB antennas. In particular, we focus on the phenomenon of signal distortion and on the concept of an ideal antenna. Because of the significant amount of data (experimental or simulated) to be handled and analyzed, various indicators of performance are then proposed making it possible to synthesize information to better expose the behaviors and imperfections, in order to more easily compare the antennas. Then a parametric modeling approach based on drastic order reduction closes the chapter.

Chapter 4 provides the necessary complement to the two preceding chapters and presents the experimental characterization methods allowing the validation of any design. The first part of this chapter takes the logic of the book, describing antenna radiation measurements in the spectral domain then the methods developed for the time domain characterization of UWB antennas. The methods presented are detailed and specificities of the instrumentation are also described. Measurements of a compact UWB antenna make it possible to illustrate the preceding definitions. The chapter is concluded by the measurement methods of the electric characteristics of the inputs of the antennas.

Chapter 5 is devoted to a panorama of existing antennas with matching impedance characteristics on very wide bandwidths and to some techniques making it possible to improve their performances. The frequency-independent antennas which present the property to be dimensioned identically at all the frequencies are initially detailed. Then, the elementary antennas with a widened shape are also described, in particular for UWB communications. Directive antennas, then antennas

with progressive transition and horns finish this non-exhaustive presentation. The second part of this chapter is devoted to the reduction of UWB antenna dimensions for mobile terminals and provides the main strategies. After detailing at lenght the solutions adopted for communication applications, this chapter presents some UWB antenna technologies for ground penetrating radars.

Chapter 6 presents the joint antenna-channel effects in UWB. The objective is to show that the effective behavior of the antennas within a radio link cannot be analyzed separately. After some reminders on the propagation channel, the influence of the channel on the performance of the UWB systems is presented. The study of the antenna effective performances with ideal channel, then dispersive for directive antennas or not, is then detailed. The chapter ends with a factorization of the radiation pattern making it possible to show that, according to the architecture, it can be useful to evaluate the quality of a radio link in UWB.

This final chapter concludes the volume and directs the reader towards the book by our colleagues Pascal Pagani, Friedman Tchoffo Talom, Patrice Pajusco and Bernard Uguen on the UWB propagation channel [PAG 08]. With the transmission channel closely associating the propagation channel with antennas, the book by Pagani *et al*. can also be referred to as the necessary complement to our book.

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October 2010