ACE 2 ACTIVITIES ON SMALL TERMINAL TECHNOLOGIES AND APPLICATIONS

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ABSTRACT

This paper presents the work carried out in the ACE Network of Excellence regarding technologies for small terminal antennas. The aim is to identify the newest trends in antenna design for personal communications devices, and suggest novel solutions and design methodologies for various applications.

1. INTRODUCTION

The Networks of Excellence were introduced in the 6th Framework Program of the European Union as a new instrument to integrate and structure research activities around Europe, to increase the relevance of their results by avoiding overlapping [1]. Among them, the Antenna Centre of Excellence (ACE, 2004-2005) was created, complementing the activities of the COST 284 action: "Innovative Antennas for Emerging Terrestrial & Space-based Applications" [2]. ACE 2 (2006-2007) follows up the work started in ACE, to try to achieve a durable structuring.

This paper gives an overview of the activities carried out within the ACE 2 (Antenna Centre of Excellence) Network of Excellence, regarding antenna technologies for small terminals and their applications. The aim is to carry on with the work initiated in the first ACE, where new had already been identified.

2. AIM OF THE WORK

As personal communications devices have become almost omnipresent in everyday life, the demarcation between different devices, such as mobile telephones, organisers or computers, has disappeared whilst universal connectivity has improved. The idea is to enable wireless access to private or public networks, anywhere, anytime. This trend, coupled with the advent of new standards and applications resulted in a requirement for enhanced bandwidth and quality of service.

The new generations of mobile and wireless personal devices challenge ever more the ability of antenna designers. A lot of research goes on in this area, but is often performed without sufficient systems background and connection to the market. The newest trends in terminal design have to be rapidly detected, as they will have a major influence on the requirements for antenna technology and design.

The market of communications terminals shows great flexibility, with ever growing demands for miniaturised, multi-application devices. Antenna design must be adapted to the need for increased efficiency and bandwidth. Also, new techniques and architectures can be exploited, with the introduction i.e. of new materials, diversity schemes or MIMO (Multiple-Input, Multiple Output) systems. At the same time, new applications as Multiradio or UWB (Ultra Wide Band) systems are being developed, which will demand yet more effort from antenna engineers, to satisfy new requirements.

In a context in which terminal technology evolves rapidly, it is essential to make a continuous survey of the latest developments in this area, in order to update and optimise the technology and design methodologies for mobile and wireless terminals.

The work is also focussed on antennas for advanced applications, such as MIMO, DAB (Digital Audio Broadcast), DVB-T/H (Digital Video Broadcast), UWB systems, RFID (Radio Frequency Identification)or bio-medical applications, both in-body (implants) and on-body. This work must be done taking into account not only the present and future needs concerning personal communications terminals, but also the interaction with the user. Special attention will is given to the problem of the integration of antennas (single and multimode elements or multiple antennas) into portable devices.

3. SMALL TERMINAL TECHNOLOGIES

The first focus of this activity is to keep on with the identification of the emerging needs, trends and standards that may be deployed in the near future. This will be accompanied by a follow-up of the review of novel applications, technologies and materials. On-going research lines concerning mobile communications terminals will be analysed and evaluated, to ascertain if they are leading to relevant results with possible application to future terminals.

The problem of the integration of the antenna into the terminal will also be addressed, to gain new insight on the coupling mechanisms between the radiating element and the surrounding devices. Indeed, the assessment of the integration of small antennas into the terminal has to

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be done as a whole, that means taking into account other components, such as PCB, battery, plastic case, etc. This will include, for example, a study of the integration of receive/transmit amplifiers within the antenna, for direct optimisation of the noise temperature on receive mode, and of the radiated power efficiency on transmit mode. This should enable much better receiver sensitivity and longer battery life. The aim is to produce a set of recommendations for the integration of small antennas into user terminals, which could help enhance the efficiency of the antennas when combined with the communications devices. This is especially important in applications such as HAC (Hearing aid Compatible) phones, as near-field effects must be taken into account.

To be able to accurately assess the problem of the integration of small antennas into user terminals, the latest technologies and design methodologies will be reviewed, in order to optimise them. This includes traditional antenna design methodologies, but also new trends such as the analysis of the characteristic modes on the chassis of the handset.

Antenna design is very much connected with antenna analysis tools both in the frequency domain and in the time domain. The design and development of antennas for mobile terminals relies mostly on the expertise and know-how of the designers. Although important efforts have been focussed on developing automated design procedures, either based on genetic algorithms or other random optimizers, in-depth knowledge of the physics involved on radiation mechanisms is always necessary to provide a reliable solution. Therefore, the integration of the right analysis procedures and design tools is also a key issue in this activity. Thus, as analysis of new tools for antenna design will be carried out, and their performance will be tested with a comparison of simulation results obtained with different simulation tools. A judicious combination of both semi-analytical optimization methods based on the radiating modes of the antenna and random optimization procedures can also lead to new design strategies and tools.

4. SMALL TERMINAL APLICATIONS

4.1. Multi-antennas systems and MIMO

Another focus area of this activity is the review of state-of-the-art multi-element antenna technologies that facilitate the implementation of multi-system and MIMO terminals. Yet, the optimisation of multi-antenna topologies should be done taking into account the MIMO system performance point of view. Indeed, in new systems such as UMTS, multi-element antenna structures in the terminal are a popular way to achieve antenna diversity, in order to improve the link reliability needed for reaching high data rates.

It has been shown that MIMO wireless systems can provide increased capacity in rich multipath environments [3]. MIMO antenna systems can be used in a mobile terminal to fight the impairments of the propagation channel, and thus obtain additional gain over other well-established classical strategies. In Fig. 1, a possible UMTS dual-antenna solution for a diversity antenna structure in a mobile terminal is shown [4].

This is also a very interesting solution for nomadic applications, such as laptops in a WiMAX environment [5]. In a small mobile terminal the number of antenna elements may range typically from two in a small handset, to four in a PDA, and up to sixteen or even more, in a laptop computer [6]. A realistic number of antenna elements placed on the quite small mobile terminals is probably less than five. In this context especially dual-polarised antenna elements are interesting, as they enable locating two antennas in the same volume.

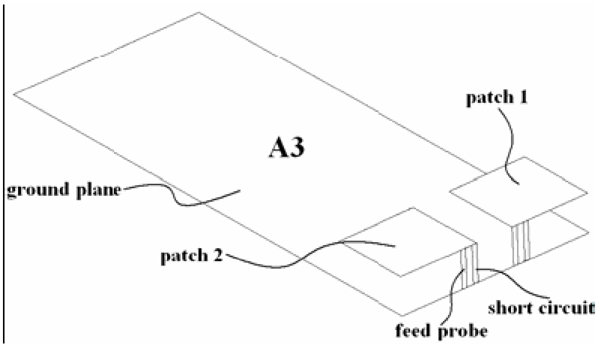

Figure 1: Dual element PIFA prototype for UMTS using polarisation diversity [4].

Moreover, as 2G and 3G mobile networks will continue to coexist during a certain period, one antenna for each communication standards will have to be integrated above the same terminal [7] or at least, when the radio front-end modules will reach maturity, a multi-band antenna covering the involved standards [8]. In Fig. 2, a possible multi-antenna solution for a multi-mode (GSM and UMTS) mobile terminal is shown [7].

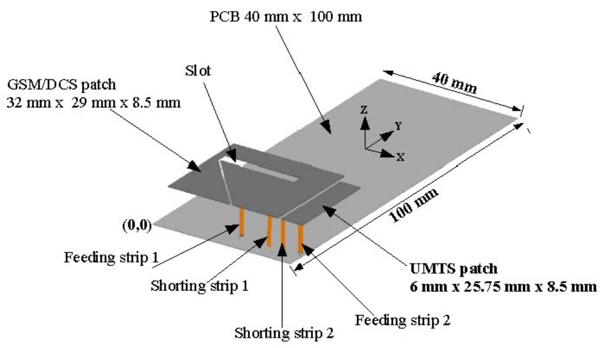

Figure 2: GSM/DCS and UMTS PIFAs

4.2. Digital broadcasting

One of the latest upcoming trends in mobile communications technology is the reception of digital-TV on mobile terminals. Besides the reception of public video streams it would also be possible to use this broadcast technology for other large-bandwidth data traffic (in the reception side), such as general or commercial localized information distribution. Antennas for DAB terminals must therefore be adapted to cover these bands with a reasonable performance. DVB-H technology adapts the successful DVB-T system for digital terrestrial television to the specific requirements of handheld, battery-powered receivers. [9]. The rather low realised gain specification was based on the common understanding of the realistic possibilities for implementing such a wideband antenna. In a receiver antenna like for DVB-H, high matching losses (i.e. a lower total efficiency) can be accepted, as the radio environment is typically noisy in the DVB-H range [10], and in a noisy environment poor antenna matching does not deteriorate the signal-to-noise ratio. The low frequency range makes the construction of antennas for the aspired small terminals very challenging. To solve this problem, novel antenna concepts such as the one in Fig. 3. Here, the metal shield of the phone is used as an antenna [11]

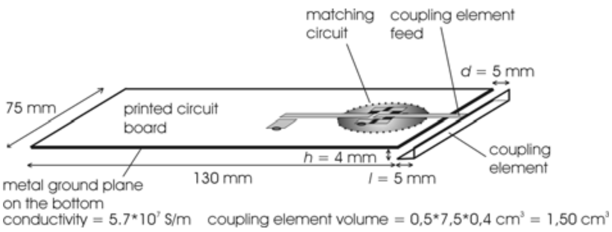

Figure 3: Prototype with matching circuit and coupling element structure for DVB-H reception on handheld terminals [11].

4.3. UWB systems

As stated previously, new, non-cellular systems are also been introduced, to cover the demands of short to medium range connectivity. Among them, UWB (Ultra Wide Band) shows promising applications for wireless multimedia systems, in which the need for high capacity implies enhanced bandwidth. UWB is based on the concept of impulse radio communications, with a bandwidth of over 500MHz. Due to the wide bandwidth (or very short pulses), it is easier to fight multipath effect. Also the signal has a higher penetrating power that makes it suitable for purposes other than simple data communication, like Ground Penetrating Radar, Position locator inside a building, in-house multimedia applications. The antennas employed have a strong influence on the performance of UWB systems. Due to the high bandwidth that has to be covered, the antenna characteristics must not be regarded to be independent from frequency any more, as it is done in narrowband systems. Instead, the antenna has to be described as a selective filter providing different radiation patterns dependent on frequency. For high performance UWB operation two main requirements have to be fulfilled by the antennas [12]: First, the antenna has to support the complete frequency range of the ultra-wideband signal to be transmitted. Second, the antenna must have an impulse response as short as possible (which is equivalent to a constant group delay). Otherwise the transmitted signal will underlie dispersion. In this activity, new solutions will be analysed, to cope with UWB requirements.

4.4. RFID

In the last years, there has been a tremendous growth in the demand for Radio Frequency Identification (RFID) procedures in manufacturing units, purchasing departments, logistics and transportation, for which identification is a prime concern [13]. The great appeal of RFID technology is that it allows information to be stored and read without requiring either physical contact or a line of sight between the tag and the reader by using electromagnetic waves. The key design challenge is achieving tag antennas with sufficiently high gain. The tags are furthermore required to be small in size and mechanically robust against vibrations. In spite of the downsizing techniques that are used in order to design such meandered antennas, their dimensions are still quite large in comparison with the rest of the circuitry. Some examples of RFID antennas can be seen in Fig. 4

Figure 4: RFID antennas.

4.5. Body Area Networks (BAN)

Future mobile communications systems will include so-called body-centric configurations, with modules distributed all over the body of the human user, forming a "Body Area Network" (BAN). Such wireless networks should provide a communication system available in all circumstances, with a high degree of reconfigurability, yet unobtrusive to the wearer. Such on-body networks have to respond to unique problems, related to the rapid changes in the communications channel. Indeed, the later will change depending on the subject carrying the equipment, and even on the position of the wearer, as described in [14]. Indeed, propagation close to the human user occurs due to both rays propagating around the body, or reflecting on different parts of it. Other effects should also be considered, such as multipath effects caused by multiple reflections in the environment of the user. UWB on-body communications are also of great interest and have been recently investigated [15].

4.6. In-body antennas

In-body antennas and applicators have been a hot topic in the last years. The use of antennas as applicators for thermal therapy is today common practice at hospitals, whereas the use of high frequency communication to and from electronic implants is in its infancy. This in contrast to low-frequency bio-medical telemetry, which is a well-established field [16]. Today an inductive link is commonly used to retrieve data from the implants regarding their performance and the health of the patient, and to make adjustments without any invasive operations. Using RF (Radio Frequency) links between the implants and the monitoring systems, doctors could more easily communicate with the implant. To accomplish this, low-power two-way RF communications systems must be employed. In this sense, the design of the antenna will partially be determined by the application. The work of this ACE activity will also focus on measurement practices for implant antennas, in order to issue recommendations for a better practice for evaluation of such antennas, with regard to impedance, radiation efficiency and SAR.

5. AKNOWLEDGEMENTS

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