Preface

General Organization of the Book

This reference book introduces the reader to the cutting edge antenna array technology used in the automotive industry. New communication multi-element antenna systems are very promising equipment for automotive applications. For example, intelligent vehicle highway systems (IVHS) including vehicle-to-vehicle communication, Drive-thru Internet, vehicle to roadside systems, anti-collision radar antenna arrays, and smart antenna arrays for automatic cruise control applications provide increased safe travelling for vehicle passengers. Vehicle localization techniques based on the antenna array technology deliver car finding services in big parking lots, at shopping and airport centers, and in music or sporting events. Electronic toll collection devices with antenna arrays mounted overhead at the highway entrance and exit are designed to assist in the management of toll operations through technology that aids in streamlining traffic movement.

Currently, numerous papers are investigating car-to-car multiple input/ multiple output (MIMO) systems. With this method, two or more antennas are employed at the transmitter side and a few antennas at the receiver side. The utilizing of MIMO systems in the automotive industry increases the capacity of rich scattering wireless fading communication channels and provides high speed communication data rate. The promising trend in automotive is the development of adaptive antenna arrays. Adaptive arrays allow steering the beam (maximum energy) to any direction of interest while simultaneously nulling interfering signals. So far, such systems are being widely used in the military industry. Now a number of papers describe these smart antennas for mobile applications. The main objective of this book is to build a "bridge" between the numerous theoretical results devoted to antenna arrays and the applications of these devices in the automotive industry. At present, the typical designer must sift through thousands of patents, papers, and

websites before settling on the right direction. Such research can take enormous amounts of time. This handbook reduces the amount of research time necessary to find optimal solutions in antenna design and applications. We sorted and systematized material from a large number of professional journals, papers, and patents, as well as describe our own results in the antenna design used in the automotive industry.

This book is organized into seven chapters. Chapter 1 introduces the reader to the different automotive antenna arrays applications: in which systems are currently being used and can be utilized in the near future. It also specifies the frequency spectrum and key parameters used for antenna array communication in the automotive industry.

Chapter 2 presents typical different array geometries, array factor parameters, basic analog, and digital beam steering techniques that are utilized for design of modern antenna systems. It also describes the scattering parameters method to demonstrate antenna characteristics with mutual coupling between the array elements. This chapter introduces the reader to the analog and digital phase shifters, which are important parts of the array with electronic beam steering control.

Chapter 3 discusses smart beamforming techniques utilized in noisy environment. Presented here, the adaptive Applebaum algorithm realizes a maximum signal to noise ratio, least mean squire (LMS) method minimizes the error between the desired and received signals, high resolution processing methods, for example MUSIC technique provides the angular resolution of two RF sources much higher in comparison with traditional Rayleigh criterion. Special attention is devoted to the MIMO systems because they provide a significant increase in communication data speed rate between transmitting and receiving devices without additional bandwidth and extra transmit power. These systems also significantly improve immunity to interference sources and multipath propagation in urban areas.

Chapter 4 describes simplified smart beamforming methods, which are very important when designing cost effective devices for automotive applications. Automotive antennas have to be compact devices and should not conflict with the esthetic requirements for the car. Therefore, simplified methods, such as Butler matrix systems, sectored small arrays, partially adaptive and phase arrays with simplified two-bit digital phase shifters are described in this chapter. Detailed explanation is devoted to the new simple phased array with two-bit phased shifter array which is based on radio hologram technology.

Chapter 5 is devoted to the practical base station antenna array design examples for communication with the moving car. These examples include fixed beam directional arrays for toll collection applications, arrays with electronically controlled beam for Drive-thru Internet projects, and vehicle localization arrays intended for car finding at big parking lots, multilevel parking structures, shopping or airport centers, and close to music or sporting events.

Chapter 6 describes practical compact vehicle mounted arrays. These systems can be mounted on the roof of the car, or on other exterior and interior parts of the vehicle body. Design examples include multiple antenna elements operating as directional arrays with a single output or multiple diversity antennas proposed for

FM radio, TV reception, remote keyless entry systems, and MIMO antennas for intelligent transportation service (ITS). The ITS based on car-to-car (C2C) or car to infrastructure (C2I) communication provides the driver with the following information:

- Road way conditions, warning on entering intersections and highways, reporting accidents and traffic jams, lane change warnings and low visibility ranges, collision safety distance between the cars.
- Travel-related information about business locations, gas stations, and car services.
- Traffic management information, including specific speed limits and adaptable traffic lights.
- Driver assistance information providing parking for vehicle, rest area locations at the highway, finding the car in big parking lots, cruise control, and so on.

Finally, examples of the antenna arrays employed in anti-collision radars and traffic monitoring systems are presented in Chapter 7. According to statistics, hundreds of thousands of people die in road accidents worldwide and millions are injured. Therefore, the use of multi-element radar sensors for driver assistance has become more popular in the last few years. These systems use extremely high frequency bands (24 and 77 GHz) and they are based on frequency modulated continuous wave (FMCW) radar technology.

We hope this book will be a useful reference source for readers interested in antenna array design and applications for the automotive industry.

Victor Rabinovich

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