Chapter 9
Radio over Fiber Access Networks for Broadband Wireless Communications

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ABSTRACT
In recent years, considerable attention has been devoted to the merging of Radio over Fiber (RoF) technologies with millimeter-wave-band signal distribution. This type of system has great potential to support secure, cost-effective coverage and high-capacity vehicular/mobile/wireless access for the future provisioning of broadband, interactive, and multimedia services. In this chapter, the authors present an overview of an RoF access networks in the context of in-vehicle networks, with special attention to the figures of merit of the system and the basic enabling technologies for downlink/uplink transmission in the RoF land network, which is divided in three main subsystems: Central Station (CS), Optical Distribution Network (ODN) and Base Station (BS). The chapter first reviews the up-conversion techniques from baseband to mm-waves at the CS, and then the different BS configurations. The work finally applies these concepts to the development of an access network proposal for in-vehicle wireless application.

INTRODUCTION
During the past two decades, the personal communications industry has faced an impressive growth in the number of subscribers worldwide, which make use of the different wireless access services and applications offered by service providers. In the early days of mobile radio only voice was demanded, with small amounts of data, which could be sent over the voice oriented channel. This requirement has evolved over the years, as large volumes of information need to be sent from source to destination, even with the additional requirement of on-line connectivity. The
objective of mobile broadband wireless access, that aims to provide the above mentioned aspects, has been addressed by the IEEE standard (802.15, Wireless Personal Area Networks) (802.16) and by the ITU evolving standard International Mobile Telecommunication- Advanced (ITU-R). The need for efficient transport systems, which could support such bandwidth requirements, are encouraged to exploit the advantages of both, optical fibers and millimeter-wave (mm-wave) frequencies (Cochrane, 1989). Such systems that use an optical distribution network (ODN) for delivering mm-wave radio signals from a Central Station (CS) to many remote Base Stations (BSs) have long been recognized to allow the increase of user capacity, bandwidth, and mobility (Ogawa H., et al., 1992).

A typical RoF system is shown in Figure 1. There is a CS that contains all the data resources, optical transmitters (TX - lasers), optical receivers (RX – photodetectors), interconnection with the Trunk Network, Internet and switching capacity of the network. In the downlink direction the CS up-converts the electrical signal to optical frequency and uses the ODN to communicate with the BSs, in some cases using Remote Nodes (RN) where the optical signal is split or demultiplexed towards the corresponding BS which converts it back to electrical domain and radiates it to the Mobile Terminal (MT) end-user in mm-wave bands (Lim, et al., 2010). In the uplink direction, the BS receives the mm-wave signal from the MT, and depending on the configuration of the BS, this signal can be down-converted to baseband before modulating an electro-optical device to transmit the uplink information via the ODN back to the CS.

RoF communication systems have several advantages over conventional wireless systems, which are summarized as follows:

- The distribution of mm-wave frequency signals by the use of optical fibers reduces the attenuation, hence reducing the use of repeaters (amplifiers). This is possible since optical fibers have almost negligible insertion loss for very long distances, something that cannot be achieved in conventional wireless links, where free space loss sets the minimum possible path loss in the link.
- The architecture of an RoF system is often simpler and less expensive since it makes use of the concept of a CS, dealing with signal generation and resource management; and remote BSs can be deployed wherever they are required for wireless access, con-

Figure 1. General RoF system architecture, where central station (CS), optical distribution network (ODN), and base stations (BS) are presented