

SHLOMO OVADIA

BROADBAND CABLE TV ACCESS NETWORKS

From Technologies to Applications



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Next-generation CATV systems: architecture, protocols, technologies, and applications

Broadband cable TV networks are undergoing a massive transformation, from simply broadcasting analog TV channels to providing sophisticated, two-way interactive services such as high-speed Internet access and video-on-demand. Now, one of the field's leading experts reviews the technologies, protocols, and applications associated with the CATV revolution, and previews the migration path from today's two-way hybrid fiber/coax networks to the awesome capacities of tomorrow's DWDM fiber networks. Coverage includes:

- HFC cable networks vs. the competition: DSL, FTTL, DBS, and MMDS
- Key fiber-optics transmission technologies: directly and externally modulated laser transmitters, optical receivers, and Erbium-doped optical fiber amplifiers (EDFAs)
- Architecture of DWDM access networks
- Hardware architecture and operation of digital set-top boxes and cable modems
- Software architecture and applications for digital set-top boxes

Ovadia offers in-depth analyses of single- and multiple-wavelength fiber-optics transmission impairments over HFC and DWDM networks, and presents the emerging two-way DWDM network architecture. Finally, he discusses the DOCSIS cable modem protocol, as well as key set-top box applications such as electronic program guides (EPGs), video-on-demand (VOD), Internet-based applications such as e-mail, and e-commerce.

Whether you're an engineer, scientist, cable professional, manager, or investor, if you want to understand where cable is headed, you need *Broadband Cable TV Access Networks: From Technologies to Applications*.

About the Author

SHLOMO OVADIA is a Principal System Architect in the Cable Network Operation business unit at Intel. Prior to joining Intel, he was involved in the development of digital set-top boxes and cable modems as a Principal Scientist at Digital Network Systems, General Instrument/Motorola. He is a Senior Member of IEEE and has written more than 60 technical publications and biographies. He is also the author of *Who's Who in America: Science and Engineering*.

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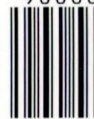
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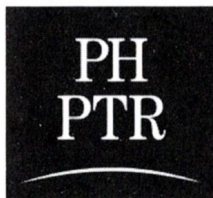
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BROADBAND CABLE TV ACCESS NETWORKS: FROM TECHNOLOGIES TO APPLICATIONS

SHLOMO OVADIA

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*To my parents, Mazal and Moshe,
My wife, Nina, and our children,
Yafit, Shlomit, Binyamin, and Leora*

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CHAPTER 7

RF DIGITAL QAM MODEMS

The purpose of this chapter is to explain the design and operation principles of RF cable modulators and demodulators (modems) for transporting digital video and data signals over the HFC network using the quadrature amplitude modulation (QAM) format based on a well-known standard. The principles of design and operation of QAM modems are essential for the understanding of cable modems and digital set-top boxes, which are discussed in Chapter 8. We shall start with a brief review of all the building blocks of QAM modems. In Section 7.2, the MPEG transport framing is discussed, which enables the transmission of MPEG packets. The next four sections will explain each of the four layers in the forward-error-correction (FEC) coding scheme. The FEC layers include Reed-Solomon coding, Trellis coded modulation, interleaving, and randomization. The building blocks, operation, and design of M-ary QAM modulators are discussed in Sections 7.7 and 7.8. Three key building blocks of the QAM receiver, namely, adaptive equalizer, carrier, and timing recovery are explained in Sections 7.9 and 7.10. Two important parameters to test the fidelity of the QAM transmitter are introduced in Section 7.11. Finally, the BER of M-ary QAM signals in a Gaussian channel are derived in Section 7.12.

7.1 RF QAM Modem Building Blocks

Radio frequency (RF) digital transmitters and receivers constitute one of the most important systems in HFC networks to transport digital video and/or data signals from the cable TV headend to the subscriber and back to the headend. In particular, the QAM modulation format was selected as the standard format for cable TV access networks by well-known standard organizations DOCSIS [1], DAVIC [2], and ITU-T J.83 Annex B [3]. Figure 7.1 shows a simplified block diagram of a QAM transmitter and receiver operating over an HFC network. The QAM transmitter portion of the modem consists of a Reed-Solomon (R-S) encoder, a convolutional interleaver, a randomizer or scrambler, a Trellis encoder (TCM), a symbol mapper, an M-ary QAM modulator with differential encoder, and an RF up-converter. The QAM receiver portion of the modem consists of an RF tuner, a QAM demodulator, a symbol demapper, a TCM decoder, a convolutional deinterleaver, an R-S decoder, and a derandomizer (descrambler). All these QAM modem building blocks are explained in the following sections based on the DOCSIS 1.1 protocol [1], which is the primary standard used in the U.S. Figure 7.2 illustrates the FEC section of the QAM modem.

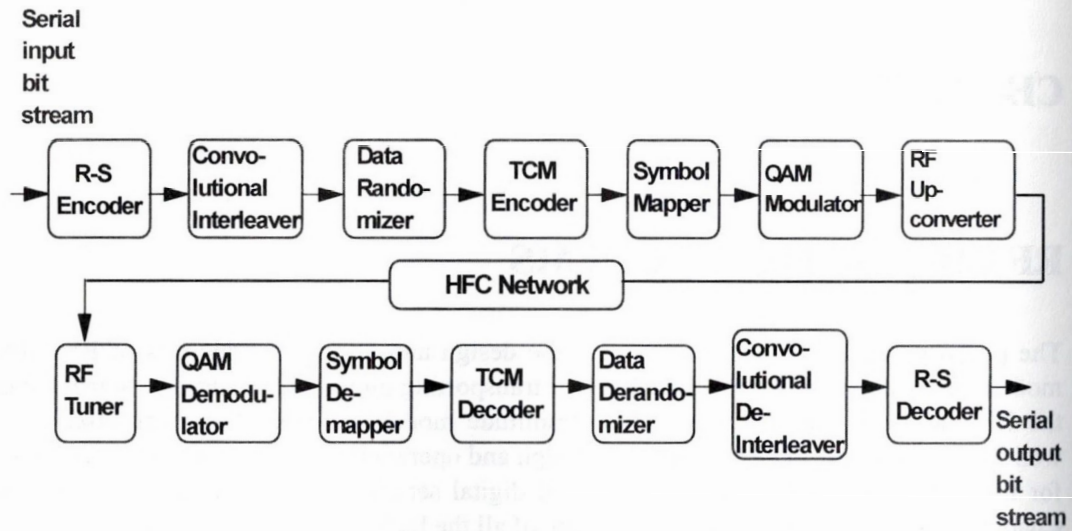


Figure 7.1 A simplified block diagram of RF QAM modem operating over HFC network.

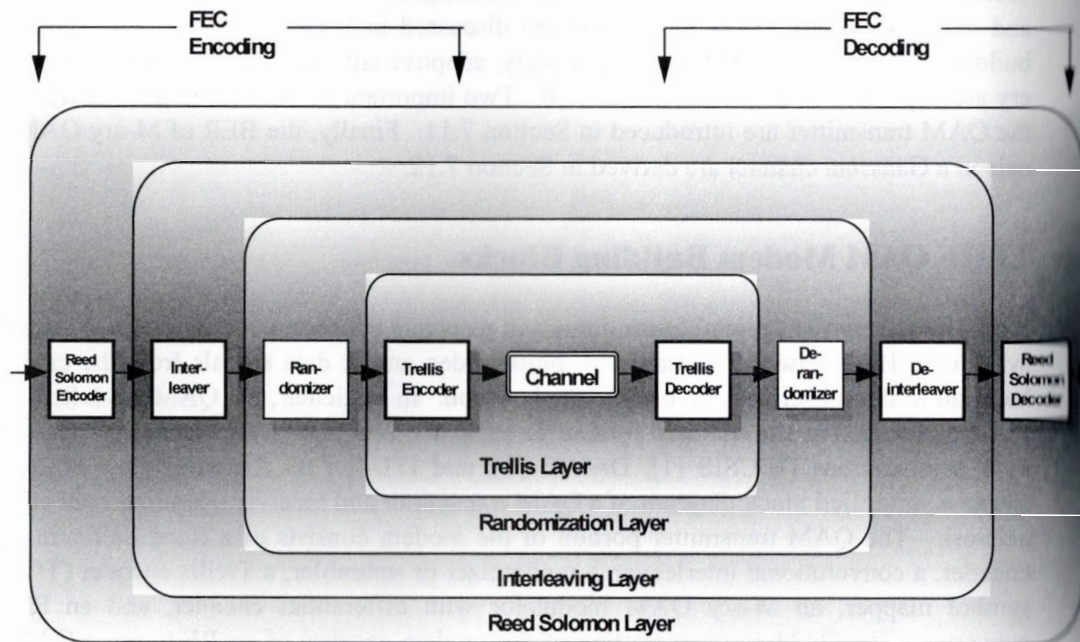


Figure 7.2 Four-layer block diagram of the forward-error-correction code.
After Ref. [4].

