A Broadcast Engineering Tutorial for Non-Engineers

Skip Pizzi
Graham Jones

Fourth Edition

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A BROADCAST ENGINEERING TUTORIAL FOR NON-ENGINEERS

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Graham Jones retired in 2010 from NAB, where he was a Senior Director working on advanced television issues. He is still active in ATSC, SCTE, and SMPTE standards committees. Previously he was Engineering Director for the Harris/PBS DTV Express, which introduced DTV to many U.S. broadcasters. He started his career with the BBC in London, and has worked as a consultant to broadcasters in many parts of the world. He holds a degree in Physics and is a chartered electrical engineer, a fellow of SMPTE, and a life member of the SBE and the Royal Television Society. He has been honored with the Bernard J. Lechner Outstanding Contributor Award from the ATSC and received a citation from SMPTE for outstanding service to the society.

Preface

There are many people without engineering backgrounds who need to have a general understanding of broadcast engineering principles. Reaching a large range of devices from TV screens and clock radios to smartphones and digital dashboards, today's broadcasting brings together a wide range of professionals, both technical and non-technical, all working within its vast and omnipresent ecosystem. They may be broadcast managers, program producers, or others who deal with broadcast clients. It is important that they all share some level of knowledge about the workings of broadcast technology.

This tutorial is therefore intended to help such non-engineers seeking to learn about the technology of radio and television. It should also be useful for broadcast engineers in training, or those in technical occupations (such as IT) who find themselves involved with broadcast operations, or who simply want an overview of areas outside their primary expertise. This book explains the jargon of broadcasting and describes the underlying principles, standards, and equipment for broadcast facilities in terms a layperson can understand.

The fourth edition has been completely revised and updated to reflect the increasing use of digital and networking techniques in all aspects of television and radio broadcasting. New chapters have been added to provide an overview of new-media applications by broadcasters and emerging standards in the broadcast industry. The focus is on over-the-air broadcasting from U.S. radio and television stations, but other methods of program delivery to the home are also covered, along with some of the different standards and technologies used in other countries.

Although later chapters build on information in earlier sections, this book can also be consulted for discrete information about a particular topic, and is copiously cross-referenced. However it is used, the overall goal of this book is to help readers further their understanding of the broadcast industry, and thus enhance their ability to perform the broadcast-related functions of their jobs.

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CHAPTER 1

Introduction

Broadcasting is a communications service that possesses two fundamental and unique attributes: (1) Broadcasting is a *point-to-multipoint* service, meaning that a broadcast service originates from a single transmitter but is receivable by an unlimited number of receivers within the coverage zone of that transmitter. (Compare this to a *point-to-point* communications system, such as telephony, in which one device typically connects only to a single device at any given time.) (2) Broadcasting is a *unidirectional* service, meaning that it carries content only in a one-way path—from the broadcast station's transmitter to the listener's or viewer's receiver—with no provision for carrying signals back the other way. (Compare this to a *bidirectional* communications system, such as telephony, in which each user's device serves as both a transmitter and a receiver, and content can flow between users in both directions simultaneously.) These two characteristics have defined broadcasting since its origin and continue to do so today. Thus, all the systems described in this book will possess these two essential qualities.

Meanwhile, the *business* of Broadcasting has evolved to include its own two primary functions: (1) The *generation* of audio or audiovisual media content, and (2) the *delivery* of such content to audiences. All broadcasting facilities are organized around one or both of these two processes. Radio and television stations typically include one of each type of facilities. Often these are placed at two different physical locations, but occasionally they are collocated.

Therefore, in its simplest form, a radio or television broadcast station consists of two basic facilities: the studio site and the transmitter site. The studio is where the content is generated. The transmitter site is where the content is sent out over the air, in a point-to-multipoint, unidirectional fashion. If those two facilities are not physically in the same place, between them is a connection called the studio-transmitter link (or "studio-to-transmitter link"), often abbreviated as "STL." But there are many individual components in each of these facilities that make up the chain from content generation to the reception of broadcast

services by the viewer or listener. This tutorial provides an introduction to the technologies and equipment that make up these chains, and thereby constitute modern broadcasting systems.

Traditionally, broadcasting was based on *analog* techniques, but for the past quarter-century or so, there has been a steady migration to *digital* systems, which provide many technical and operational benefits for broadcasting processes. The increasing use of computer-based systems has revolutionized both radio and television studios, increasing the quality and efficiency of audio and visual media content creation. More recently, new standards have evolved that also allow application of digital techniques to the transmission of content to end users of both radio and television, improving the efficiency and quality of media content delivery, as well.

All types of broadcast stations used for domestic broadcasting (AM and FM radio, and television) are covered in this tutorial, with descriptions of both analog and digital studio and transmission systems. For completeness, satellite, cable, and Internet delivery are also briefly described, although this book does not cover them in detail.

Chapters in the first section of the book, "Broadcasting Basics," discuss the main methods used for radio and television broadcasting and explain some of the basic science and the terms used later in the book. Chapters in the second section, "Studios, Production, and Playout Facilities," describe radio and television studios and remote operations, covering the main items of equipment used and how they work together. Chapters in the third section, "Transmission Standards and Systems," discuss the standards and technologies used for U.S. radio and television transmission and cover transmitter-site facilities and equipment. The penultimate chapter of this section discusses radio wave propagation and regulation of broadcasting by governmental authorities.

In each section or chapter, audio and radio topics are generally treated first, followed by video and television subjects.

Jargon words and phrases are shown in *italics* when these are used for first time in each section. The words and phrases may be defined in each section or covered in detail in other chapters. Some jargon words are unique to broadcasting, but some are regular words used in a special way that will be explained in each case.

BROADCASTING BASICS

CHAPTER 2

Types of Broadcasting

For many years, the term *broadcasting* meant the transmission of audio or video content via radio-frequency (RF) waves, often referred to as "over-the-air." More recently, with developments in advanced digital technology, the term applies to many different types of content distribution. Let's start with a summary of the main types of broadcasting in use today in the United States and elsewhere.

Many of the systems mentioned below differ only in the particular method of transmission or distribution used, whereas the studio systems used for generations of radio and television content have fewer variations. Don't worry if you don't fully understand all of the terms used in this chapter. They will be explained later in the appropriate sections.

ANALOG RADIO

Traditional radio broadcasting for local stations in the United States and throughout the world generally falls into two main types: AM and FM—standing for *amplitude modulation* and *frequency modulation*, respectively. These are the particular methods of radio transmission used for many years in broadcasting audio signals to home, car, and portable receivers. In North America, AM is used in the *medium frequency* (MF)—also known as *medium wave* band—whereas FM uses the *very high-frequency* (VHF) band.

In the United States, a given radio station frequently feeds only one transmitter and therefore is referred to as an AM station or an FM station. It is, however, quite possible for a station to feed both AM and FM transmitters in the same area, or to feed more than one transmitter covering different areas, in which case the term AM or FM may refer only to a particular transmitter and not to the station as a whole. The latter arrangement is more frequently encountered outside the United States, but is becoming increasingly common in the United States.

In some countries, AM radio also uses the *long wave band*, with frequencies somewhat lower than the MF band, and having slightly different propagation

characteristics, better for broadcasting over wide areas. AM is also used for *shortwave* radio broadcasting—also known as "HF" for the *high-frequency* band that is used. This is used for broadcasting over very long distances (usually internationally).

We cover analog radio in more detail in Chapter 12.

DIGITAL RADIO

There are four standards for over-the-air digital radio systems in the world, all different from each other in several respects. They are commonly referred to by their acronyms: IBOC, DAB, ISDB-TSB, and DRM.

IBOC (In-Band On-Channel)

Digital radio broadcasting for local stations in the United States uses a system called In-Band On-Channel (IBOC, often pronounced "EYE-bock"). The IBOC digital radio system was developed and continues to be managed by a single company, iBiquity Digital Corporation, referring to its implementation of IBOC by the trademarked name of *HD Radio*. For this reason, the two terms are essentially interchangeable in most practical parlance, and so today, the HD Radio label is more commonly applied to the format. (The HD Radio trade name has led many to assume that the "HD" stands for high definition, but in fact, iBiquity Digital specifies that it is not an acronym and simply an identifier.)

The technology is called In-Band On-Channel because it places a radio station's digital signal within the same band (AM or FM) as the station's original analog system, and within the station's existing analog channel in each case. For this reason, IBOC digital radio does not require any additional spectrum, unlike most other digital broadcasting systems. Today's IBOC station therefore transmits two versions of its primary content—one analog and one digital—thereby serving both legacy and new receivers via the same broadcast channel. (The IBOC system also provides the capability of eliminating the analog component and moving to an all-digital channel, but this mode of operation is not currently allowed by FCC rules).

There are two variants of IBOC: one for AM radio services and one for FM. The major advantage for AM radio is a qualitative improvement in received audio and freedom from the ever-growing impact of audible interference that plagues AM reception. The FM IBOC system also provides better audio quality than traditional analog FM service, but with less noticeable effect since analog FM audio quality is already relatively good to begin with. The primary improvement with FM IBOC is *quantitative*, in that it also allows a station to include multiple audio services within the same broadcast channel (called "multicast services," but often referred to as "HD-2" or "HD-3" services, owing to how