

# Modern Cable Television Technology

---

## Video, Voice, and Data Communications

WALTER CICIORA  
*Consultant*

JAMES FARMER  
*Antec Corporation*

DAVID LARGE  
*Media Connections Group*



Morgan Kaufmann Publishers, Inc.  
San Francisco, California

*Senior Editor* Jennifer Mann  
*Director of Production and Manufacturing* Yonie Overton  
*Production Editor* Cheri Palmer  
*Editorial Assistant* Karyn Johnson  
*Cover Design* Ross Carron Design  
*Cover Photographs* Daniel Motz and Richard Graulich for Cox Communications, Inc.  
*Text Design* Rebecca Evans & Associates  
*Copyeditor* Robert Fiske  
*Proofreader* Jennifer McClain  
*Composition and Illustrations* Technologies 'n Typography  
*Indexer* Steve Rath  
*Printer* Courier Corporation

Designations used by companies to distinguish their products are often claimed as trademarks or registered trademarks. In all instances where Morgan Kaufmann Publishers, Inc. is aware of a claim, the product names appear in initial capital or all capital letters. Readers, however, should contact the appropriate companies for more complete information regarding trademarks and registration.

Morgan Kaufmann Publishers, Inc.  
*Editorial and Sales Office*  
340 Pine Street, Sixth Floor  
San Francisco, CA 94104-3205  
USA

Telephone 415 / 392-2665  
Facsimile 415 / 982-2665  
Email [mkp@mkp.com](mailto:mkp@mkp.com)  
WWW <http://www.mkp.com>  
Order toll free 800 / 745-7323

© 1999 by Morgan Kaufmann Publishers, Inc.  
All rights reserved  
Printed in the United States of America

03 02 01 5 4 3

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means—electronic, mechanical, photocopying, recording, or otherwise—without the prior written permission of the publisher.

#### **Library of Congress Cataloging-in-Publication Data**

Ciciora, Walter S.  
Modern cable television technology : video, voice, and data  
communications / Walt Ciciora, James Farmer, David Large.  
p. cm.  
Includes bibliographical references and index.  
ISBN 1-55860-416-2  
1. Cable television. I. Farmer, James, (date) II. Large,  
David, (date) III. Title.  
TK6675.C53 1999  
621.388'57—dc21 98-35328  
CIP

## 1.1 Introduction

Currently, cable television service is enjoyed by nearly 65 million U.S. households. This is a market penetration of nearly 67%. Cable service is available to 96.7% of U.S. television households.<sup>1</sup>

Cable television is an important part of the way in which the citizens of the United States are informed and entertained. It is a means of providing large numbers of television channels to more than two-thirds of the U.S. population in a cost-effective way.

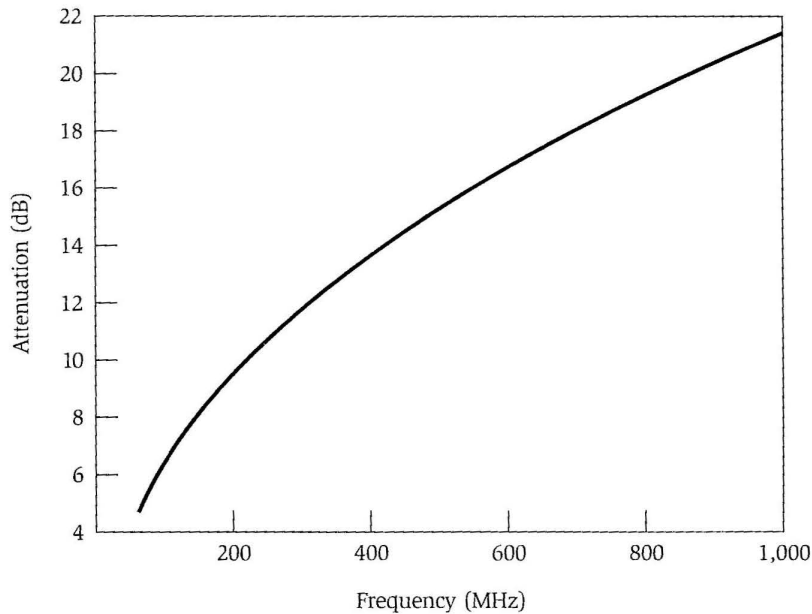
Because cable television has been so successful and has enjoyed such vigorous growth and acceptance, it has spawned competitors, including prerecorded media (tape and disk sales and rentals), direct broadcast satellite (DBS), as well as the interest of the telephone industry. Cable's high visibility has also attracted the attention of regulators and legislators. Important public policy issues are involved. Understanding what cable television is, how it works, and its economics will help decision makers in these arenas. This understanding will also aid technologists in determining which technologies are appropriate for cable television applications and which are not.

Television has long been the preferred source of information for the general public, and cable television offers viewers more choice than ever before. In fact, if cable had to be described with one word, that word would be *choice*. Choice is made possible by cost-effective bandwidth to deliver programming to almost 70% of the households having televisions in the United States. Since cable is available to more than 90% of television households, nearly everyone has the opportunity to subscribe to cable. In the United States, more people have televisions than telephones, and most of those people have cable.

There are more than 160 programs on the satellites that feed cable headends. Cable systems must select some of the programs they will offer to their subscribers from all those available since no analog cable system has sufficient capacity to carry them all. In addition, cable systems carry the local broadcasts and some programs locally originated or designated for local citizen access. In some cable systems, the local schools, library, or government has channels to deliver programs of special interest. In this way, the needs of a democratic society are served while citizens are well informed and entertained.

The broadband cable infrastructure can deliver an appealing analog service while adding hundreds of digital channels. This hybrid service is important for the transition to digital television since an abrupt changeover from analog to digital television would be chaotic. Most citizens will continue to enjoy analog television for many years to come. Even those who purchase a digital television receiver for their principal viewing room will have analog receivers in the rest of the house.

The same broadband cable can carry high-speed data service to subscribers, making Internet-based and other information services fast and convenient. The cable infrastructure is inherently two way, requiring only modest additional in-



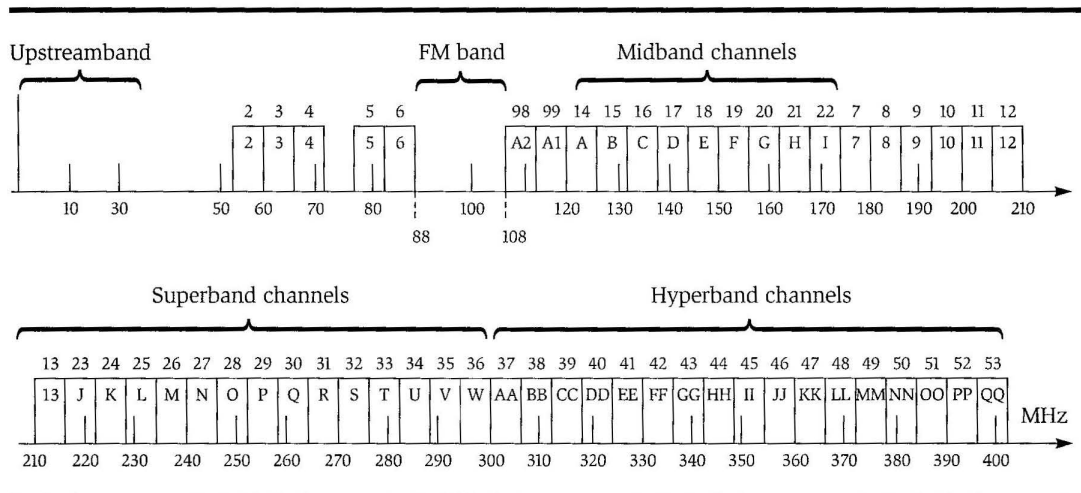
**Figure 1.1** Coax cable attenuation versus frequency.

and operating frequency. A ballpark figure is 1 dB of loss per 100 feet. Half-inch diameter aluminum cable has around 1 dB of attenuation per 100 feet at 181 MHz; at 1-inch diameter, the attenuation drops to 0.59 dB per 100 feet. The attenuation of cable varies with the square root of the frequency. Thus, the attenuation at 216 MHz (within TV channel 13) is twice that of 54 MHz (within TV channel 2) since the frequency is four times as great. If channel 2 is attenuated 10 dB in 1,000 feet, channel 13 will be attenuated 20 dB. Figure 1.1 demonstrates this relationship for 1,000 feet of 5/8-inch aluminum cable.

## 1.4 Cable Network Design

Since cable television originally was not a general-purpose communications mechanism, but rather a specialized system for transmitting numerous television channels in a sealed spectrum, the topology or layout of the network was customized for maximum efficiency. The topology that has evolved over the years is called tree-and-branch architecture.<sup>3</sup>

There are five major parts to a cable system: (1) the headend, (2) the trunk cable, (3) the distribution (or feeder) cable in the neighborhood, (4) the drop



**Figure 1.2** Cable frequency plan. Numbers above the rectangles are the EIA-542 designations. Historical designations are inside the rectangles. Current cable plant bandwidth can exceed 1 GHz.

cable to the home and in-house wiring, and (5) the terminal equipment (set top terminals and consumer electronics hardware).

Flexible coaxial cable is used to bring the signal to the terminal equipment in the home. In the simplest cases, the terminal equipment is the television set or VCR. If the TV or VCR does not tune all the channels of interest because it is not "cable compatible," a converter is placed between the cable and the TV or VCR tuner.

Broadcast channels 13 are not in a continuous band. Other radio services occupy the gaps. Cable can reuse these frequencies because its spectrum is self-contained within the coaxial environment. The cable converter has a high-quality broadband tuner and output circuitry that puts the desired cable channel on a low-band channel not occupied in the local off-air spectrum. Typically, this is channel 2 or 3 and occasionally 4 or 5. The TV or VCR is tuned to this channel and behaves as a monitor. Premium programming is typically "scrambled" so that it is not clearly visible on an ordinary television receiver. The picture appears torn up, and the pieces jump around on the screen in the usual display. The subscriber wishing access to premium programming pays an additional fee and is supplied with a *descrambler*, which is a component of the set top terminal. The subscriber who has purchased a product labeled "cable ready" may expect to avoid the set top terminal. The requirement to use a set top terminal with a descrambler for premium services can be a sore point.

Figure 1.2 shows the cable frequency plan. Although Figure 1.2 goes up to only 400 MHz, cable systems have been built to slightly in excess of 1 GHz with more than 150 analog channels. Cable systems with bandwidths of 750 MHz are not uncommon, and 550 MHz is typical for upgrades and new construction. The home is connected to the cable system by the flexible drop cable, typically 150

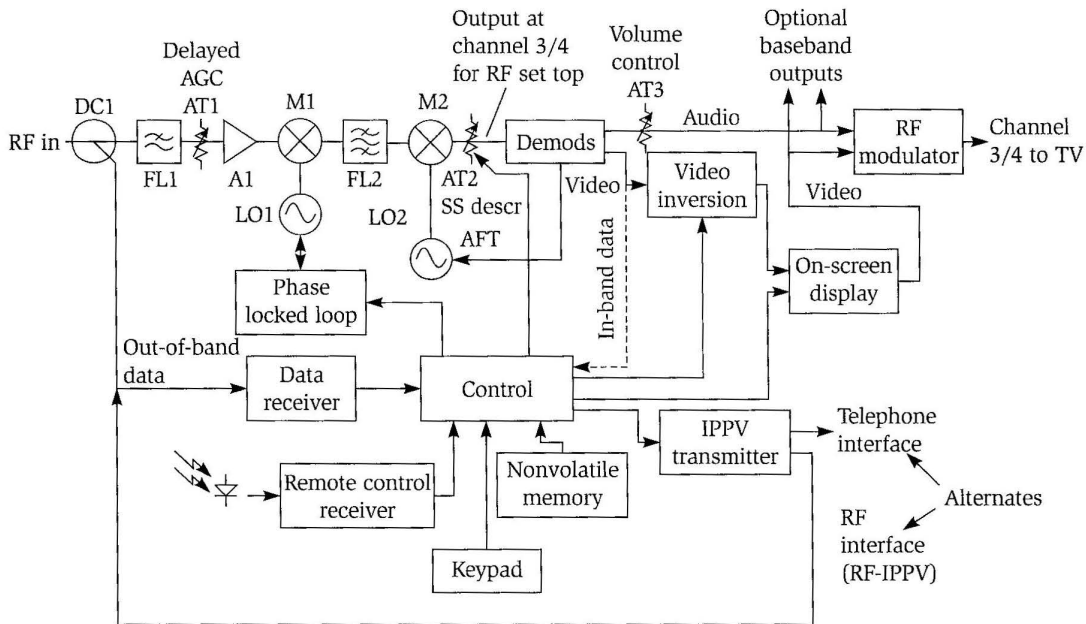


Figure 18.10 Modern addressable set top terminal.

switched attenuator, which offers, usually, 6 or 10 dB of attenuation during active video, and is switched out during horizontal and vertical blanking intervals. Operation of the descrambler is described in Section 18.3.1.

After sync suppression restoration at IF (for the common RF sync suppression systems), the signal is supplied to video and audio demodulators. At this point, the video has had sync suppression removed, but if it is inverted, that still must be corrected. The video inversion circuitry handles this task. As in the case of sync suppression descrambling, recovered in AT2, video inversion is controlled by the controller circuitry, as appropriate to the scrambling system being used.

Most set top terminals today have an on-screen display (OSD), which is used to indicate the channel tuned, time, the program service on that channel, and other functions. In ordering pay events, the OSD is normally used. It is becoming popular to include electronic program guides in set top terminals, and the OSD will also be used for this.

Audio is normally demodulated to just the composite BTSC stereo signal, as described in Chapters 2 and 7. It is not common, but is possible, to include a BTSC decoder. It is not likely that a BTSC encoder would be included owing to its cost. Volume control is effected at attenuator AT3, which operates on the composite BTSC stereo signal. This does not yield a truly accurate volume control

devices “see” the complete IR emission sequence and respond appropriately, or the result may be disappointing.

Another model of advanced universal remote control includes a clock and a timer. The remote control can be positioned so that it simultaneously communicates with both the VCR and the set top terminal. The universal remote control is programmed with the VCR control instructions. The remote turns on the VCR at the appropriate time, ensures that the VCR is tuned to the output channel of the set top terminal, then tunes the set top terminal to the desired channel, and finally starts the VCR recording. Consecutive recording of different channels is made possible.

A few models of two-way remote controls have a small screen on the remote control that displays signals received from the set top terminal. Titles of songs, purchase order forms, interactive games, and other instructions can be viewed.

### 19.6.2 Electronic Program Guides

Electronic program guides (EPGs) have been introduced with features that alleviate some of the interface problems. The EPGs are available as stand-alone devices, built into cable set top terminals, or built into TVs or VCRs. Several of these devices include one or more infrared light-emitting diodes (LEDs) on short wires that are meant to be attached near the remote control window of the VCR, the cable set top terminal, or the TV. The device with the EPG controls the other devices to accomplish the desired result. If the EPG is built into the cable set top terminal, the LED controls the VCR so that it turns on and off at the correct times and is tuned to the correct channel. If the EPG is built into the VCR, the LED controls the channel on the cable set top terminal. Of course, none of these approaches can ensure that sufficient blank tape has been put into the VCR!

A related device, called VCR Plus, uses numeric codes published in printed guides (or conveyed electronically in a later version) to the VCR or to a form of universal remote control. The codes are decoded using a proprietary algorithm to derive the start and stop times and the channel number. Infrared emissions control the VCR and cable set top terminal.

### 19.6.3 The TV Integrating Device

In the mid-1980s, the research department of a cable operator, American Television and Communications in Englewood, Colorado, began development of an approach the engineers called the TV integrating device (TVID). It was intended to be included in a cable set top terminal and to use IR LEDs to control the TV and one or more VCRs. It had a built-in EPG and an on-screen display. The goal was to provide a simple menu that would allow subscribers to indicate their desires. The subscriber would indicate what he or she wanted recorded and what he or she wanted to watch. The TVID would take care of switching the descrambler into the correct part of the system and turn things on and off at the right time to implement the subscriber’s desires. If a conflict arose, such as wanting to watch a

scrambled channel while recording another scrambled channel, the subscriber would be advised of his or her choices and allowed to act upon them.

The TVID included a "mood guide," which gave the subscriber a way of indicating his or her mood. Those programs that were appropriate to his or her mood would then be displayed for selection to watch or record. The microprocessor could keep track of the programs watched and deduce the subscriber's interests. The subscriber would then be alerted to future programs that fit his or her previous viewing habits. The project reached the early prototype stage but was not completed because of other priorities.

## 19.7 Management of Expectations

Most of the subscriber's problems have solutions. Some solutions are more complex than others. The crux of the compatibility problem seems to be the expectation that the term "cable ready" brings. To consumers, this means that the TV or VCR can be connected to cable and all features and all services are readily available. When operation of features is complicated or unexpected results are obtained, frustration and anger set in. If instead, expectations were properly managed and the subscriber/consumer had a correct understanding of what was possible, the likelihood of disappointment would be reduced. The fundamental problem is the management of expectations.

### 19.7.1 Complexity Overload

A major contributor to the difficulties of the consumer electronics interface is the wide variety of choices available in features and functions, the way in which the features and functions are operated and controlled, and the diversity of services offered by cable operators. The number of combinations and permutations is almost infinite. Just the simple matter of entering channel numbers has several methods. Some products use an enter button. Others prescribe the way in which the digits must be entered. For example, on some products, requesting channel 7 requires pressing 07. Others can require waiting for a fixed time after entering the command. The names for common functions are brand specific. The number of complex features boggles the mind. It may simply not be possible to preserve all the product functions and features while offering access to all the available cable services.

## 19.8 Legal Aspects of Cable-Consumer Electronics Compatibility

### 19.8.1 Compatibility Definitions

The word *compatibility* should mean that two things work well with each other. In the case of compatibility between cable service and consumer electronics,

The *antenna and cable/converter switch* feature (usually operated by remote control) switches between two or more inputs to the TV. One input is intended to be from the converter and the other directly from the cable (or an antenna). The intention here is to allow the TV's tuner to do the work when nonscrambled channels are watched and just use the converter/descrambler's tuner when scrambled channels are watched. This feature is similar in function and purpose to the auto bypass switch option in converter/descramblers.

The *TV/VCR switch* feature on a VCR determines whether the entire cable spectrum is presented to the TV or just the channel tuned by the VCR or the tape playback.

#### 19.2.4 Consumer Frustration

The two principal aspects of consumer frustration are the installation and the utilization of consumer electronics products with cable services. Both of these frustrations come from the variety of services and features found in these products.

### 19.3 Connecting Cable, TVs, VCRs, and Set Top Terminals

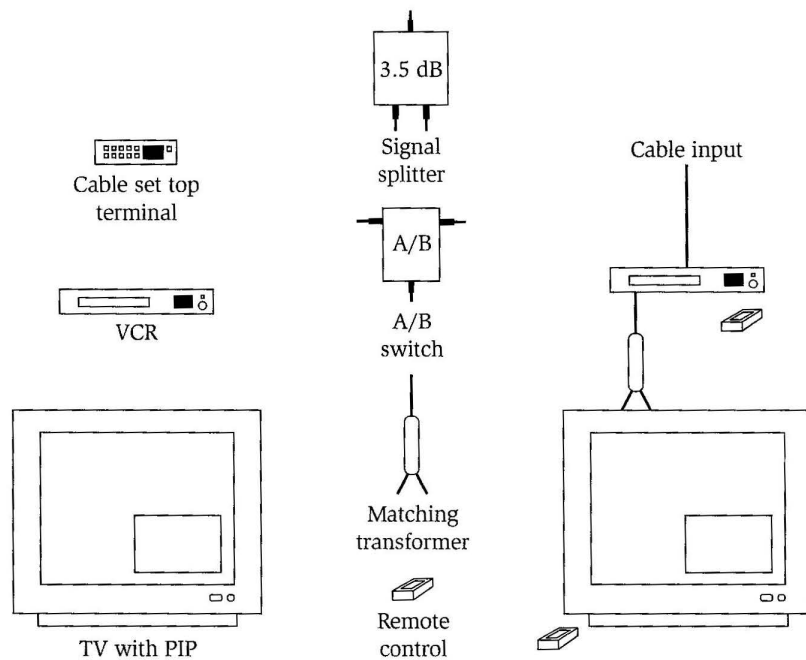
In 1987, the NCTA Engineering Committee formed a Subcommittee on Consumer Interconnection and developed a set of 27 diagrams indicating the most likely methods of connecting a TV, VCR, and one or more set top terminals along with an assortment of switches and signal splitters. Many of these diagrams are also found in consumer's manuals that come with new TVs and VCRs. All the interconnection schemes have advantages and disadvantages. None solves all of the problems. Reviewing some of these diagrams results in a better understanding of the complexity of the problem.<sup>4</sup>

#### 19.3.1 Basic Cable and Trapped Premium Service Connection

Figure 19.1 is illustration 12 of the NCTA connection diagram set. The cable is connected to the VCR, which is connected to the TV. This diagram is for the basic-service-only subscriber and the subscriber who has premium services controlled by traps. No set top terminal is used. Since less than half of cable subscribers have set top terminals and since most subscribers connect more than one TV or VCR to cable, the majority of cable connections use this simple configuration.

##### **Advantages**

1. Least expensive.
2. TV and VCR operate as with antenna connections.

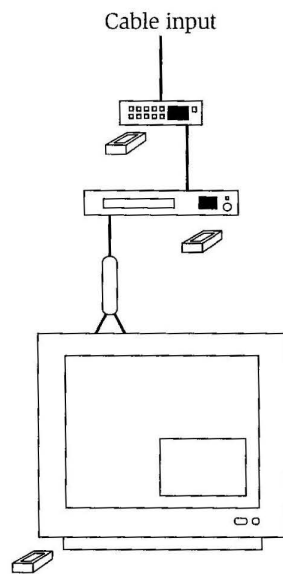


**Figure 19.1** In-home equipment and simplest connection without set top terminal.

3. Can consecutively record different unscrambled channels automatically.
4. Can watch one unscrambled channel while recording a different unscrambled channel.
5. PIP works with unscrambled channels when VCR's baseband output is connected to TV's baseband input.

**Disadvantages**

1. No scrambled services available for either watching or recording.
2. No interactive services available.
3. Have to remember to put TV to channel 3 when watching recorded tapes.
4. Need to use two remote controls or a "universal" remote control.
5. TV's parental control is inoperative when using VCR's tuner.
6. Consumer's tuner subject to overload and damage from lightning strikes on cable.
7. Signal leakage possible from inadequately shielded tuners.



**Figure 19.2** Most common cable connection with set top terminal.

### 19.3.2 A Simple Start

Figure 19.2 is illustration 1 of the NCTA connection diagram set. The cable is connected to the set top terminal, which is connected to the VCR, which is connected to the TV. This is by far the most popular connection method involving a set top terminal because it is the least expensive and simplest to implement and use.

#### **Advantages**

1. Inexpensive and easy to install.
2. Easy to understand.
3. Can record scrambled channels.

#### **Disadvantages**

1. Can't watch one channel and record a different channel.
2. Can't consecutively tape different channels automatically because VCR tuner does not do channel selection.
3. Neither the TV tuner nor the VCR tuner has any control.
  - (a) TV's parental control, favorite channels, and last channel recall features are inoperative. The TV is just tuned to channel 3 (or 4).

- (b) VCR's timer, parental control, favorite channels, and last channel recall features are inoperative. The VCR is just tuned to channel 3 (or 4).
4. Need to use three remote controls or a universal remote control to turn on the three devices and put the TV and VCR to channel 3 (or 4).
  5. Makes the TV's picture-in-picture feature useless.

### **Special Case**

1. If the converter/descrambler has an auto bypass switch, then when the converter is turned off, the entire cable spectrum passes through to the VCR, and the situation is exactly the same as in Figure 19.1, which is the case where no set top terminal is used. When again using a scrambled channel, the subscriber must remember to put the VCR to channel 3 (or 4). If the set top terminal has the channel-mapping feature and the TV or VCR does not, the same programming may appear on two different channel numbers. One channel number will be found on the set top terminal and the other on the TV or VCR. This may be confusing.

### **19.3.3 Two Set Top Terminal Case**

Figure 19.3 is illustration 2 of the NCTA connection diagram set. The cable signal is split and connected to two set top terminals. The left set top terminal is connected to a VCR, which is connected to one input of an A/B switch, which is connected to the TV. The right set top terminal is connected to the other input of the A/B switch.

This is one of the least popular installations because of its expense and complexity. It would be used by "techie" who want the most flexible system and can both visualize how it works and handle multiple remotes with ease. It will be very frustrating to others. The dual descrambler feature could be used to simplify both the installation and operation of this connection. On-screen displays could further assist the subscriber. Despite the flexibility of this connection and the potential to make it relatively easy to use with on-screen displays, its usage is very limited.

### **Advantages**

1. Most flexible.
2. Can watch any authorized scrambled or unscrambled program.
3. Can record any (other or same) authorized scrambled or unscrambled program.
4. PIP can be used with both channels if the TV has baseband inputs that are connected to the VCR's baseband outputs.
5. Useful in systems that have both analog scrambling and digital television.

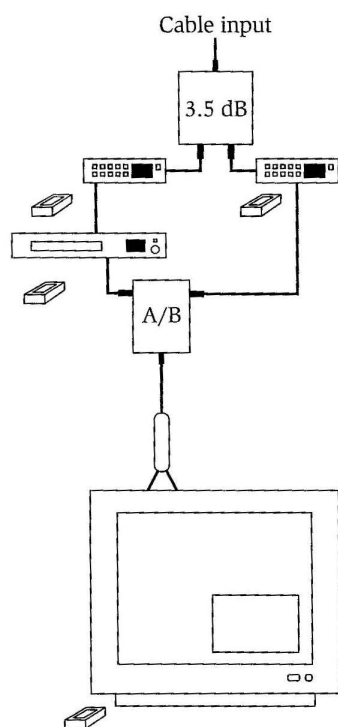


Figure 19.3 Connection with two set top terminals.

### Disadvantages

1. Can't consecutively tape different channels automatically because VCR tuner does not do channel selection.
2. Expensive hardware and monthly fees.
3. Complex to install, many cables, many opportunities for signal leakage.
4. Complex to operate; need to use at least three remote controls.
5. Neither the TV tuner nor the VCR tuner has any control.
  - (a) TV's parental control, favorite channels, and last channel recall features are inoperative. The TV is just tuned to channel 3 (or 4).
  - (b) VCR's timer, parental control, favorite channels, and last channel recall features are inoperative. The VCR is just tuned to channel 3 (or 4).
6. Need to use three of four remote controls or a universal remote control.
7. Most brands of set top terminals will operate simultaneously from one remote control. Consequently, the subscriber may have to operate one terminal

as manual. If the set top terminal supports two control codes, four remote controls may be used with this configuration.

8. If both analog scrambled and digital channels are being used, may need to interchange set top terminals depending on which is to be recorded and which is to be watched.
9. Switch at TV is usually manual, requiring getting out of the chair unless the switch is built into the TV and remote controllable.
10. Splitter cuts signal in half and may introduce noticeable noise.

### **Special Cases**

1. If the left converter/descrambler has an auto bypass switch, then when the converter is turned off, the entire cable spectrum passes through to the VCR, and the situation is exactly the same as in Figure 19.1.
2. If the right converter/descrambler has an auto bypass switch, then when the converter is turned off, the entire cable spectrum passes through to the TV, and the situation is similar to that shown in Figure 19.1 but without the VCR.
3. If the set top terminal has the channel-mapping feature and the TV or VCR does not, the same programming may appear on two different channel numbers. One channel number will be found on the set top terminal and the other on the TV or VCR. This may be confusing.

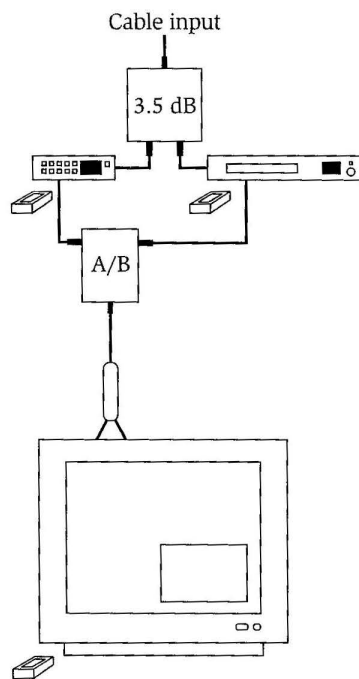
### **19.3.4 Minimal Scrambled Channel Usage**

Figure 19.4 is illustration 5 of the NCTA connection diagram set. The cable signal is split into two paths. The left path is connected to a set top terminal, which is connected to an A/B switch, which is connected to a TV. The right path is connected to a VCR, which is connected to the other input of the A/B switch.

This connection could be used by someone who wishes to continue the use of the features of their TV and VCR as enjoyed before cable, and only occasionally watches, but never records, scrambled channels. This is especially convenient for someone with only one scrambled channel or who uses the converter/descrambler only for pay per view but doesn't record that programming. The right-hand path is identical to Figure 19.1. Alternatively, since the path with the converter can be used to watch either scrambled or unscrambled channels, the only purpose for the switch is to watch recorded tapes. That could also be accomplished with the VCR's baseband output and the TV's baseband input.

### **Advantages**

1. Easy to use if most of the usage is for unscrambled channels.
2. Can watch any channel while recording any unscrambled channel.
3. Can consecutively record unscrambled channels automatically.



**Figure 19.4** Connection for few scrambled channels.

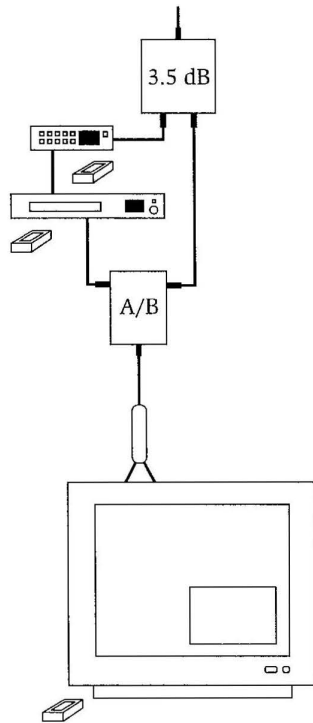
4. Especially easy if only one scrambled channel is taken.
5. PIP can be made to work as long as the second picture is unscrambled.

### **Disadvantages**

1. Can't record scrambled channels.
2. On the left side, TV's parental control, favorite channels, and last channel recall features are inoperative. The TV is just tuned to channel 3 (or 4).
3. Switch must be manually operated unless it is built into the TV.
4. Need to use three remote controls or a universal remote control.
5. Splitter cuts signal in half and may introduce noticeable noise.

### **Special Cases**

1. If the converter/descrambler has an auto bypass switch, then when the converter is turned off, the entire cable spectrum passes through to the



**Figure 19.5** Modified most common connection.

TV, and the situation is similar to that shown in Figure 19.1 but without the VCR.

2. If the set top terminal has the channel-mapping feature and the TV or VCR does not, the same programming may appear on two different channel numbers. One channel number will be found on the set top terminal and the other on the TV or VCR. This may be confusing.

### 19.3.5 Improved Simple Connection

Figure 19.5 is illustration 4 of the NCTA connection diagram set. This configuration inexpensively overcomes some of the difficulties of Figure 19.2 and especially makes sense if the TV has a built-in A/B switch.

#### **Advantages**

1. Inexpensive and easy to install.

2. Easy to understand.
3. Can record scrambled channels.
4. PIP feature can be used when one of the channels is always unscrambled and the VCR's baseband output is connected to TV's baseband input.

#### **Disadvantages**

1. Can't consecutively tape different channels automatically because VCR tuner does not do channel selection.
2. Need to use three remote controls or a universal remote control.
3. On the left side, neither the TV tuner nor the VCR tuner has any control.
  - (a) TV's parental control, favorite channels, and last channel recall features are inoperative. The TV is just tuned to channel 3 (or 4).
  - (b) VCR's timer, parental control, favorite channels, and last channel recall features are inoperative. The VCR is just tuned to channel 3 (or 4).
4. Switch at TV is usually manual, requiring getting out of the chair unless the switch is built into the TV and remote controllable.
5. Splitter cuts signal in half and may introduce noticeable noise.

#### **Special Cases**

1. If the converter/descrambler has an auto bypass switch, then when the converter is turned off, the entire cable spectrum passes through to the VCR, and the situation on the left side is exactly the same as in Figure 19.1.
2. If the set top terminal has the channel-mapping feature and the TV or VCR does not, the same programming may appear on two different channel numbers. One channel number will be found on the set top terminal and the other on the TV or VCR. This may be confusing.

### **19.3.6 Problematic Connection Example**

Figure 19.6 is illustration 7 of the NCTA connection diagram set. This figure is almost never used with modern set top terminals because they usually require a separate frequency for receiving control signals. The VCR would block those signals, and the set top terminal would turn itself off after a preset time. Also, this configuration would block upstream signals, making impulse pay per view (IPPV) and other two-way services impossible.

#### **Advantages**

1. Attempts similar functionality to Figure 19.4 but without the need for the A/B switch.
2. PIP can be used with the second picture unscrambled if the TV has baseband inputs connected to baseband outputs from the VCR.

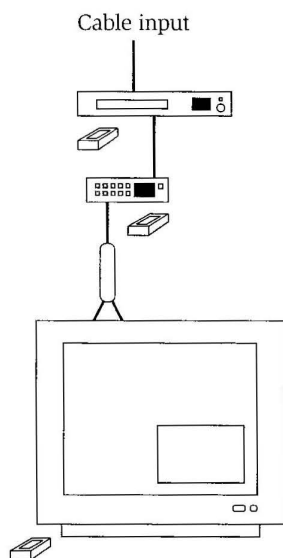


Figure 19.6 Connection with set top terminal difficulties.

### ***Disadvantages***

1. Many set top terminals can't be used in this configuration.
2. Impulse pay per view and other two-way services are impossible.
3. Can't record scrambled programs.
4. TV's parental control, favorite channels, and last channel recall features are inoperative. The TV is just tuned to channel 3 (or 4).
5. Need to use three remote channels or a universal remote control.
6. Converter/descrambler's parental control is inoperative when using VCR's channel 3 (or 4) output.

### ***Special Cases***

1. If the converter/descrambler has an auto bypass switch, then when the set top terminal is off, the entire output of the VCR passes through to the TV, and the situation is exactly the same as in Figure 19.1.
2. If the set top terminal has the channel-mapping feature and the TV or VCR does not, the same programming may appear on two different channel numbers. One channel number will be found on the set top terminal and the other on the TV or VCR. This may be confusing.

### 19.3.7 Improvements

One of the main disadvantages of the configurations shown in Figures 19.2, 19.3, and 19.5 is that the VCR is not able to consecutively record different programs except if the set top terminal has an auto bypass switch and no scrambled programming is to be recorded.

This disadvantage can be overcome, at least in theory, with set top terminals that include a programming function similar to that found in VCRs. This programming function can be set up to turn on and change channels at appropriate times. Usually, an on-screen menu is used for this purpose. The subscriber then uses the same principles to program the set top terminal as are used to program the VCR, with the VCR programmed only to turn on and record the output channel of the set top terminal at the appropriate time. In practice, this procedure meets with limited success by the occasional user since there are additional opportunities to make mistakes and thereby fail to record the desired programs. Nonetheless, the careful subscriber can master these techniques and successfully record different channels consecutively.

An alternative approach to overcoming the deficiency that inhibits the recording of consecutive programs on different channels is found in certain premium VCRs. These products have an infrared (IR) light emitter on a short wire. This device is sometimes called an IR blaster. The IR control is set up to use the IR control codes of the brand set top terminal employed by the cable operator. The VCR can then change the channels of the set top terminal and thereby record different channels, scrambled or unscrambled, consecutively. Since the set top terminal is now controlled by the VCR, the set top terminal's remote control is not necessary. Only two remote controls are needed by the subscriber, one for the TV and one for the VCR.

In the case of Figure 19.3, this type of VCR overcomes yet another difficulty. That is, if the two set top terminals respond to the same IR codes, the VCR's IR controller can be placed in such a way that the set top terminal used with the VCR is isolated from the IR signals used with the set top terminal connected to the TV. Then only three remote controls are necessary, and both set top terminals can be controlled remotely.

It is possible to use the same IR blaster technique with the TV controlling the set top terminal (if the TV is so equipped). Also, the set top terminal may use an IR blaster to control the VCR or TV. In that case, the subscriber programs the set top terminal and uses its remote control.

An unfortunate complication with the IR blaster stems from the fact that the usual on-off control on consumer electronics products and set top terminals is a toggle function. That is, there is not a separate on and a separate off control. Rather, if the unit is on, the control turns it off, and vice versa. This uncertainty over the current state is a source of error in setup and usage of these techniques.

There are numerous complications in these configurations. Most subscribers have difficulty visualizing what is happening with the multiple remote controls or the multiple modes of use of the universal remote control.<sup>5</sup>