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TELEVISION ELECTRONICS: Theory and Servicing

MILTON S. KIVER
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eighth edition

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PREFACE

The eighth edition of *Television Electronics: Theory and Servicing* (formerly *Television Simplified*), has been completely redesigned and updated to the current state of the art. The book is designed as a text for television electronics courses that follow a course in basic electronics or basic radio.

The purpose of the book is to prepare electronics technicians and engineers for a career in some phase of the television industry. Every effort has been made to ensure the book's usefulness to instructors, their students, and to self-study students.

This book covers in detail the operation, circuitry, and trouble-shooting of solid-state color and monochrome television receivers. Some coverage of vacuum-tube television receivers is also presented. Other current and important topics that are covered include (1) cable television, (2) video-tape and video-cassette recorders, (3) video games, (4) integrated circuits, (5) communications satellites, (6) color television signal generation, (7) digital circuitry, and (8) closed-circuit television.

NEW CHAPTERS AND CHAPTER REORGANIZATION

The eighth edition contains 27 chapters. The previous edition contained 24 chapters. The new chapters are

- *Chapter 2: Television System Applications.* This chapter includes topics such as cable television, video-tape and video-disc recording, video games, and closed-circuit television.
- *Chapter 7: Principles of Monochrome Television Receivers.* This is a basic block diagram explanation of the operation of monochrome television receivers. It also includes the test equipment and tests used for monochrome television receivers.
- *Chapter 10: Frequency Synthesis, Automatic Fine Tuning, and Remote Control.* This chapter includes discussions of binary numbers, digital frequency dividers, the phase-locked loop, microcomputers, and frequency synthesis push-button tuning. The topics of Automatic Fine Tuning and Remote Control are also updated and covered in detail.

The material on vertical deflection oscillators has been placed in a separate chapter (Chapter 21), which also includes a digital IC vertical countdown circuit. Horizontal oscillators and horizontal AFC appear in Chapter 22, which also includes a digital IC horizontal countdown circuit. All chapters in the eighth edition have been reorganized and updated. Obsolete material has been removed.

CHAPTER FORMAT

The opening format of each chapter has been improved to increase the usefulness of

this edition. The beginning of each chapter includes

- A chapter outline
- An introduction
- Chapter objectives

The format at the end of most chapters includes

- A summary of chapter highlights.
- Examination questions with answers. These questions are multiple choice, true-false, and fill-in blank types.
- Review essay questions. These require the application of text information, drawing diagrams, answering questions by referring to diagrams, solving troubleshooting problems, providing definitions, and giving the functions of circuit components.
- Examination problems with selected answers. These are generally numerical problems related to the chapter contents.

A comprehensive summary is presented at the end of each chapter. This provides students with a review of the chapter material. Reference figure numbers or chapter section numbers are given for many items in each summary. This makes it easier for students to obtain specific additional information.

The self-testing aids in the text can be very helpful in improving the student's understanding of the material in each chapter. They can also be helpful to instructors in providing class assignments and to self-study students in checking their progress.

NEW CIRCUITRY AND DIAGRAMS ADDED

The very latest types of circuitry have been added to the eighth edition. Among these are frequency synthesis tuning, more integrated circuits, noise cancellers, horizontal and vertical digital countdown circuits, and new FM demodulators. The latest remote control techniques are described in detail. Also described, is the latest color television receiver automatic circuitry, including automatic hue and saturation control, and automatic brightness and contrast control.

Many new circuit schematic and block diagrams have been added to enhance the reader's understanding of the material. Among these are a number of simplified diagrams presented wherever a more detailed analysis of the information is required.

TEXT ORGANIZATION

The eighth edition begins with two introductory chapters. These chapters explain the basic concept of the television system. They also describe the various applications of television and its associated equipment. Chapters 3 and 4 describe video signals and the principles of scanning and synchronizing a television picture. This is followed in Chapter 5 by discussions of television camera tubes and camera systems. Next we explain television frequency radio-wave propagation, and various indoor and outdoor television receiving antennas.

Following this, the principle of monochrome and color television receivers are described in Chapters 7, 8, and 9. Beginning with Chapter 10, the individual sections of television receivers are discussed in detail. This material begins with tuners and progresses through various signal circuits. This is covered in Chapters 10 through 17. Monochrome and color picture tubes are covered in Chapter 18.

A synchronized scanning raster is produced on a picture tube by the action of synchronizing and deflection circuits. These circuits are described in Chapters 20 through 24. Following the discussion of the synchronizing and deflection circuits, the FM sound system is explained in Chapter 25. This

chapter also includes discussions of the latest types of FM demodulators.

Chapters 26 and 27 provide details on the operation of a complete solid-state color television receiver. Information is also provided on the alignment, adjustment, and troubleshooting of television receivers. In addition, various types of test equipment are described.

TROUBLESHOOTING AND ALIGNMENT

Each chapter that describes a section of a television receiver ends with a section describing common troubles that might occur in that section. This information is enhanced by the use of photographs and drawings. Chapter 26 presents a detailed explanation of the operation of a solid-state color television receiver. Chapter 26 also includes detailed instructions for the alignment and adjustment of color television receivers. A new type of oscilloscope, a color-bar generator and a color-pattern generator are described in Chapter 26. Their uses are also discussed there.

Chapter 27 presents important information on the techniques of troubleshooting television receivers. The methods of signal tracing and signal injection are covered in detail and many explanatory diagrams are presented. Many types of television receiver faults are described with the aid of photographs and drawings. A number of full-color photographs help to clarify possible troubles in color circuitry. Additional types of test equipment and their uses are covered in Chapter 27. These include transistor testers, color picture tube brighteners, and a color picture tube analyzer and restorer.

END OF BOOK MATERIALS

The end of this book contains a comprehensive glossary of terms and abbreviations. These will prove most helpful to students desiring definitions relating to television electronics. Four useful appendices are also provided: (1) U.S. television channels and related frequencies, (2) Frequently used metric units, (3) A table of binary numbers with a method of conversion from decimal to binary numbers, and (4) SI unit prefixes.

ACKNOWLEDGMENTS

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TABLE OF CONTENTS

Chapter 1

TELEVISION SYSTEM CONCEPTS

INTRODUCTION

Television is the science of transmitting rapidly changing pictures from one place to another. Radio-frequency waves are usually used for the transmission of television pictures. However, in some applications, such as closed-circuit television (CCTV) or cable television (CATV), coaxial cables carry the signal from one point to another. Television dominates the home-entertainment industry. It is also used widely in science, industry, education, and military applications.

New types of components, new circuits, and new concepts are continually being introduced in the television industry. Therefore, it is crucial that the TV technician know about the modern technical aspects of television systems. A number of advancements have been made since 1941, when the complete television receiver consisted only of **monochrome,** or black and white, circuitry. These include color television, solid-state television receivers, satellite television relays, video-tape and video-disc recorders and players, and closed-circuit television. Other changes include home video and sound cameras, video games, automatic time-programmed channel selection, push-button channel selection for VHF and UHF channels, cable television, and large-screen projection television.

When you have completed the reading and work assignments for Chapter 1, you should be able to:

- Define the following terms: random access, monochrome, integrated circuit, scanning, synchronizing pulse, vestigial sideband transmission, and line-of-sight broadcasting distance.
- Describe how modern television receivers differ from those manufactured in 1941 and explain briefly how digital techniques are used in television receivers.
- Describe the function of VIR circuits.

- Discuss the advantage of using ICs in television receivers and list several applications.
- Summarize the qualities of a desirable television image.
- Describe the different sizes and styles of television receivers.
- Understand the basic operation of television transmitters and receivers.

MODERN TELEVISION RECEIVERS

Early television receivers contained as many as 30 vacuum tubes. However, almost all modern receivers use many integrated circuits (ICs) and are completely solid state. Digital techniques are used in some receivers for electronic channel selection, both at the receiver and also with remote control systems. The tuners (VHF and UHF) on these sets have no moving parts. All tuning is done electronically. On some sets a digital readout of the channel number being viewed and the time in hours, minutes, and seconds, may also be shown on the screen whenever desired. Home computers are now quite popular. The television receiver screen may be used for the computer readout, if desired.

This brief introduction, shows that the television system accommodates many different applications. In this chapter and the next, the basic concepts and some of the more important applications of the television system are described.

1.1 DIGITAL TECHNIQUES

Digital techniques[1] have replaced analog techniques in many applications, including the digital multimeter. Other examples are microprocessors,[2] high-fidelity audio tape recording, frequency counters, timers, and satellite communications. Some advantages of digital techniques are greater accuracy, faster response, less noise and distortion, less drift, fewer errors, and more automatic operation.

The binary number scheme is used in digital electronics. Two discrete voltage levels represent an "on" or "off" condition. The voltage levels that are commonly used are 0 volts and +5 volts. The use of standard integrated circuits (ICs) is crucial in the practical application of digital devices. An example is the popular TTL (transistor-transistor logic) family of IC logic devices. These devices "recognize" the 0-volt and 5-volt conditions. The use of standard, mass-produced ICs greatly reduces the cost of digital devices. It also substantially decreases space requirements, weight, and power consumption.

DIGITAL USES IN TELEVISION RECEIVERS

Some of the uses of digital techniques in color television receivers are as follows:

1. Push-button channel selection (including remote control). In this case, the selected channel and correct time may be shown momentarily as a digital display on the screen (see Figure 1.1A).
2. Digital techniques can eliminate some conventional television receiver controls. These include the fine-tuning control and the vertical and horizontal hold controls.

[1]Digital circuits operate on the basis of pulses, or "on-off" conditions. This type of operation differs from analog circuits where the information is present as continuous data, such as voltage or current.

[2]A microprocessor (μP) is one part, the central processing unit, of a microcomputer (μC). The μP may be manufactured on a single integrated circuit (IC) chip or on several chips.

3. Digital techniques make time-programmed channel selection possible.
4. Microprocessors and other computer techniques used in automatic timers and automatic channel selection.
5. Vertical-interval reference (VIR) circuits. These enable automatic color corrections to be made in both hue and saturation.

DIGITAL USES IN TELEVISION TRANSMISSION

A proposal has been made to transmit television video signals by digital techniques. Such techniques are currently used in transmitting television from space vehicles. The major advantage is the almost total elimination of "snow" (noise) from the picture. However, this digital system requires extremely wide bandwidths which are not available with the present television transmission frequencies. One possible solution to this problem is to originate the signal from a space satellite, with a carrier frequency of 12 000 MHz (12 gigahertz). Then, the increased bandwidth can be accommodated. It is also anticipated that bandwidth-compression schemes may reduce the required bandwidth. (The use of digital techniques in television receivers is covered later.)

1.2 MODERN TELEVISION RECEIVERS

A highly sophisticated, completely solid-state color television receiver is shown in Figure 1.1A. Figure 1.1B shows a front view, with the computer-type section pulled forward and opened up in the servicing position. Figure 1.1C shows the rear of the receiver and the TV circuit modules that can be removed for convenient servicing.

MAJOR FEATURES

This receiver can be programmed to provide up to 32 automatic channel changes within two 12- or 24-hour periods. This is accomplished by operating the programmer keyboard (8 buttons) and the random access[1] keyboard (12 buttons) shown in Figure 1.1B. The tuners (VHF and UHF) are completely electronic and contain no moving parts.

Another feature of this receiver is the automatic antenna rotor control. When using an antenna with a motorized rotor, the automatic rotor control turns the antenna to the correct azimuth heading each time a channel is changed. Up to eight separate headings can be selected, with up to three stations for each individual heading. This feature is very useful in reception areas where it is necessary or desirable to receive television stations from widely different directions.

The horizontal and vertical oscillators are connected in phase-locked loop circuits. This eliminates conventional horizontal and vertical hold controls.

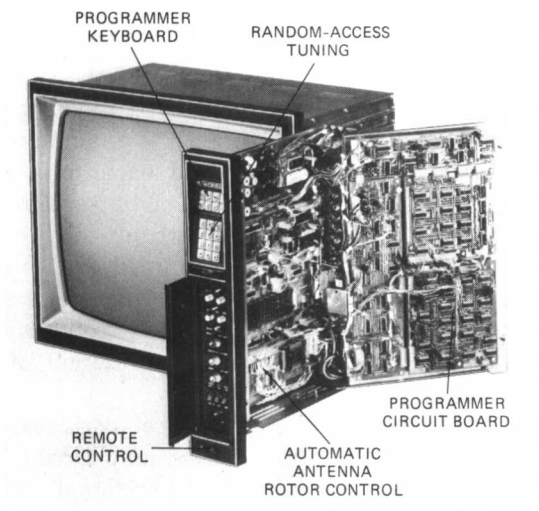
A wireless remote control device permits the viewer to turn the set "on" or "off," adjust the volume, adjust the tint, scan up or down through the channels, and turn the automatic programmer "on" or "off."

DIGITAL SCREEN DISPLAY

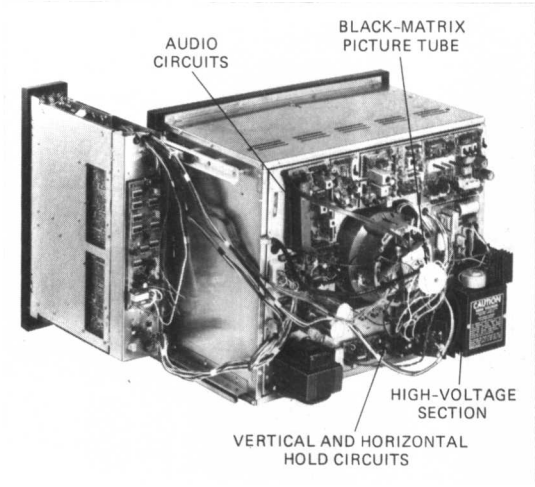
In this receiver, the digital readout is used as a computer readout for the time-programmable system. The first entry is the

[1] *Random access* means that channels may be chosen in any order.

A



B



C

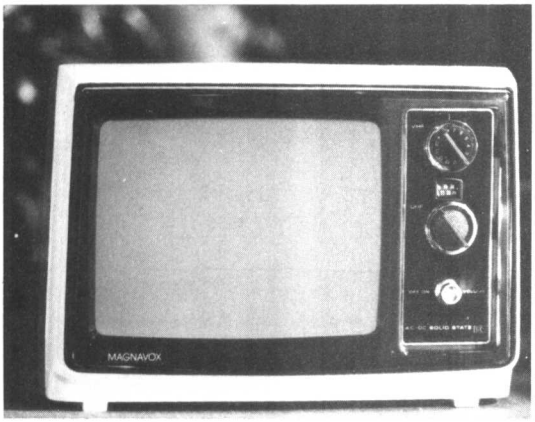
Figure 1.1A A 25-in (63.5-cm) solid-state color television receiver using digital techniques. The channel number in use and the correct time are displayed briefly. B. An open computer section, showing the large number of ICs in the receiver of Figure 1.1A. C. The individual plug-in circuit modules, the audio section, and the high-voltage section of the receiver in Figure 1.1A are shown in this rear view. *(Courtesy of Heath Company.)*

time the viewer wants to see a program. The second entry is the channel number. This information appears individually on the screen for each selection but briefly, to avoid interfering with the desired program.

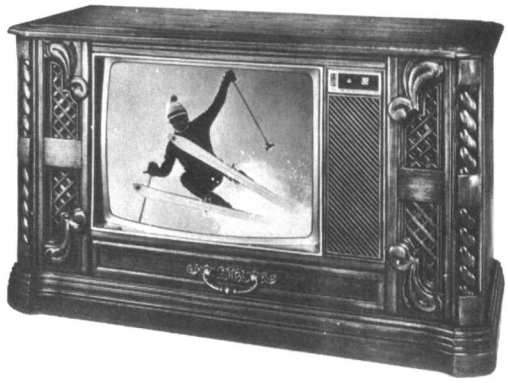
The receiver is completely solid-state and examination of Figure 1.1B reveals a large number of integrated circuits (ICs), in the opened-up computer section. Also note the individual, solid-state, plug-in circuit modules, the separate high-fidelity audio section, and the high-voltage section.

STYLES OF TELEVISION RECEIVERS

Modern television receivers come in a variety of styles and sizes ranging from tiny monochrome receivers with 3-in (7.5-cm) screens to large console, color receivers with 25-in (63.5-cm) screens. More sophisticated features, such as time-programmed channel selection, are available only in the "top-of-the-line" receivers. Three other styles of television receivers are shown in Figure 1.2.



A



C

B

Figure 1.2A A 9-in (22.9-cm) solid-state portable monochrome television receiver. This receiver is only 7 in (17.8 cm) deep and can be operated from 120 V AC, a battery pack, or an auto cigarette lighter socket. *(Courtesy of Magnavox Consumer Electronics Company.)* B. A 19-in (48.3-cm) solid-state portable color television receiver with automatic picture brightness and VIR IC circuitry. *(Courtesy of Panasonic Company.)* C. A 25-in (63.5-cm) solid-state console color television receiver with push-button electronic tuning. Note that the receiver has a digital channel number display. *(Courtesy of Quasar Electronics Corp.)*

9-in Monochrome Portable A 9-in (22.9-cm) portable monochrome receiver is shown in Figure 1.2A. This receiver features three-way power. That is, it may be operated from 120 V AC, from a battery pack, or from a car battery using an optional adapter. The receiver is 100% solid-state, except for the picture tube.

19-in Color Portable Figure 1.2B shows a portable 19-in (48.3-cm) color receiver that is for AC operation only. The receiver is solid-state and has an automatic room-light sensing device which adjusts the picture brightness to ambient room-light conditions. An important feature is the VIR (vertical-interval reference) circuitry.[1] (The VIR system is briefly discussed later in this chapter.) VIR circuitry automatically maintains color inten-

[1]See Section 1.3 for a discussion of the VIR system.

sity and hue by reference to a special signal broadcast by the television station.

25-in Color Console Figure 1.2C shows a 25-in (63.5-cm) console color receiver that is all solid-state, including push-button, solid-state (varactor) VHF and UHF tuners. A newly developed "tri-potential" picture tube, with in-line guns and a "black matrix" screen provides excellent picture quality. The same type of picture tube is also used in many other receivers.

The receiver features a "super modular" chassis containing a large percentage of the receiver circuitry. A color correction system, called "dynacolor" automatically corrects errors in flesh tones and color intensity. A "sharpness" control allows the user to regulate the degree of picture detail. An "over-voltage shutdown" circuit assures X-ray protection. An over-voltage sensor turns off the horizontal oscillator (and thus, the high voltage), if the high voltage exceeds a predetermined level.

1.3 USE OF SEMICONDUCTORS IN TELEVISION RECEIVERS

There are a number of reasons why semiconductor devices have replaced tubes in the design of television receivers. For signal application, the transistor is more efficient than a tube because it does not require a heated filament. The fact that there are no filaments also means fewer cooling problems with solid-state operation. Since filament burn-out is the most frequent cause of tube failure, solid-state circuitry is more reliable. Solid-state sets are also smaller and lighter than comparable tube sets. Solid-state components do not require warmup time.

The smaller physical size of semiconductor circuits and the lower cost of printed circuit fabrication makes it possible to use more automatic circuitry to simplify the operation of television receivers. Figure 1.1B shows how modern transistor circuits are fabricated with compact circuit boards. A service kit of television transistors is shown in Figure 1.3A.

INTEGRATED CIRCUITS

One of the important developments in the use of semiconductors is the *integrated circuit* (IC). This is a method of making a number of circuits on a single semiconductor unit called a *chip*. Figure 1.3B shows an integrated circuit. The inset of this illustration shows the chip with connections to the various individual circuits. One chip may contain a complete audio section, and an IF section, or other sections in the receiver. The chip shown in Figure 1.3B contains a complete color demodulator. Other ICs may be used for automatic fine tuning, video signal processing (brightness and sharpness), volume control, and color signal processing.

VIR ICs

Another important use of ICs is for VIR television receiver operation. A non-IC VIR circuit may require as many as 180 components and needs adjustment. The VIR IC designed for the receiver illustrated in Figure 1.2B reduces the number of components by two-thirds and is integrated on an 0.366-in^2 (9.3-cm^2) chip. This IC requires no adjustment and is fabricated in a single-chip, 24-pin, dual-in-line package.

ADVANTAGES OF ICs

ICs are more reliable than transistor circuits because fewer soldered connections are needed for a complete circuit. Their reliability had been proven many times in computer applications before they were used in