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PREFACE

This is an intensive view and review of television troubleshooting in its many practical and theoretical aspects. It begins with an overview of receivers in the 50s and 60s, progressing to typical video/audio processors of today, and then details the latest information on digital receivers, in addition to large-scale integration (LSI), integrated circuit (IC) technology, and surface mount components.

Interspersed among extensive but definitive explanations are voluminous troubleshooting hints reinforced by hundreds of illustrative drawings and Polaroid waveform photos of good and bad circuit conditions that should prove of major assistance in understanding system faults. As theory and applications accumulate, their contents peak in the chapter titled "The Art, Science, and Practice of TV Servicing."

This is Chapter 5, where test equipment from oscilloscopes to meters, color bar generators, field strength meters, spectrum analyzers, power supplies, and sweep generators are all explained and applied to the various subsystems in *color* television receivers. Special emphasis is placed on new techniques in IF alignments, pattern generators, vectors with gated rainbow generators, NTSC color bars, VITS, VIRS, and all the equipment and service aids currently available to those who wish to restore TV to its original best-operating condition. And with one special technique involving multiburst, you could *easily* and very *quickly* upgrade a set's resolution and definition to a state equal to or better than new. Superior color adjustments are also possible with vector techniques that directly illustrate tuning, phase, bandpass alignment, and possible faults.

In this same chapter a complex breakdown in high voltage and switching-regultor power supplies is examined and repaired, just as you would tackle these twin problems yourself. This is followed by a novel method of detecting overvoltage *and/or* overcurrent shutdown. Here you will learn there is no such thing as a Texas "tripper transformer," and why high wattage, fusible resistors in power transformer-less sets shouldn't be reconnected without a rated current/voltage check.

Following these explicit examples, individual and updated portions of illustrative receivers are examined for sound, tuners, luma, chroma, and sync processing, with special attention paid to *switch mode power supplies,* high voltage, projection television, and cathode ray tubes. Especially, projection TV cathode ray tubes are explained, along with their liquid cooling and operational details. And finally, RCA's Coty-29 system, used by so many TV manufacturers, and Zenith's flat-faced CRT that so far is appearing only in table-top computers are explained.

You will also have extensive information on MATV systems, pertinent calculations, layouts, and troubleshooting accompanied by useful tables, charts, and specifications.

Antennas and transmission lines are discussed, too, along with cable analysis and notes of caution.

In short, there's very little about TV receivers that isn't included in this very generously illustrated volume—and all by an engineer-servicer who's been around the business for more than 30 years. Good luck!

ACKNOWLEDGMENTS

Those whose names follow are both leaders in the industry and special people who have given freely of their talents and technical information to make the contents of this book especially accurate and informative. Were there unlimited space available, individual biographies of this group would occupy at least a separate chapter and offer fascinating reading and a record of significant accomplishment. The author is deeply indebted to each for his or her efforts and would also like to thank Carol Atkins for careful, intelligent editing.

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CONTENTS

CHAPTER 1

TELEVISION RECEIVERS: THEN AND NOW

The days of vacuum tubes, discrete capacitors and resistors, hand wiring, bulky transformer-isolated power supplies, R-Y, B-Y, G-Y luma/chroma separation and recombination in the cathode ray tube, 10-, 12-, and 14-inch consoles, inductor tuning, separate shipment of cathode ray tubes and chassis, ion traps to be adjusted for best brightness and no neck shadow, folded diapoles, twin lead for every installation, and $25 service calls are now all part of history. And so are the great and near-great names such as the *original* Dumonts, Capeharts, Farnsworths, Pilots, Motorolas, Airlines, and others. RCA, of course, remains, but has passed into the hands of France's Thompson, C.H.; Magnavox, Philco, and Sylvania are currently owned by North American Philips of the Netherlands; while Emerson continues to effect an American identity. Now as we look at Japanese names such as Sony, Panasonic, Toshiba, Mitsubishi, NEC, and JVC, plus Tiahan, Samsung, and Gold Star (the Koreans), we might well wonder where our television industry is going. . . . Probably more and more overseas, although a number of the Japanese companies have U.S. assembly plants even now working overtime. At the last Electronic Industries Association count, color television sales will top 19 million receivers should the market remain strong. Zenith, almost alone, remains all-American, even though its printed circuit boards often come from Mexico, as do many of RCA's, with some of the Japanese moving in that direction also.

So times have changed since 1948–1949 when television was first formally introduced to the eastern U.S., and it will predictably evolve further as digital information systems and surface mount components increase reliability, deliver improved pictures and sound, and maintain costs to the public at better than bargain prices. And because of the all-important satellite uplink and downlink transmissions and receptions, there's every reason to believe that 1,000-line high-definition pictures may become almost immediately available shortly after this book is in print.

Several U.S. and Japanese systems have already been proposed, and a few are now in preparatory plans for commercial distribution. From our limited 4.2-MHz broadcast bandpasses today, we may see as much as 20-MHz passbands when Direct Broadcast Satellites with 200 W per transponder begin flying in the 1990s. The lesser-powered 12/14-GHz Ku band could easily accommodate a 10-MHz bandwidth right now if the necessary Tx/Rx systems were in place and operating. Ku, however, has satellites no more powerful than 45–60 watts, and transponder bandspreads of 54–72 MHz. As you can see, wideband transmissions today are entirely possible, but there'll probably be no rush to commence this service because of clientele and extra receiver costs. Regardless, the spacecraft systems are frequency modulated for *both* video and sound, while terrestrial systems in the U.S. have amplitude modulation for video and frequency modulation for sound. Using FM for video reduces both chroma and monochrome noise considerably; measurements, of course, being done in terms of carrier-to-noise (C/N) and signal-to-noise (S/N) ratios:

$$S/N = C/N + 37.5 \text{ dB}$$

with studio quality video established at 54 dB for broadcasters and 56 dB for the satellite people. Television receiver S/N levels should not go *below* 35 dB, and even then it's not an agreeable picture for comfortable viewing. Most receivers should deliver at least 45 dB S/N for decent video quality. Sound is usually better since we're dealing in kilohertz (kHz) rather than video's megahertz (MHz).

The dB, you may recall, stands for decibels, or 1/10 of a Bel, and is handy for handling large numbers such as gains, losses, and other large electrical measurements. Calculating dBs with logs and their mantissas was formidable before scientific calculators, but they're extremely handy in today's calculations when complex determinations are now made with the press of a single button.

You will therefore realize that converting voltage or current and power from digits to decibels is virtually a cinch. All you really need is a reference since you are usually dealing in terms of one voltage/current or power to another, even though the reference may be nothing more than 1. For instance, a ratio of 10 amperes to 2 would become

$$I_2/I_1 \text{ in dB} = 20 \log 5 = 13.98 \text{ dB}$$

and voltage E_2/E_1 in the same proportion would be identical. Power, on the other hand, in terms of DC or sine wave rms equals:

$$P = E \times I,\ I^2 \times R, \text{ or } E^2/R,$$

and its log is multiplied only by 10:

$$P = E \times I, \text{ or } P_2/P_1 = 10 \log P_2/P_1$$

Which decreases the final answer by a factor of 2 when compared with E or I. Rms, for effective voltages or currents, originates from the average or effective power that alternating current or voltage through or across a resistor generates compared with that of a simple DC voltage or current. It can be derived by the following basic equation:

$$\frac{\text{Emax or Imax}}{\sqrt{2}} = \frac{\text{E or I rms (peak)}}{1.414}, \text{ or E/. . .I/2.828 for } \textit{peak-to-peak}$$

The conversion of temperature to decibels is also very easy in terms of absolute Kelvin relative to earth's 290°K:

$$\text{dB} = 10 \log (\text{T}/290° + 1)$$

And to convert from dB to °K, use the following:

$$\text{T} = [(\text{antilog dB}/10) - 1]\ 290°$$

Here, the antilog is used because you cannot conveniently take the logarithm of a number less than 1; and 1, itself, equals 0 log. Also, if the P_2 or E_2, I_2 numbers are *less than* P_1 or E_1, I_1, put a negative number in front of the answer but *always* divide the smaller into the larger. As an example,

$$P_2 = 3 \text{ and } P_1 = 6,$$

therefore

$$6/3 = -2, \text{ and } 10 \log (-)\ 2 = -3 \text{ dB}$$

which, of course, is a half-power loss.

True, television servicing doesn't often deal with voltage and current in terms of power except for AC power consumption, electromagnetic carrier transmissions, and signal-to-noise in either video or audio. Otherwise, E and I max. constitute the going measurements except where sine waves are rendered during their complete alternations from one peak to another, or peak-to-peak.

The foregoing has been a deliberate attempt to have you think in terms of contemporary measurements, since these will be used consistently throughout succeeding chapters. Therefore, if Ohm's Law and decibels are not mastered before we really dig in, some of the material that follows may be (sadly) missed. It's difficult to conceive of any effective servicing without the application of basic math. Bluntly, it can't be done!

And now, because multichannel broadcast sound requires certain S/N and positive channel separation, the use of decibels is that much more important. Similarly, spectrum analysis of certain video/audio information, while not always a "must," becomes surprisingly handy in critical situations where such signals, or the lack of them, have to be identified and studied for processing problems. Also, autoranging multimeters and 3% accurate oscilloscopes with considerable vertical deflection can also be viewed as prime troubleshooting equipment. The day of 20% vacuum tube voltmeters and recurrent sweep oscilloscopes has completely passed down the drain and into waste disposal. Integrated circuits operating on 5-12 volts require considerably more accuracy than even the 5% that was often suitable for discrete transistors. As the "world turns," so must servicing, with precision measurements a principal requirement. For these reasons, practical and specific instrument usage will constitute a considerable portion of this book.

OLD TIMERS

There's no intention to dwell on ancient history, but understanding the past is but prologue to the future. Hot voltage-operated vacuum tubes and receivers drawing 300–400 watts were routine in the early days following the 1954 National Television Systems (NTSC) color standard approval by the Federal Communications Commission. And even 32-tube monochrome receivers with 19-inch round, metal-encased cathode ray tubes, graced fine-grained wood cabinets for $600 and up. Fortunately, 30-kV accelerating anode voltages weren't then in vogue or many a serviceman might never have survived. On the other hand, 400-V DC supplies delivered quite a jolt, too, when rippling across high milliamperes (mA) of current, and woe be the capacitor whose paper or electrolyte dielectric developed porous pimples and shorted one of these supplies to ground. The acrid smell of carbon composition and wire-wound resistors was unmistakable, and many a housewife called either some TV quick-service shop or the fire department, certain that home and belongings were also going to soon depart in a larger cloud of smoke.

In those days, however, if outside servicers could usefully operate a 20,000 ohms/volt VOM, they were jewels, and most bench-type insiders had more than considerable difficulty in aligning audio and video intermediate frequency (IF) strips due to both their own inadequacy and also that of difficult-to-use, inaccurate sweep/marker equipment. A few of us outside servicers carried deflection yokes, flyback transformers, and assorted capacitors and resistors sufficient to attack and solve most problems in the home, especially for RCA and Dumont receivers. And a lesser number of outside servicers lugged around 5–10-MHz bandpass vacuum tube oscilloscopes with both low-capacitance and diode demodulator probes. In those days, if some 80% of all service calls weren't completed in the home, any commission pay arrangement was useless. Further, if a shop job entailed an automatic gain control (AGC) problem, the outside servicer probably faced several callbacks until the shop technician had "shotgunned" the poor circuit to virtual extinction. As you may assume, AGC and high voltage problems were not well understood in those early TV repair days. Unfortunately for some, they still aren't, especially since modules have surrendered to cost-conscious manufacturers and offshore vendors. As this book proceeds, every attempt will be made to offer practical solutions to these and other prime problems that still plague service people today. However, if you thoroughly understand how and why a circuit or subsystem operates, then additional techniques and approaches should develop to solve almost all situations as they arise.

Service-related difficulties that have not changed involve leaky and open capacitors, value-changing resistors, open coils, leaky or shorted active components (meaning tubes/transistors/ICs), and the various mechanical portions of a receiver that wear and fail with age and environment. The latter always involves heat and humidity—especially heat. But the two combined, particularly in the dog days of summer, contribute mightily to shop service as June segues into July and August.

As summer sweltered, so did the tube, hybrid (tubes and transistors), and early semiconductor receivers. Passive components gradually improved from paper dielectric capacitors to ceramics, milar, and tantalum, but so did costs; therefore some of these advances weren't consumer-possible. However, with the coming of 24-, 12-, and even 5-volt DC supplies originating from the introduction of discrete transistors and especially integrated circuits (ICs), film resistors and modified dielectric capacitors began to last many times longer in these lower voltage circuits, reducing servicing to a bare minimum.

Had it not been for the welcome (or otherwise) advent of video cassette recorders, the service business would have declined even more precipitously than it has—at least for the mom and pop stores without first-class technicians who depended somewhat on sales for a substantial portion of their income. The better shops, meanwhile, have diversified into satellite earth terminals, computers, audio, VCRs, and so on, and continue to prosper, some with 50 or more pretty good servicers. They do not, however, attempt to compete with the chain store discounters who buy consumer equipment in carload lots and sell items for what the small dealer must pay. It's estimated that the little sales/service shops have declined at least 30% in the past 10 years (1978–1988) across the country. These numbers continue to diminish even more rapidly in some parts of the U.S. This means more direct factory service is on the way.

With all such changes considered, you're about ready to begin the study/analysis of tube/hybrid/transistor/IC circuits that have developed over approximately the past 20 years. Curiously enough, you'll note that most principles remain, but the electronics have altered radically—fortunately, all for the better. So saying, let's begin with tuners and work through several of the old-line receivers—two of which some may not even remember.

TUNERS

First, a 1969 (or thereabouts) General Electric became available (Fig. 1-1) with a high MU triode amplifier and dual tubes in a single glass envelope, the first of which is a sharp cutoff pentode and the second a medium MU triode. Both tubes have radio frequency (RF) shielding and drive a turret tuner with 12 slugs for channels 2–13, each tuned individually as the schematic shows. Incoming signals through the VHF antenna input via twin lead were transformed into a single-ended input by a balanced-to-unbalanced (balun) transformer, routed through a high-pass constant K filter, an FM trap, and then through a 30-picofarad (pF) capacitor into whatever coil had been selected by the manual tuner to accept some 6-MHz-wide frequency between 54 MHz and 216 MHz (excepting 88–108 MHz FM). Small deflectors on either side of the plate helped guide electron flow from the coil-loaded plate into the control grid of the converter. At the same time, a DC control voltage from the automatic gain control (AGC) maintained override grid action on the 6HA5 to prevent overconduction on strong signals.