

The how-to magazine of electronics...

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ELECTRONIC

Servicing & Technology

MARCH 1988/\$2.25

Back-to-basics Primer • Replacement Parts Directory

Servicing J.C. Penney Vertical Problems • Symcure



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SPECIAL EXPANDED ISSUE

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TTL Logic Probe: 20MHz
Hi/lo/off indications
Detects 25nS pulse widths

hFE (NPN or PNP):
1 range (1000)

DMM: Input Impedance—
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DCA/ACA-5 ranges
(200µA to 2A)

Ohms-8 ranges (200 ohms
to 2000 Megohms)

Continuity beeper



also gives you frequency counting. A full-function DMM, and more, doesn't have to cost over \$195.00. If it's a Circuitmate DM800.

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True RMS

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Hi/lo/off indications
Detects 25nS pulse widths

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(2nF to 20µF)

hFE (NPN or PNP):
1 range (1000)

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Circle (1) on Reply Card



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When Vann's Electronics — Great Neck, New York contacted us with lots of good news about our new products, we thought you would like to hear about it too. Vann's Electronics has been growing since 1966. Its staff of 11 technicians services everything from TVs and VCRs to home computers and telephones. They even maintain service contracts for electronic equipment at many New York hospitals.

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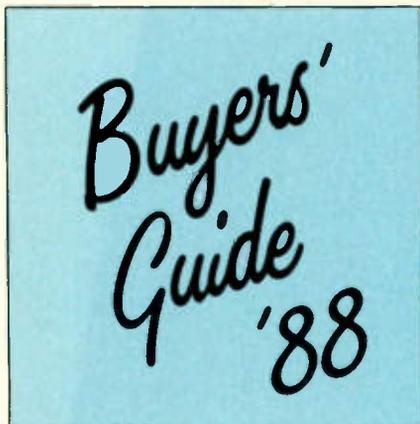
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"IPA saturated **Chemswab**™ and **Chempad**™ are perfectly designed for magnetic head maintenance and general electronic cleaning."

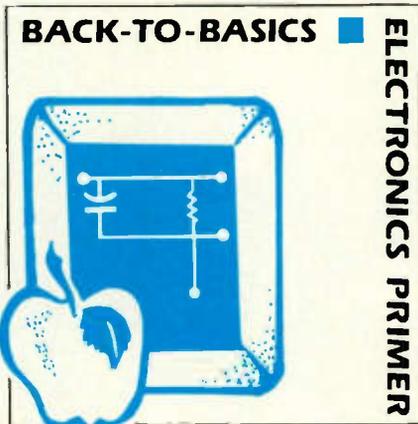
"**Gold Guard**® and **TF Pads**™ clean and preserve contacts easily. The lint-free pad provides a gentle burnishing action not achievable with sprays and they occupy very little space in our tool kits."

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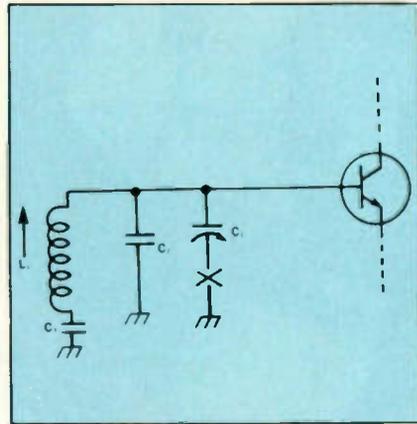
For free evaluation samples, contact us today. We're sure you will agree with leading industry professionals that Chemtronics makes servicing easier.



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FEATURES

8 Buyers' Guide

If you've ever run into the problem where you have isolated a problem, but you just don't know where to look for the replacement part, this guide will help. Whether you're looking for a specific product, a service or just a company address, the following sections should point you in the right direction.

- 8 Product directory
- 24 Replacement parts/ components directory
- 32 Services directory
- 32 Association/educational sources directory
- 34 Company mailing addresses

58 Creating resistor values

By Art H. Meyerson
Perhaps you need a resistor value you just don't have on hand, or maybe you need a non-standard value. The answer to your problem is parallel resistances. This simple formula will help you find which values to use to create the value you need.

60 Extending DVM ohmmeter ranges

By Art H. Meyerson
The new DVMs are low-priced and often give you highly accurate resistance measurements, but there is one problem—the highest resistance range is limited to 2MΩ. However, a simple procedure can extend your DVM range to 20MΩ or beyond.

62 Troubleshooting the op-amp

By Christopher H. Fenton
In the last 20 years, the op-amp has become a basic building block of computers, VCRs and many other electronic products. Read on to find out how they work and how best to troubleshoot them when something goes wrong.

68 Servicing J.C. Penney vertical problems

By Homer L. Davidson
Although the vertical-output circuits in J.C. Penney models may look similar, there are some vital differences. Developing a series of tests for a certain symptom will help you troubleshoot not only J.C. Penney models, but other televisions with similar problems as well.

78 That dreaded drift...

By Joseph J. Carr, CET
When you're servicing radios, the word drift may be the customer

complaint you dread the most. Here are some tips to ferreting out the cause of drift problems.

DEPARTMENTS

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ON THE COVER

Whether you're looking for a piece of test equipment, a specific component or an association that can help you learn more about electronics servicing, the 1988 Buyers' Guide can direct you to the information you need. (Concept and design by Barbara Miles, graphic designer.)

The how-to magazine of electronics

ELECTRONIC
Servicing & Technology

LEADER

A TYPICAL "PORTABLE" SCOPE

THE TRULY PORTABLE
LBO-315

If both of these scopes are portable,
then this is a lapdog.

What's the difference between a portable scope and the *truly* portable LBO-315? A lot of weight, among other things. At just 10 lbs and 10.5 x 3 x 13" with battery, the full-function LBO-315 can easily go everywhere a technician goes.

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No so-called "portable" even comes close.

Compact 60-MHz LBO-315 packs all the performance of a bench scope. Operates from

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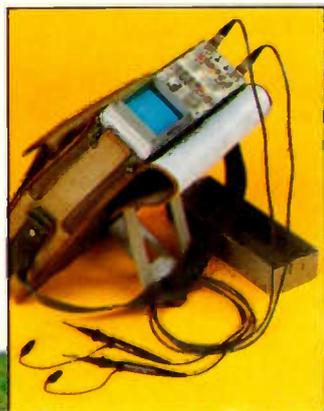
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The truly portable LBO-315 comes with complete accessories, as shown at left.



Are you looking for something?

One of the difficult problems in a complex world like ours is the matter of how and where to find things. That's attested to by the numbers of documents and other aids that have been created to help people find things and information: telephone directories, yellow pages, maps, street listings and more. Spend a night in the hotel and, in addition to the directory of hotel services, you'll probably find a directory to what's going on in the local area, including shows, restaurants, churches and more.

TV Guide is a response to the viewers' need for a directory of what will be shown on television. Almost every newspaper publishes its own guide for its readers, usually on both a daily and a weekly basis.

In fact, the need for a directory to the directories is so strong that in many cities you can find telephone numbers you can call to find out what's going on where.

Many special-interest groups have some kind of directory. Until a year ago, there was no one place where consumer electronics servicing technicians could find information on products and services available to them. The 1987 *Electronic Servicing & Technology Buyers' Guide* changed that. For the first time, there was a guide designed and produced just for people who service consumer electronics products.

That guide was well-received by our readers, who were pleased to have a single directory of products, services and information for them. There was one complaint from readers about the guide: The pages devoted to the buyers' guide listings were subtracted from the pages normally used to publish servicing articles and Profax schematics. This year's buyers' guide corrects that problem. Instead of using precious article space for the listings, we have added the listings to our usual package. This issue represents a huge value to readers. In this issue, we bring you our buyers'

guide listings *in addition to* our regular features and our usual Profax schematics.

That's close to 100 information-packed pages in this month's issue—more pages than *ES&T* has published in recent memory, and perhaps in the history of the magazine.

Renew your subscription now and save

Also please note that you have a special opportunity to save money with this issue. The costs of paper, ink, postage, transportation and everything that affects the cost of publishing a magazine are going up. We have no choice but to increase our subscription rates from \$18 for one year to \$19.49 (our first increase in four years). If you renew your subscription now, however, you may do so at the current rate and save yourself a little money. If that appeals to you, see details on page 40, then fill out the subscription renewal card and send it in today.

SYMCURES and Troubleshooting Tips needed

And on another subject, here's an opportunity to help your fellow technicians and earn some money as well. We need SYMCURES and Troubleshooting Tips. We pay \$60 per printed page (six separate problems and solutions) for SYMCURES and \$25 per Troubleshooting Tip. See page 76 in this issue for an example of SYMCURE. If you're interested in submitting either a SYMCURE or a Troubleshooting Tip and you'd like detailed instructions, write to:

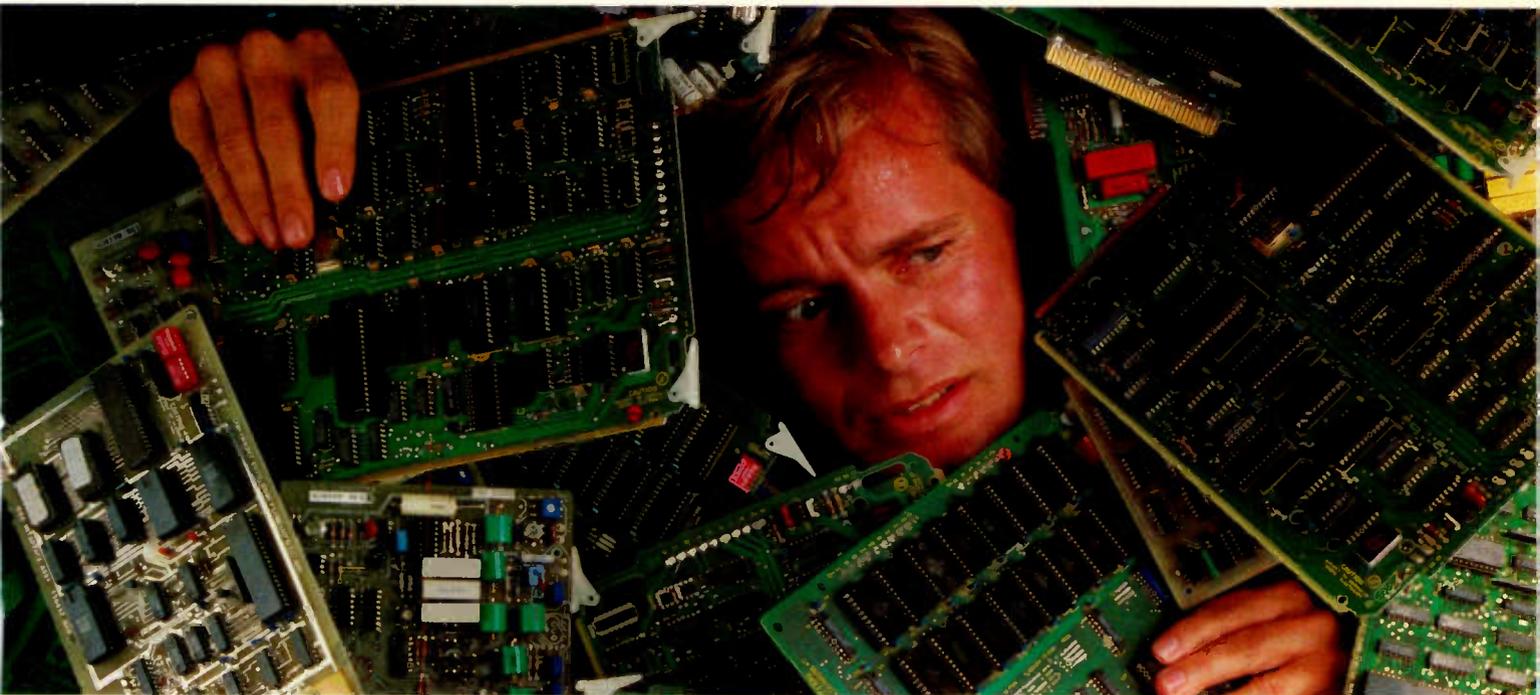
SYMCURE/Troubleshooting

Tips Editor
Electronic Servicing & Technology
P.O. Box 12901
Overland Park, KS 66212

Nile Conrad Pearson



PHILIPS



How to rescue yourself from a landslide of microprocessor board failures.

Complementing traditional troubleshooting tools, the Fluke 9010A can help decrease your board repair times by 55-80%.

You've got your oscilloscopes, your logic analyzers and your signature analyzers. But Fluke offers a better way to troubleshoot: the tool you'll reach for most. It's the 9010A Troubleshooter, a versatile board tester that's so easy to use, you can start testing the very first day.

The Fluke 9010A has a proven track record in saving repair time and substantially reducing board float. In fact, it has become the microprocessor repair tool of choice for over 2800 companies worldwide, including the leading computer and electronics manufacturers.

Test the easy way: from the microprocessor socket.

To begin board repair, remove the microprocessor from its socket and insert the interface pod connector in its place. Each

element of the microprocessor kernel (the bus, ROM, RAM and I/O) can be tested with a few simple commands.

Fluke's patented emulation technology offers real time testing and complete visibility throughout the circuit. This lets you test even the tough problem areas, including DMA, disk, video, communications and peripheral controllers. All diagnostic messages are presented in simple-to-understand English.

Comprehensive support from Fluke.

The 9010A supports over 50 microprocessors (including 180X, 6502, 680X, 680XX, 803X, 804X, 805X, 808X, 874X, 80X86, 9900, Z80, Z800X, 8751). And it is backed by Fluke's complete support network, which offers training courses nationwide on test strategy, basic operation and even μ P fundamentals.

In addition to the 9010A, the leader in emulative board test technology also offers the 9100A Digital Test System for a fully automated repair solution; plus the 90 Series, a compact inexpensive troubleshooting solution for 6809, Z80 and 8085 μ Ps.

To learn how you can escape the landslide, get your free video brochure "The 9010A μ P Board Repair Solution."

Call 1-800-44-FLUKE, EXT. 88 today.

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The 9010A Microsystems Troubleshooter



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It doesn't take a storm to wreck your sensitive computer and upset the business that depends on it. Over ninety per cent of computer problems are due to irregular power. Just the slightest surge or dip in electricity can trigger costly errors, memory loss or a complete system shutdown. And anything from an air conditioner turning off to a nearby appliance starting up can make it happen.

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Buyers' Guide '88



Our 1987 Buyers' Guide—ES&T's first, which ran in the March issue—was an unqualified success. Many readers told us that they were pleased to find a source of information on where to find parts, test equipment, services, servicing information and all those other things that a servicing technician needs to know about. So we're doing it again. Here's the 1988 Buyers' Guide.

How to use the guide

This Buyers' Guide is intended to be a useful reference throughout the year. It is divided into five main sections:

- Product Directory
- Replacement Parts/Components Directory
- Services Directory
- Association/Educational Sources Directory
- Company Address Directory

The Product Directory is further subdivided by type of product. (The *D designates companies that distribute, not manufacture, a particular product.) To find the product, service or information source you need, just turn to the appropriate section and review the listings. You will note that some of the listings are printed in blue. These are the companies that have advertised in this issue. For more information about any of these companies, just turn to the page number opposite the entry to find the ad.

Once you have located the name of a company that supplies the product or service you're interested in, turn to the alphabetical listing of companies to find the address and telephone number you need.

Looking toward next year
The ES&T staff has expended every

effort to make this Buyers' Guide accurate, comprehensive and useful to you. Because this is our second buyers' guide, we have been able to locate many sources of products and services that were not listed last year. However, because of the large number of sources and the continuous introduction of new companies and products, we may have inadvertently left out some information that's vital to you.

If you need information, a product or a component to fix a consumer electronics product, but you don't see it here, please take just a moment to bring it to our attention. Give us as many facts as possible so that we can find the information. If we deem it appropriate for the majority of readers, we'll do our best to incorporate this material into next year's Buyers' Guide.

ES&T

Product Directory



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TEST EQUIPMENT

AC LEAKAGE TESTERS

Abatron Electronics*D	
Accutest Instruments*D	
AEMC Corp.	
Allied Electronics, A Subsidiary of Hall-Mark Electronics*D	
B&K-Precision Maxtec International Corp.	
CG Soar Corp.	
Consolidated Electronics, Inc.*D	82
E.I.L. Instruments, Inc.	
Electro Rent Corp.*D	
Electronics Warehouse Corp.*D	88
Fordham Radio Supply Co.*D	39
The Instrument Mart, Inc.*D	
Joseph Electronics*D	81
Miltex Supply Corp.*D	
Projector-Recorder Belt*D	90
RAG Electronics Inc.*D	
Sencore, Inc.	73,75, 77,79
Simpson Electric Co.	
TIF Instruments, Inc.	
Transcat*D	
Verite	

VIZ Test Equipment Div. of Kappa Networks Inc.

AUTOMATED TEST EQUIPMENT

Abatron Electronics*D	
Accutest Instruments*D	
American Reliance Inc.	23
Arium Corp.	
Arrow Electronics Inc. Catalog Sales Div.*D	
Biddle Instruments	
BitWise Designs, Inc.	
Cabletest Products Co.	
Convex Corp.	
Electro Rent Corp.*D	
Elgar Corp.	
John Fluke Mfg. Co. Inc.	5,19
Greenbrier Electronics Div. Temco Instruments, Inc.	
Hameg, Inc.	
Heath Co.	80
Hilevel Technology, Inc.	
HI-Techniques Inc.	
Hollex Inc.	
Huntron Inc.	
IET Labs, Inc.	
IQ Technologies, Inc.	
W.S. Jenks & Son*D	
Joseph Electronics*D	81

Leader Instruments Corp.	3
Markenrich Corp.	
Pacific Power Source	
PanSon Electronics*D	
Pioneer Research	
Pioneer-Standard Electronics*D	
Racal-Dana Instruments Inc.	
RAG Electronics Inc.*D	
Sencore, Inc.	73,75, 77,79
Spanta, Inc.	
United States Instrument Rentals*D	35
Verite	
Vu-Data Corp.	
D.S. Walker & Associates, Inc.	67
Wandel & Goltermann, Inc.	

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American Reliance Inc.	23
Arrow Electronics Inc. Catalog Sales Div.*D	
Atrix, Inc.*D	
B&B Electronics Mfg., Co.	
Beckman Industrial Corp.	IFC
Black Box Corp.	
Computer Doctors	
Consolidated Electronics, Inc.*D	82
Contact East, Inc.*D	67

Convex Corp.	
Datacom Northwest, Inc.	
Datatron Corp.	
E.I.L. Instruments, Inc.	
Electro Rent Corp.*D	
Electronic Parts Supply*D	
Electronics Warehouse Corp.*D	88
Fordham Radio Supply Co.*D	39
Hall-ComSec, Inc.	
Hand Tool Industries, Inc.	
HMC-Hub Material Co.*D	85
IAM	
International Data Sciences	
IQ Technologies, Inc.	
JDR Microdevices*D	IBC
W.S. Jenks & Son*D	
Jensen Tools Inc.*D	87
Joseph Electronics*D	81
Kobatron Inc.	
L-Com Inc.	
Marconi Instruments	
MCM Electronics*D	54
Milo Associates, Inc.*D	
Miltex Supply Corp.*D	
M-Test Equipment	
Network Solutions Inc.	
Nu-Data Inc.	
ORA Electronics	
Patton Electronics Co.	
Pioneer-Standard Electronics*D	
RNJ Electronics Inc.*D	88
Scooter Products Ohm Electric, Inc.	

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Sintec Co.*D
Specialized Products Co.*D
Support Systems International Cables
& Accessories Div.
Techni-Tool Inc.*D 64
Telecommunications Techniques Corp.
G.C. Thorsen Co.
Tool Kit Specialists, Inc.
Transcat***D**
Tucker Electronics Co.*D
**United States Instrument
Rentals***D**** 35
Wandel & Goltermann, Inc.

CONTINUITY TESTERS

Accutest Instruments***D**
Allied Electronics, A Subsidiary of
Hall-Mark Electronics***D**
Arrow Electronics Inc. Catalog Sales
Div.***D**
Atrix, Inc.***D**
Biddle Instruments
B&K-Precision Maxtec International
Corp.
Cabletest Products Co.
CG Soar Corp.
**Consolidated Electronics,
Inc.***D**** 82
Contact East, Inc.*D**** 67
C&S Sales*D**** 61
CSTS Inc.
Desco Industries
E.I.L. Instruments, Inc.
Electro Rent Corp.***D**
Electronics Warehouse Corp.*D**** 88
EMCO Electronics
Extch Instruments Corp.
Fordham Radio Supply Co.*D**** 39
GenRad, Inc.
Hand Tool Industries, Inc.
HMC-Hub Material Co.*D**** 85
Hollex Inc.
The Instrument Mart, Inc.***D**
JDR Microdevices*D**** IBC
W.S. Jenks & Son***D**
Jensen Tools Inc.***D** 87
Joseph Electronics***D** 81
Wayne Kerr Inc.
Jlein Tools, Inc.
L-Corn Inc.
Milo Associates, Inc.***D**
Miltex Supply Corp.***D**
MiniTool Inc. 56
Nu-Data Inc.
O.K. Industries Inc. 11
Oldaker Mfg. Corp.
OmniTron Electronics***D**
Projector-Recorder Belt*D**** 90
RAG Electronics Inc.***D**
The Rex Co.***D**
RNJ Electronics Inc.*D**** 88
Sintec Co.***D**
Spanta, Inc.
Specialized Products Co.***D**
Synchronicity Research Co.
Techni-Tool Inc.*D**** 64
Telephone Extension Corp.
G.C. Thorsen Co.
TIF Instruments, Inc.
Tool Kit Specialists, Inc.
Tool-Tronics, Inc.***D**
Transcat***D**
The Triangle Tool Group, Inc.
Tucker Electronics Co.***D**
Vaco Products Div.
Verite
Yokogawa Corp. of America

CRT TESTERS/RESTORERS

Accutest Instruments***D**
B&K-Precision Maxtec International
Corp.
Bursma Electronic Distributing***D**
**Consolidated Electronics,
Inc.***D**** 82
Dandy Mfg. Co.
Electro Rent Corp.***D**
Electronic Parts Supply***D**
Electronics Warehouse Corp.*D**** 88
Fordham Radio Supply Co.*D**** 39
HMC-Hub Material Co.*D**** 85
The Instrument Mart, Inc.***D**
International Data Sciences

W.S. Jenks & Son***D**
Joseph Electronics***D** 81
MCM Electronics***D** 54
NAP Consumer Electronics Corp.
Nu-Data Inc.
OmniTron Electronics***D**
PanSon Electronics***D**
Projector-Recorder Belt*D**** 90
RNJ Electronics Inc.*D**** 88
Sencore, Inc. 73,75,
77,79

CURVE TRACERS

Accutest Instruments***D**
Advanced Test Equipment Rentals***D**
B&K-Precision Maxtec International
Corp.
Bursma Electronic Distributing***D**
**Consolidated Electronics,
Inc.***D**** 82
EDS, Inc.
Electro Rent Corp.***D**
Electronics Warehouse Corp.*D**** 88
Huntron Inc.
The Instrument Mart, Inc.***D**
Joseph Electronics***D** 81
Leader Instruments Corp. 3
Leasametric IRD***D**
Miltex Supply Corp.***D**
NAP Consumer Electronics Corp.
Non-Linear Systems
OmniTron Electronics***D**
PanSon Electronics***D**
Polaris Div. of UXL Corp.
Projector-Recorder Belt*D**** 90
RAG Electronics Inc.***D**
RNJ Electronics Inc.*D**** 88
Synchronicity Research Co.
Tucker Electronics Co.***D**

DATA COMMUNICATION**ANALYZERS/MONITORS/
TESTERS**

Abatron Electronics***D**
Accutest Instruments***D**
Atrix, Inc.***D**
Beckman Industrial Corp. IFC
Computer Doctors
Contact East, Inc.*D**** 67
Convex Corp.
Datacom Northwest, Inc.
Datatran Corp.
Digitex Industries Inc.
Electro Rent Corp.***D**
Frederick Engineering, Inc.
Genstar Rental Electronics Inc.***D**
Global Specialties Mail Order Div.***D**
Gould Inc. Test & Measurement
Group
Greenbrler Electronics Div. Temco
Instruments, Inc.
HMC-Hub Material Co.*D**** 85
Jensen Tools Inc.***D** 87
Joseph Electronics***D** 81
Kobatron Inc.
Leasametric IRD***D**
Marconi Instruments
Micromax Corp.
Nu-Data Inc.
Projector-Recorder Belt*D**** 90
RAG Electronics Inc.***D**
Specialized Products Co.***D**
Techni-Tool Inc.*D**** 64
Tekelec
Tektronix Communications Network
Analyzers Div.
Telecommunications Techniques Corp.
Transcat***D**
Tucker Electronics Co.***D**
**United States Instrument
Rentals***D**** 35
Wandel & Goltermann, Inc.

DISC DRIVE**ANALYZERS/TESTERS**

Advanced Test Equipment Rentals***D**
Applied Data Communications
Applied Memory Technology
AVA Instrumentation, Inc.
Brian Instruments, Inc.
Computer Doctors

Contact East, Inc.*D**** 67
Data Tech Reliance, Inc.
E.I.L. Instruments, Inc.
GenRad, Inc.
HMC-Hub Material Co.*D**** 85
Huntron Inc.
Jensen Tools Inc.***D** 87
Kobatron Inc.
PanSon Electronics***D**
Pioneer Research
RAG Electronics Inc.***D**
Specialized Products Co.***D**
D.S. Walker & Associates, Inc. 67

DISTORTION ANALYZERS

Accutest Instruments***D**
Advanced Test Equipment Rentals***D**
Allied Electronics, A Subsidiary of
Hall-Mark Electronics***D**
Bursma Electronic Distributing***D**
**Consolidated Electronics,
Inc.***D**** 82
E.I.L. Instruments, Inc.
Electro Rent Corp.***D**
Electronics Warehouse Corp.*D**** 88
Genstar Rental Electronics Inc.***D**
Hameg, Inc.
Hewlett-Packard Co.
The Instrument Mart, Inc.***D**
W.S. Jenks & Son***D** 81
Joseph Electronics***D** 81
Leader Instruments Corp. 3
Leasametric IRD***D**
NAP Consumer Electronics Corp.
Tucker Electronics Co.***D**
**United States Instrument
Rentals***D**** 35
Wandel & Goltermann, Inc.
Zenith Electronics Corp. BC

FREQUENCY COUNTERS

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Beckman Industrial Corp. IFC
B&K-Precision Maxtec International
Corp.
Bursma Electronic Distributing***D**
CG Soar Corp.
**Consolidated Electronics,
Inc.***D**** 82
Contact East, Inc.*D**** 67
C&S Sales*D**** 61
Daetron 87
Datel, Inc.
Davle Tech Inc.
Echosphere Corp.
E.I.L. Instruments, Inc.
Electro Rent Corp.***D**
Electronics Warehouse Corp.*D**** 88
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Fordham Radio Supply Co.*D**** 39
Genstar Rental Electronics Inc.***D**
Hameg, Inc.
Hand Tool Industries, Inc.
Heath Co. 80
Hewlett-Packard Co.
HMC-Hub Material Co.*D**** 85
IET Labs, Inc.
The Instrument Mart, Inc.***D**
Interplex Electronics/Global Specialties
Iwatsu Instruments Inc.
W.S. Jenks & Son***D**
Joseph Electronics***D** 81
Kikusui International Corp.
Leader Instruments Corp. 3
Leasametric IRD***D**
MCM Electronics***D** 54
Mercer Electronics
Milo Associates, Inc.***D**
Mouser Electronics***D**
NAP Consumer Electronics Corp.
O.K. Industries Inc. 11
OmniTron Electronics***D**
PanSon Electronics***D**
Philips Test & Measuring Instruments
Projector-Recorder Belt*D**** 90
Pulse Instruments
Racal-Dana Instruments Inc.
RAG Electronics Inc.***D**
Rapid Systems
RNJ Electronics Inc.*D**** 88
Rochester Instruments Systems
Rohde & Schwarz-Polarad, Inc.
Simpson Electric Co.
Sintec Co.***D**
Spanta, Inc.
Specialized Products Co.***D**
Techni-Tool Inc.*D**** 64
Transcat***D**
Tucker Electronics Co.***D**
**United States Instrument
Rentals***D**** 35
VIZ Test Equipment Div. of Kappa
Networks Inc.

PanSon Electronics***D**
Philips Test & Measuring Instruments
Pioneer-Standard Electronics***D**
Projector-Recorder Belt*D**** 90
Racal-Dana Instruments Inc.
RAG Electronics Inc.***D**
Ramsey Electronics Inc.
RNJ Electronics Inc.*D**** 88
Rochester Instruments Systems
Sencore, Inc. 73,75,
77,79
Simpson Electric Co.
Sintec Co.***D**
Specialized Products Co.***D**
Sutton Designs, Inc. Computer
Security Div.
Tektronix, Inc. 13,15,
16a-16b,17
Tool-Tronics, Inc.***D**
Transcat***D**
Tucker Electronics Co.***D**
**United States Instrument
Rentals***D**** 35
VIZ Test Equipment Div. of Kappa
Networks Inc.
WestCon
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Advanced Test Equipment Rentals***D**
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Div.***D**
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Beckman Industrial Corp. IFC
B&K-Precision Maxtec International
Corp.
Bursma Electronic Distributing***D**
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Inc.***D**** 82
Contact East, Inc.*D**** 67
C&S Sales*D**** 61
Daetron 87
Davle Tech Inc.
E.I.L. Instruments, Inc.
Electro Rent Corp.***D**
Electronics Warehouse Corp.*D**** 88
Elenco Electronics, Inc.
John Fluke Mfg. Co. Inc. 5,19
Fordham Radio Supply Co.*D**** 39
Genstar Rental Electronics Inc.***D**
Global Specialties Mail Order Div.***D**
Hameg, Inc.
Heath Co. 80
Hewlett-Packard Co.
Hi-Techniques Inc.
HMC-Hub Material Co.*D**** 85
The Instrument Mart, Inc.***D**
Interplex Electronics/Global Specialties
Iwatsu Instruments Inc.
W.S. Jenks & Son***D**
Joseph Electronics***D** 81
Kikusui International Corp.
Leader Instruments Corp. 3
Leasametric IRD***D**
MCM Electronics***D** 54
Mercer Electronics
Milo Associates, Inc.***D**
Mouser Electronics***D**
NAP Consumer Electronics Corp.
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OmniTron Electronics***D**
PanSon Electronics***D**
Philips Test & Measuring Instruments
Projector-Recorder Belt*D**** 90
Pulse Instruments
Racal-Dana Instruments Inc.
RAG Electronics Inc.***D**
Rapid Systems
RNJ Electronics Inc.*D**** 88
Rochester Instruments Systems
Rohde & Schwarz-Polarad, Inc.
Simpson Electric Co.
Sintec Co.***D**
Spanta, Inc.
Specialized Products Co.***D**
Techni-Tool Inc.*D**** 64
Transcat***D**
Tucker Electronics Co.***D**
**United States Instrument
Rentals***D**** 35
VIZ Test Equipment Div. of Kappa
Networks Inc.

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GAUGES: HEAD PROTRUSION/SPRING TENSION/STYLUS FORCE/OTHER			LOGIC ANALYZERS: SIGNATURE/STATE	
Atrix, Inc.* D Contact East, Inc.* D 67 HMC-Hub Material Co.* D 85 Jensen Tools Inc.* D 87 Jonard Industries Joseph Electronics* D 81 NAP Consumer Electronics Corp. Tentel Corp. 86 Tool-Tronics, Inc.* D			Abatron Electronics* D Accutest Instruments* D Advanced Test Equipment Rentals* D Allied Electronics, A Subsidiary of Hall-Mark Electronics* D B&K-Precision Maxtec International Corp. Bursma Electronic Distributing* D Consolidated Electronics, Inc.* D 82 Electro Rent Corp.* D Electronics Warehouse Corp.* D 88 EMCO Electronics John Fluke Mfg. Co. Inc. 5,19 Genstar Rental Electronics Inc.* D Hameg, Inc. The Instrument Mart, Inc.* D W.S. Jenks & Son* D Joseph Electronics* D 81 Leader Instruments Corp. 3 Leasametric IRD* D MCM Electronics* D 54 Milo Associates, Inc.* D NAP Consumer Electronics Corp. OmniTron Electronics* D PanSon Electronics* D Philips Test & Measuring Instruments Projector-Recorder Belt* D 90 RAG Electronics Inc.* D RNJ Electronics Inc.* D 88 Rohde & Schwarz-Polarad, Inc. Sencore, Inc. 73,75, 77,79 Dick Smith Electronics* D Tucker Electronics Co.* D United States Instrument Rentals* D 35 Video Midwest & AVC Divs. of Vaughn Communications* D VIZ Test Equipment Div. of Kappa Networks Inc. Wandel & Goltermann, Inc. Wavetek Corp.	LOGIC ANALYZERS: SIGNATURE/STATE Abatron Electronics* D Accutest Instruments* D Advanced Test Equipment Rentals* D Arium Corp. Atrix, Inc.* D BBC-Metrawatt/Goerz Becktron BitWise Designs, Inc. Bursma Electronic Distributing* D CG Soar Corp. C&S Sales* D 61 E.I.L. Instruments, Inc. Electro Rent Corp.* D Electronics Warehouse Corp.* D 88 John Fluke Mfg. Co. Inc. 5,19 Fordham Radio Supply Co.* D 39 Genstar Rental Electronics Inc.* D Global Specialties Mail Order Div.* D Gould Inc. Test & Measurement Group Greenbrier Electronics Div. Temco Instruments, Inc. 80 Heath Co. 80 Hewlett-Packard Co. Hilevel Technology, Inc. HMC-Hub Material Co.* D 85 Interplex Electronics/Global Specialties W.S. Jenks & Son* D Joseph Electronics* D 81 Kobetron Inc. Leasametric IRD* D Micromax Corp. NAP Consumer Electronics Corp. OmniLogic, Inc. OmniTron Electronics* D Orion Instruments Philips Test & Measuring Instruments PrimeLine A Div. of Soltec Corp. Projector-Recorder Belt* D 90 Pulse Instruments Racal-Dana Instruments Inc. RAG Electronics Inc.* D Rapid Systems RNJ Electronics Inc.* D 88 Simpson Electric Co. Sintec Co.* D Techni-Tool Inc.* D 64 Tektronix, Inc. 13,15, 16a-16b,17 Transcat* D Tucker Electronics Co.* D United States Instrument Rentals* D 35 Valley Data Sciences Ziltek Corp.
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			Joseph Electronics* D 81 PanSon Electronics* D Tucker Electronics Co.* D	



NEW TEMPERATURE SENSING SMD REWORK STATION O.K. Industries Inc. introduces a new closed loop thermocouple controlled rework station capable of removing and replacing large leaded and unleaded surface mount devices. Designated the ED-500, the unique temperature control protects both board and component during the entire rework cycle. The component is further protected by a stream of cool air during the reflow process. The ED-500 utilizes vacuum pickup for gentle component handling and localized hot gas heating to avoid thermal stress to adjacent areas. Maximum control is afforded by closed loop heat sensing, a timer function and board pre-heater. The heating head is easily movable in all directions, giving the operator unprecedented flexibility during rework. An optional stereo microscope increases placement accuracy and allows for close inspection of the rework.

Prices start as low as \$6495.00.
Contact: O.K. Industries Inc. 1-800-523-9667 (outside of N.Y.S.) or (914) 969-6800.

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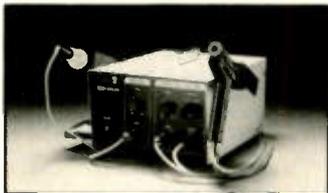


O.K. INDUSTRIES SA-3 SOLDERING STATION The O.K. Industries SA-3 is a temperature controlled soldering station. This unit boasts a variable temperature control ranging from 210°-930°F, making the SA-3 a mandatory tool for all applications requiring maximum temperature flexibility and accuracy.

In addition, 3 wattage irons (30, 48, 60) are available to cover most every soldering application. Each iron comes equipped with grounded tips, making the SA-3 MOS and CMOS safe. Repair of this unit is made simple with the modular PCB design. Delivery is Ex-stock. List Price is \$105.00.

For more information, contact: O.K. Industries Inc., 4 Executive Plaza, Yonkers, NY 10701, 1-800-523-0667 (In N.Y.S. call (914) 969-6800).

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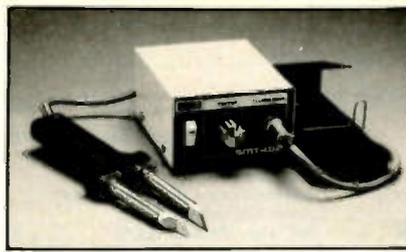


O.K. INDUSTRIES ADDS SOLDER/DESOLDER STATION TO CURRENT DESOLDER LINE UP O.K. Industries has introduced a new completely self-contained solder and desolder system. The SA-1200 is designed for multilayer board rework and repair. Its desolder handpiece has a powerful 65 watt heating element for extremely rapid heat recovery. The desolder handpiece has a high heat capacity, non-threaded tip which provides sufficient heat for boards with high thermal masses. The SA-1200 has a 24 volt, 48 watt variable temperature solder iron. The SA-1200 has a self-contained pump with quick rise vacuum, (21 inches/Hg), variable temperature control of 660°-880°F (desolder and solder), safe 24 volt handpieces, zero voltage heater switching. Additionally, the desolder handpiece, with its ergonomic pistol-grip design has hot air blow control for heat shrink tubing. The unit comes complete with tip cleaning sponge and tray, iron holder, non-burn Silicone rubber cord, separate lighted on/off power indicator and a full range of tip sizes.

The SA-1200 is available from stock and list price is \$495.00.

For more information and the name of your local stocking distributor, contact: O.K. Industries Inc., 4 Executive Plaza, Yonkers, NY 10701, (914) 969-6800.

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SMT-W2 SMD REMOVAL SYSTEM O.K. Industries introduces the SMT-W2, a hand-operated SMD removal tool. Featuring a variable temperature controller, tweezers-action handpiece, handpiece stand, and a wide variety of optional tips, the system affords an effective low-cost solution for SMD removal.

The SMT-W2 tips have a high thermal capacity to support removal of the most demanding components. Dual 80W ceramic heating elements provide rapid heat recovery and

exceptional temperature stability. Additionally, the variable temperature controller enables the user to vary temperature over a range of 330°-740°F.

A full range of tips are available including 5mm tips for resistors or capacitors, mini-flats for SOIC's and right angle tips for PLCC's to 84 pins.

Delivery is Ex-stock. List price is \$425.00.

For more information contact: O.K. Industries Inc., 4 Executive Plaza, Yonkers, NY 10701, 1-800-523-0667 (In N.Y.S. call (914) 969-6800).

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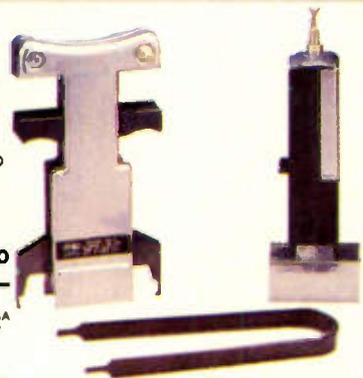
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**METERS, CAPACITANCE/
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Arrow Electronics Inc. Catalog Sales
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B&K-Precision Maxtec International
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**Consolidated Electronics,
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Creative Electronics
C&S Sales*D 61
Daetron 87
EDS, Inc.
E.I.L. Instruments, Inc.
Electro Rent Corp.*
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EMCO Electronics
Extch Instruments Corp.
Fordham Radio Supply Co.*D 39
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Hameg, Inc.
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Hewlett-Packard Co.
HMC-Hub Material Co.*D 85
IET Labs, Inc.
The Instrument Mart, Inc.*
Itera/Belmoor
JDR Microdevices*D IBC
W.S. Jenks & Son*
Jensen Tools Inc.*D 87
Joseph Electronics*D 81
Keithley Instruments, Inc. Instruments
Div.
Wayne Kerr Inc.
Leader Instruments Corp. 3
Leasametric IRD*
MCM Electronics*D 54
Milo Associates, Inc.*
Mouser Electronics*
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PanSon Electronics*
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Pioneer-Standard Electronics*
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RAG Electronics Inc.*
RNJ Electronics Inc.*D 88
Sencore, Inc. 73,75,
77,79
Shogyo
Simpson Electric Co.
Sintec Co.*
Dick Smith Electronics*
Spanta, Inc.
Specialized Products Co.*
A.W. Sperry Instruments, Inc. 33
Synchronicity Research Co.
Tool-Tronics, Inc.*
Transcat*
Tucker Electronics Co.*

METERS, CLAMP ON

Accutest Instruments*
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AEMC Corp.
Allied Electronics, A Subsidiary of
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American Reliance Inc. 23
Amprobe Instrument 21
Arrow Electronics Inc. Catalog Sales
Div.*
Ballantine Labs, Inc.
Beckman Industrial Corp. IFC
Biddle Instruments
B&K-Precision Maxtec International
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Bursma Electronic Distributing*
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**Consolidated Electronics,
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Contact East, Inc.* 67
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E.I.L. Instruments, Inc.
Electro Rent Corp.*

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Electronics Warehouse Corp.*D 88
Elenco Electronics, Inc.
EMCO Electronics
Esterline Angus Instrument Corp.
Extch Instruments Corp.
HMC-Hub Material Co.*D 85
The Instrument Mart, Inc.*
W.S. Jenks & Son*
Jensen Tools Inc.*D 87
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Leader Instruments Corp. 3
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Milo Associates, Inc.*
Omnitron Electronics*
PanSon Electronics*
Phillips ECG
Pioneer-Standard Electronics*
RAG Electronics Inc.*
RNJ Electronics Inc.*D 88
Shogyo
Simpson Electric Co.
Sintec Co.*
Spanta, Inc.
Specialized Products Co.*
A.W. Sperry Instruments, Inc. 33
TIF Instruments, Inc.
Tool Kit Specialists, Inc.
Tool-Tronics, Inc.*
Transcat*
Triplett Corp.
Tucker Electronics Co.*
Yokogawa Corp. of America

METERS, FIELD STRENGTH

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Echosphere Corp.
Electro-Metrics
Electro Rent Corp.*
Electro-Tech Systems, Inc.
Electronics Warehouse Corp.*D 88
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77,79
Shogyo
The Simco Co., Inc.
Spanta, Inc.
Sutton Designs, Inc. Computer
Security Div.
Techni-Tool Inc.*D 64
Tucker Electronics Co.*
**United States Instrument
Rentals*D** 35
Video Midwest & AVC Divs. of Vaughn
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Zenith Electronics Corp. BC

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The Simco Co., Inc.
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Security Div.
Techni-Tool Inc.*D 64
Tucker Electronics Co.*
**United States Instrument
Rentals*D** 35
Video Midwest & AVC Divs. of Vaughn
Communications*
Zenith Electronics Corp. BC

METERS, SIGNAL LEVEL

Accutest Instruments*
Advanced Test Equipment Rentals*
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Deluxe Electronics
Echosphere Corp.
E.I.L. Instruments, Inc.
Electro-Metrics
Electro Rent Corp.*
Electronics Warehouse Corp.*D 88
Genstar Rental Electronics Inc.*
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The Instrument Mart, Inc.*
W.S. Jenks & Son*
Joseph Electronics*D 81
Leasametric IRD*
MCM Electronics*D 54
Milo Associates, Inc.*

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NAP Consumer Electronics Corp.
Omnitron Electronics*
PanSon Electronics*
Philips Test & Measuring Instruments
Pioneer-Standard Electronics*
Racal-Dana Instruments Inc.
RAG Electronics Inc.*
RNJ Electronics Inc.*D 88
Sencore, Inc. 73,75,
77,79
Shogyo
Sutton Designs, Inc. Computer
Security Div.
Tucker Electronics Co.*
**United States Instrument
Rentals*D** 35
Video Midwest & AVC Divs. of Vaughn
Communications*
Wandel & Goltermann, Inc.
WestCon
Zenith Electronics Corp. BC

METERS, SOUND LEVEL

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Accutest Instruments*
AEMC Corp.
Allied Electronics, A Subsidiary of
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**Consolidated Electronics,
Inc.*D** 82
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Electro Rent Corp.*
GenRad, Inc.
The Instrument Mart, Inc.*
W.S. Jenks & Son*
Joseph Electronics*D 81
Kenwood U.S.A. Corp. 65
Leasametric IRD*
NAP Consumer Electronics Corp.
PanSon Electronics*
Pioneer-Standard Electronics*
Projector-Recorder Belt*D 90
RAG Electronics Inc.*
RNJ Electronics Inc.*D 88
Rohde & Schwarz-Polarad, Inc.
Shogyo
Simpson Electric Co.
Transcat*
Tucker Electronics Co.*
**United States Instrument
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Wandel & Goltermann, Inc.
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METERS, VOLTMETERS, AC

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**Consolidated Electronics,
Inc.*D** 82
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C&S Sales*D 61
Echosphere Corp.
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Extch Instruments Corp.
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Global Specialties Mail Order Div.*
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Hand Tool Industries, Inc.
Hewlett-Packard Co.

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HMC-Hub Material Co.*D 85
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Itera/Belmoor
JDR Microdevices*D IBC
W.S. Jenks & Son*
Jensen Tools Inc.*D 87
Joseph Electronics*D 81
J&W Electronics Inc.
Keithley Instruments, Inc. Instruments
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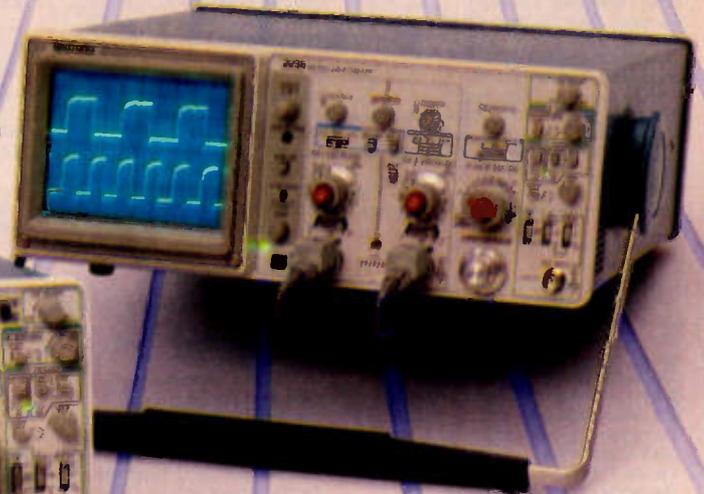
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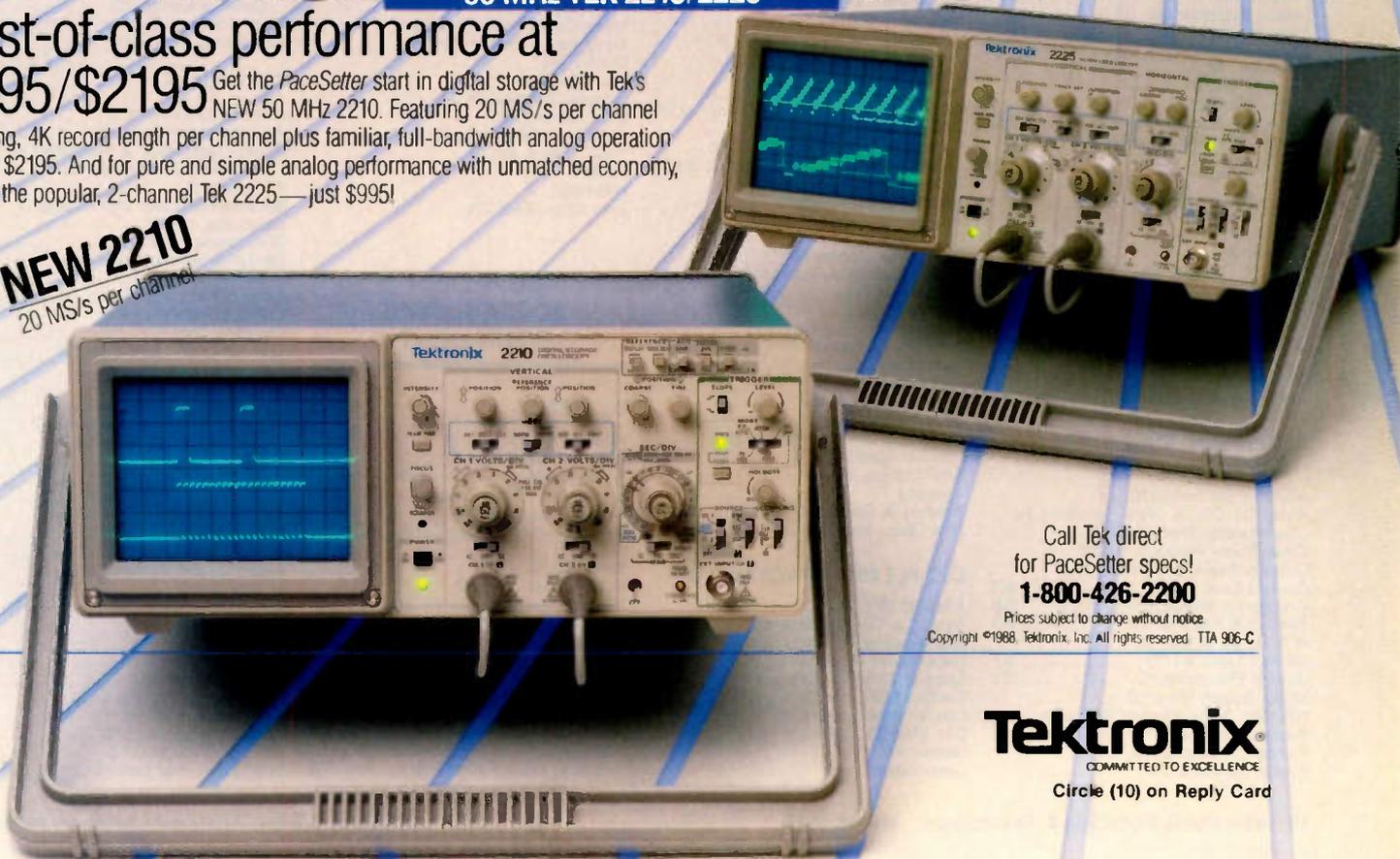
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 Astec Co. Div. of Static Solutions Inc.
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 The Simco Co., Inc.
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 Static Prevention Inc.
 Statikil, Inc.
 Tech Spray, Inc.
 Gregory Thomas, Inc.
 G.C. Thorsen Co.
 Tool Kit Specialists, Inc.
 Tool-Tronics, Inc.*D
 Video Midwest & AVC Divs. of Vaughn
 Communications*D
 Wescorp
Zenith Electronics Corp. BC

**ANTISTATIC IONIZATION
 DEVICES**

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 Charleswater Products, Inc.
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 Plastic Capacitors Inc.
 Plastic Systems, Inc.

The Rex Co.*D
 Semtronics Corp.
 The Simco Co., Inc.
 Start Mfg. Inc.
 Static Control Services, Inc.
 Static Inc. A Sealed Air Co.
 Statikil, Inc.
 Gregory Thomas, Inc.
 3M/Static Control Systems Div.
 Wescorp

**ANTISTATIC MATS/
 BENCHTOPS/
 WRISTSTRAPS/OTHERS**

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 Allied Electronics, A Subsidiary of
 Hall-Mark Electronics*D
 American Static Systems Co.
 (ASSCO)
 Astec Co. Div. of Static Solutions Inc.
 Atrix, Inc.*D
 Chapman Corp.
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 Davle Tech Inc.
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 Formica Corp.
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 Shogyo
 The Simco Co., Inc.
 Dick Smith Electronics*D
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 Specialized Products Co.*D
 Start Mfg. Inc.
 Static Control Services, Inc.
 Static Inc. A Sealed Air Co.
 Static Prevention Inc.
 Tech Spray, Inc.
 Gregory Thomas, Inc.
 G.C. Thorsen Co.
 3M/Static Control Systems Div.
 Tool Kit Specialists, Inc.
 Tool-Tronics, Inc.*D
 Wescorp
 Winders & Geist, Inc.
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ESD FLEXIBLE PACKAGING

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 Astec Co. Div. of Static Solutions Inc.
 Charleswater Products, Inc.
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 Partfolio, Inc.
 Plastic Systems, Inc.
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 Republic Packaging Corp.
 The Rex Co.*D
 Richmond Technology
 Seco Industries
 Semtronics Corp.
 Sentinel Foam Products
 The Simco Co., Inc.
 Static Inc. A Sealed Air Co.
 Gregory Thomas, Inc.
 3M/Static Control Systems Div.
 Tool-Tronics, Inc.*D
 Wescorp

STATIC DETECTION METERS

Abatron Electronics*D
 Astec Co. Div. of Static Solutions Inc.
 Atrix, Inc.*D
 Biddle Instruments
 Chapman Corp.
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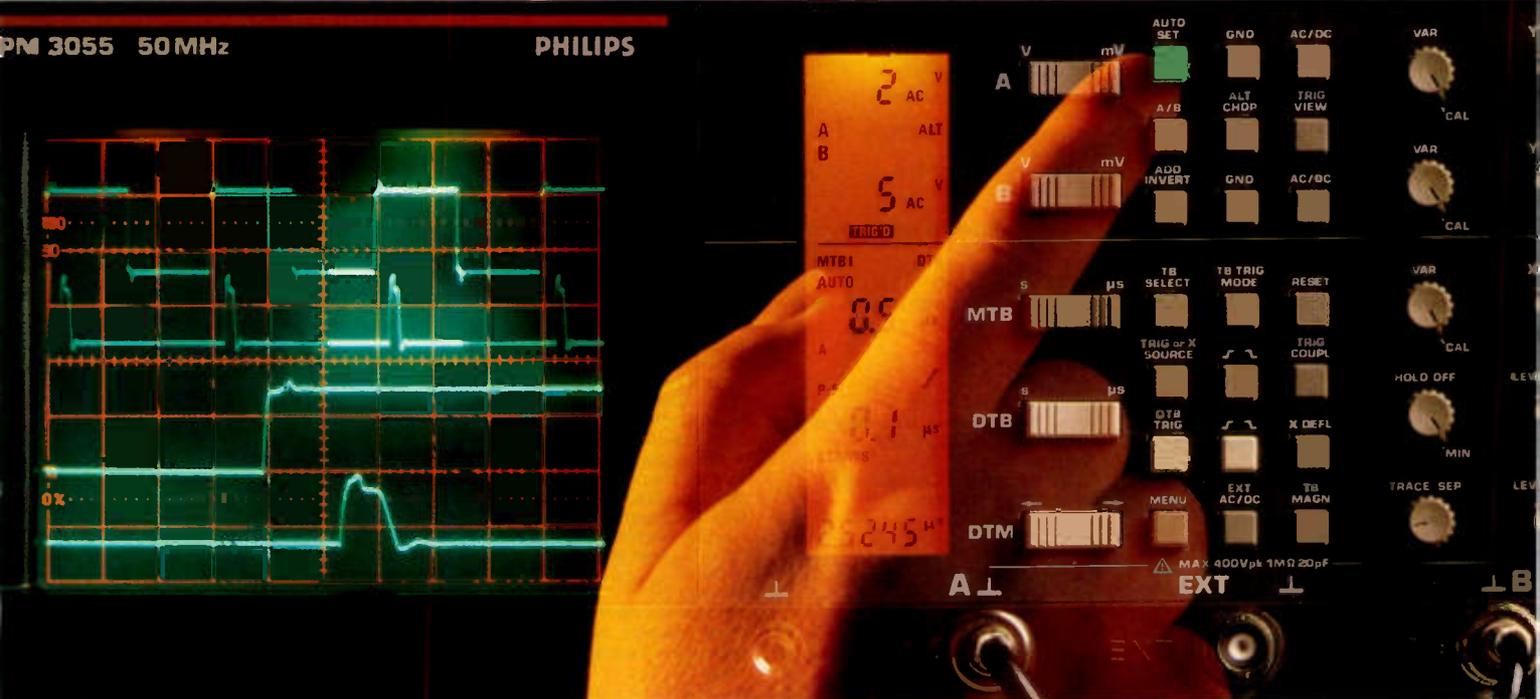
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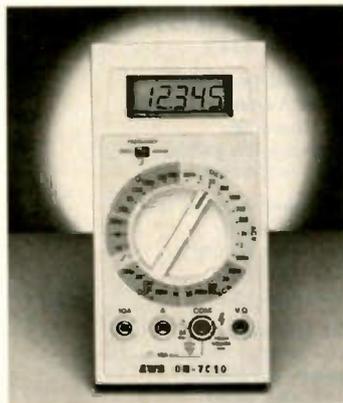
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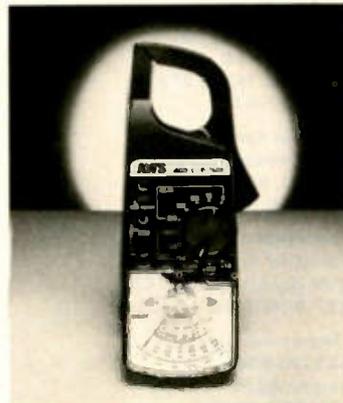
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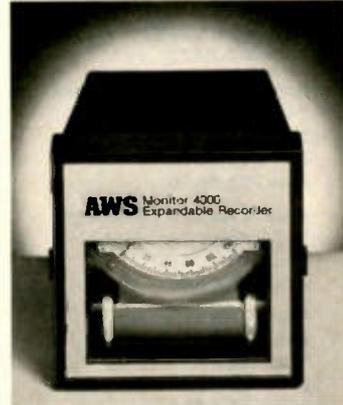
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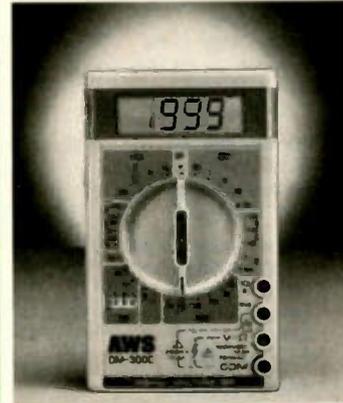
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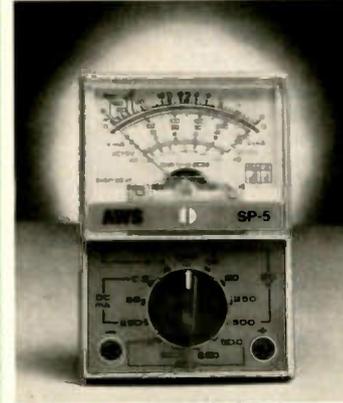
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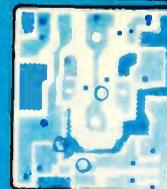
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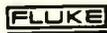
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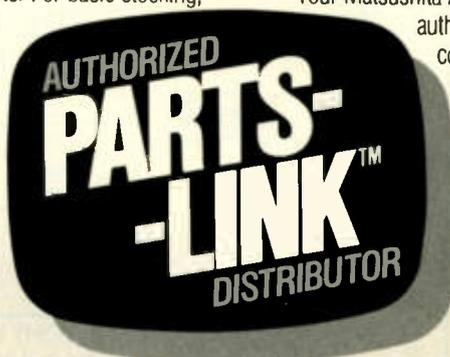
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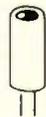
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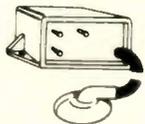


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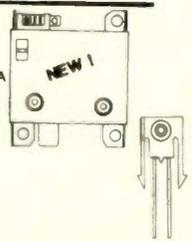
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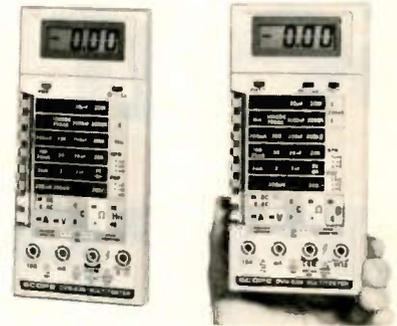


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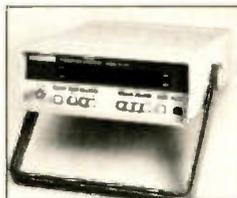
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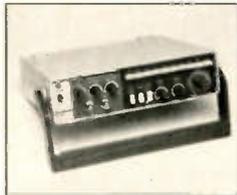
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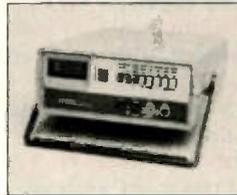
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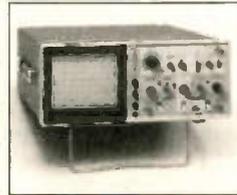
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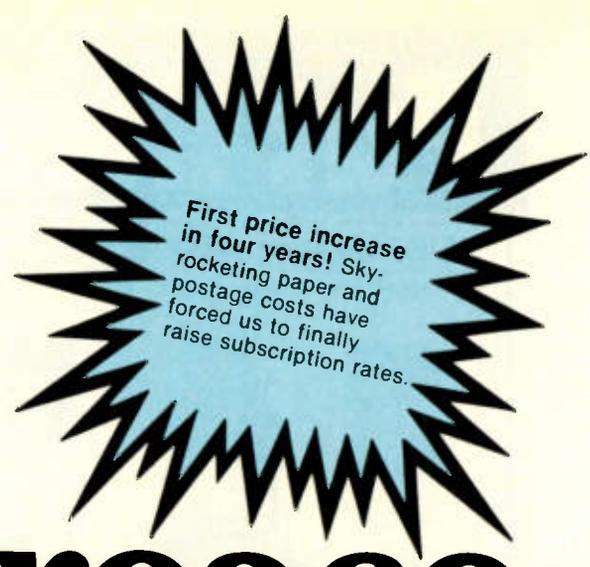
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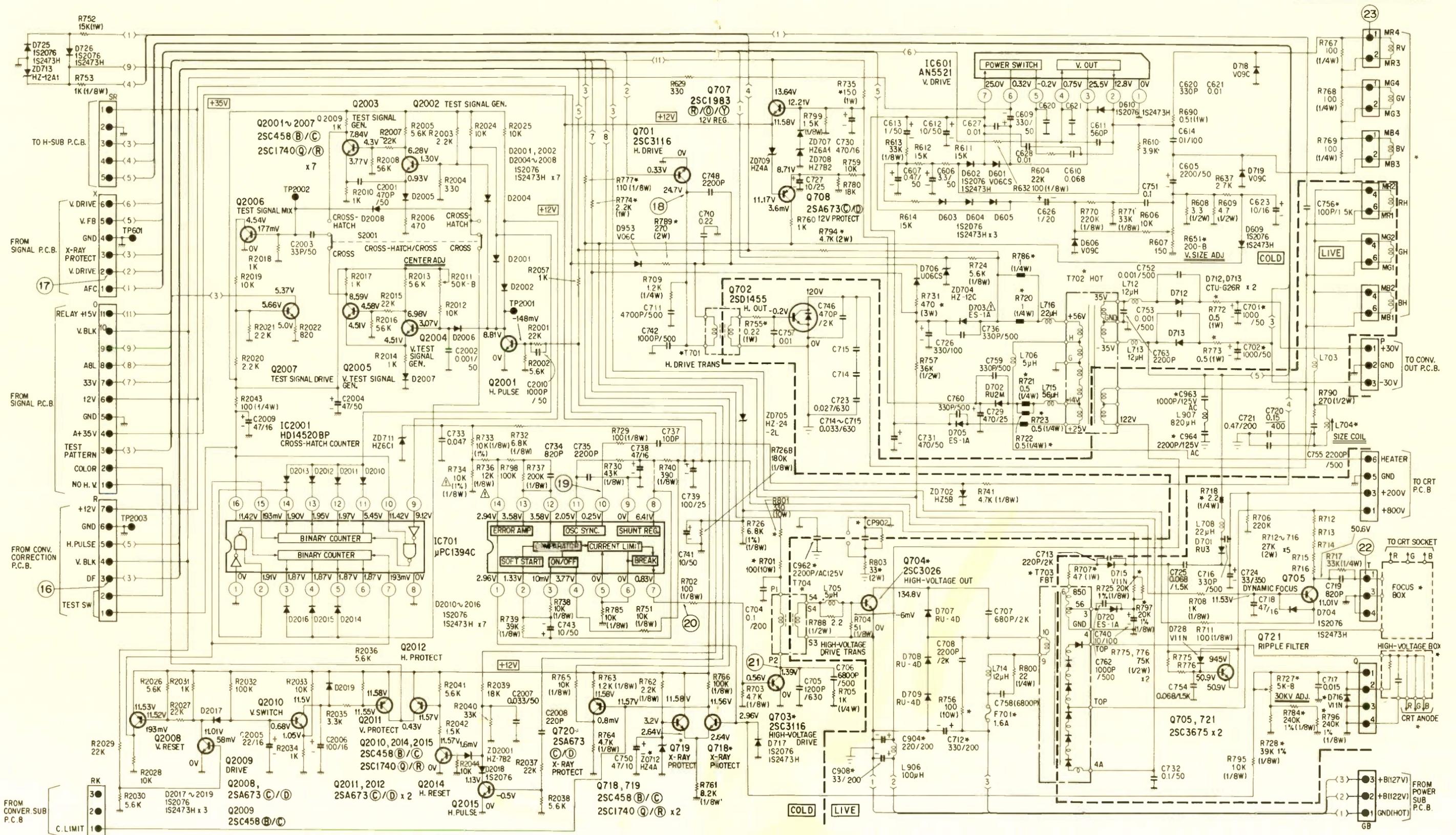
significance. It is recommended that only exact cataloged parts be used for replacement of these components. Use of substitute replacement parts that do not have the same safety characteristics as recommended in factory service information may create shock, fire, excessive x-radiation or other hazards.

This schematic is for the use of qualified

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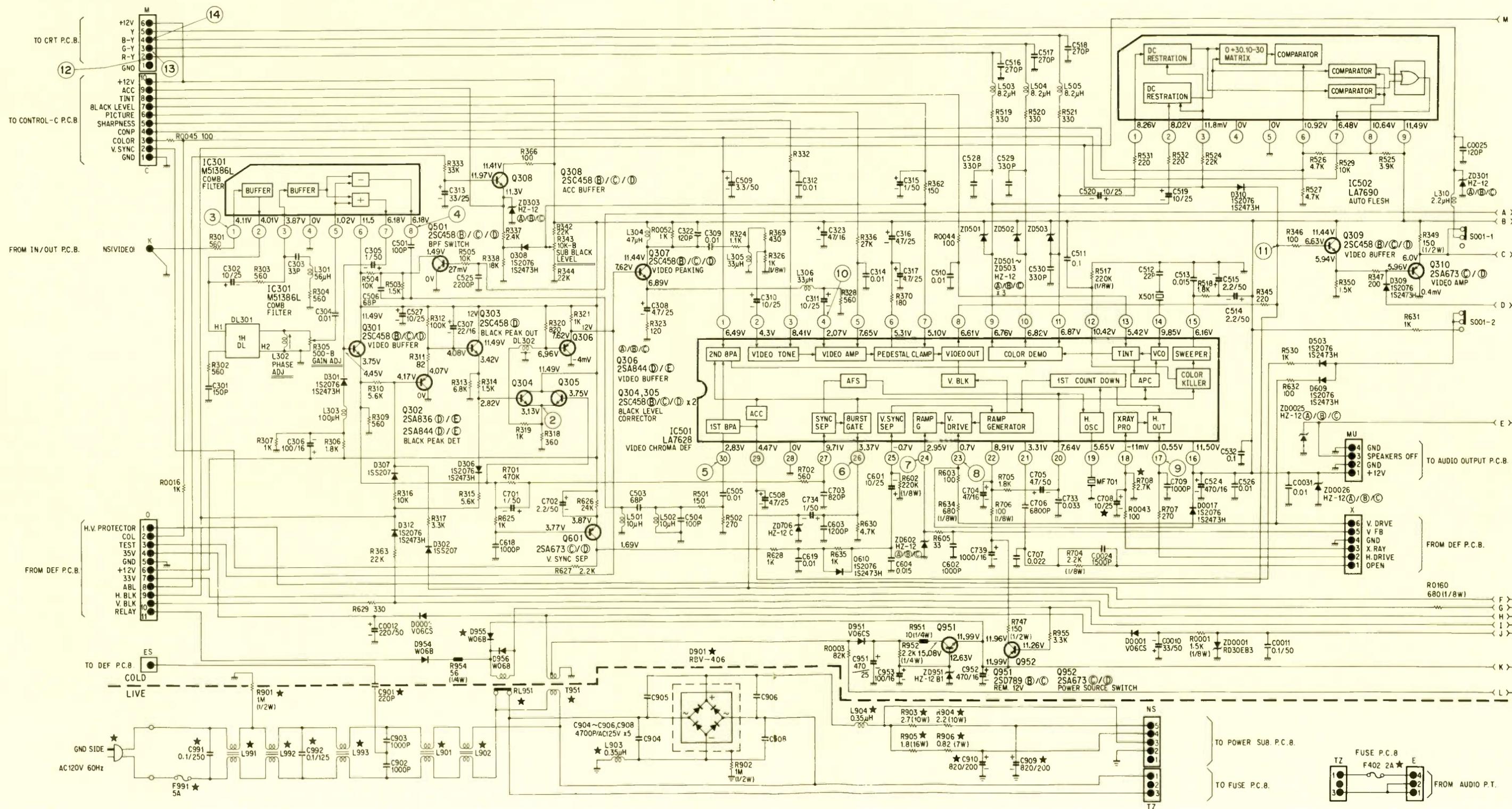
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Callouts next to wiring plugs indicate connections to other schematics.

Note: Resistance not designated is 1/16W.



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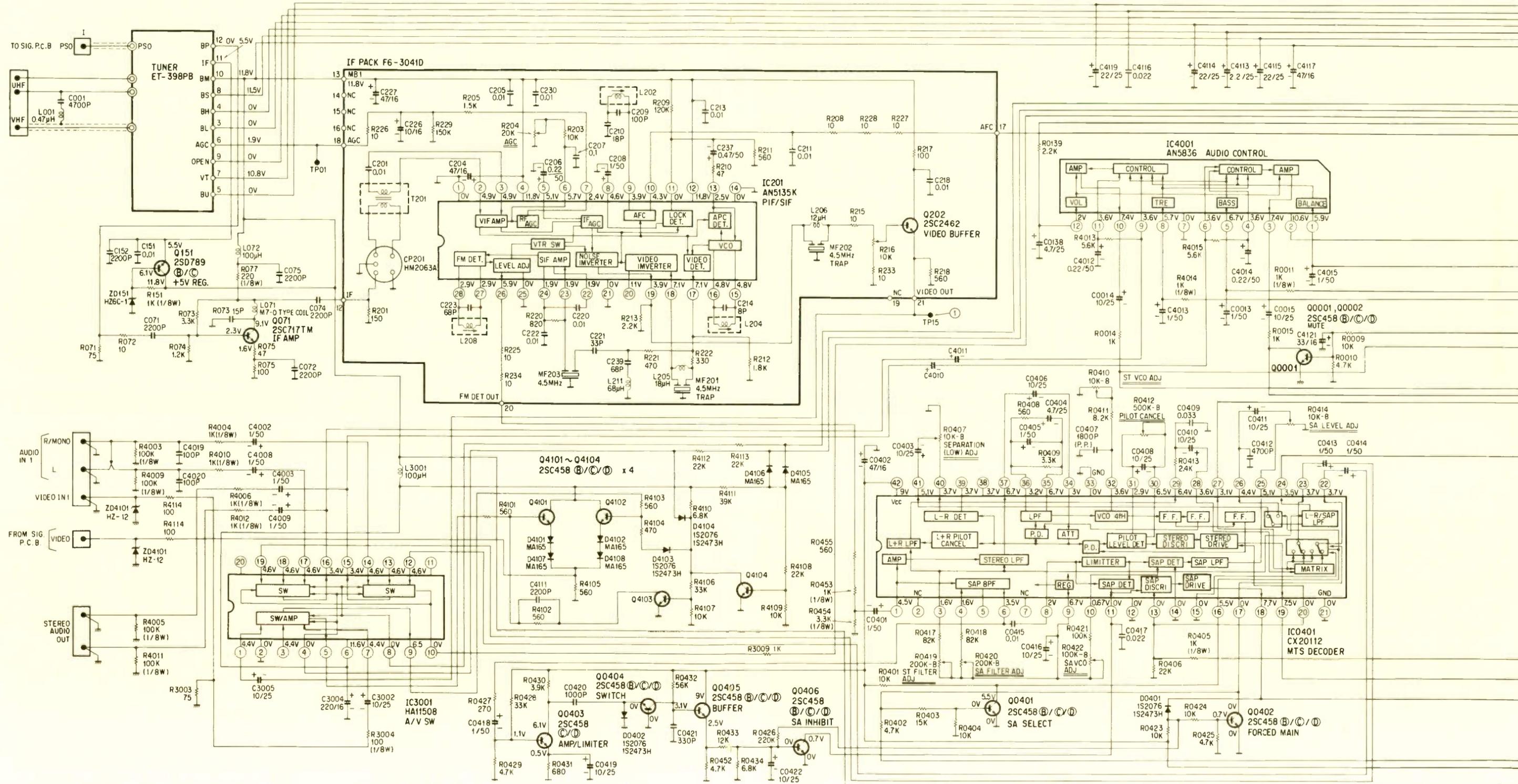
INPUT/OUTPUT TERMINAL SCHEMATIC

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INPUT/OUTPUT TERMINAL SCHEMATIC



...continued from page 38

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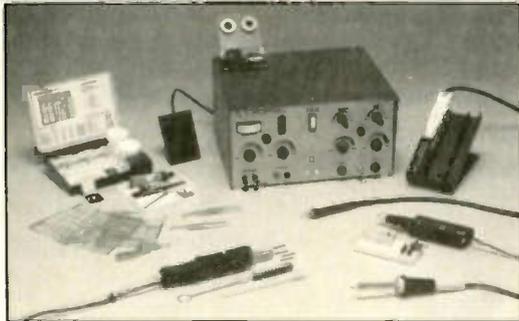
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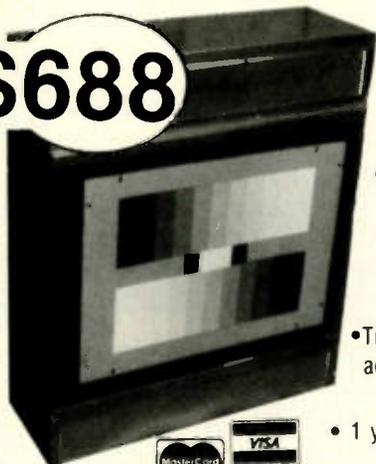
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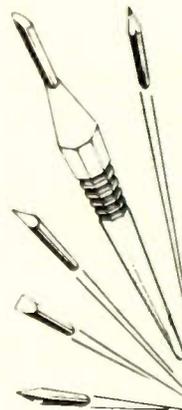
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116	07	06	05	184	30	28	25	319P	24	20	18
123A	14	12	10	185	30	28	25	331	40	38	35
123AP	08	07	06	194	10	09	08	332	40	38	35
125	07	06	05	196	38	34	30	375	45	43	39
128	29	26	23	197	38	34	30	376	48	44	40
129	29	26	23	198	44	39	36	379	1.45	1.35	1.25
152	25	22	18	199	10	09	08	394	1.95	1.85	1.75
153	25	22	18	233	10	09	08	396	75	68	60
154	49	45	40	234	10	09	08	397	75	68	60
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157	38	34	30	262	42	39	36	399	39	36	30
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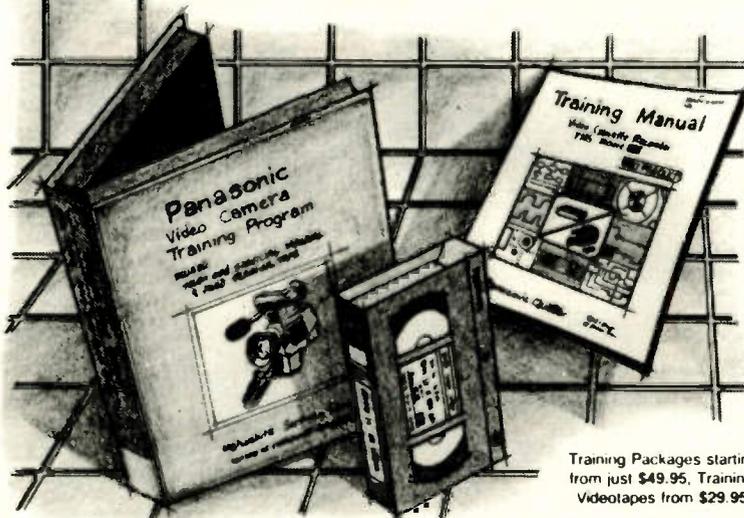
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Circle (29) on Reply Card



Extending DVM ohmmeter ranges

By Art H. Meyerson

If you're in the market for a new digital voltmeter (DVM), you might be thinking about the recent introduction of several excellent, low-priced DVMs with resistance accuracy measurements of 1% or better. The only drawback has been that the highest resistance range has been limited to a maximum of $2M\Omega$.

Meyerson, a former high-school technical electronics instructor, has worked in electronics since 1925.

However, expanding the range to $20M\Omega$ or beyond involves a very simple procedure. (See Figure 1.) You just connect a $2M\Omega$ resistor in parallel with the test leads. Keep in mind that this will be no more accurate than the accuracy of the $2M\Omega$ resistor.

Using the formula

Table 1 is a chart of the resultant resistive readings for the parallel combination of the $2M\Omega$ resistor across the

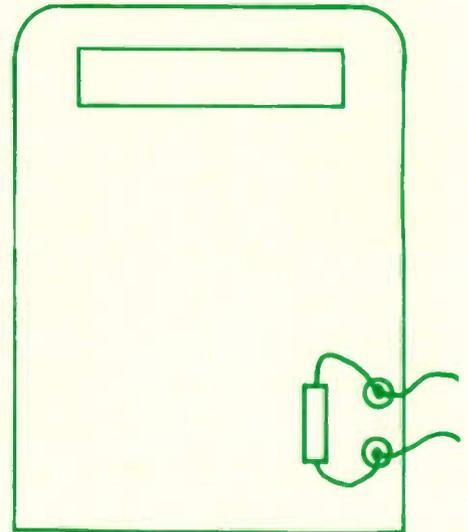


Figure 1. Placing a resistor across the input of an ohmmeter will allow you to extend the value of the largest resistor measurable.

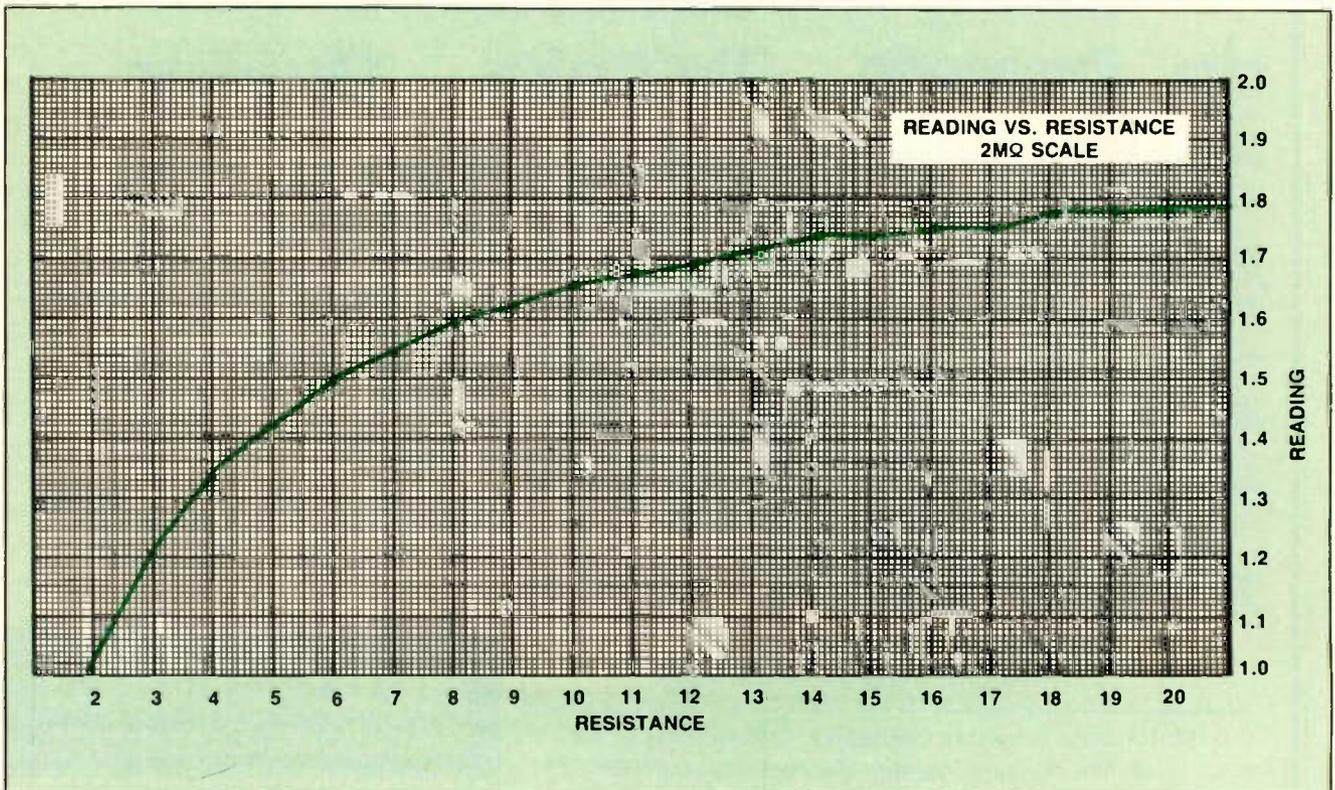


Figure 2. This graph can be used to find the value of resistance for voltmeter readings when the input is shunted by a $2M\Omega$ resistance.

leads in shunt with the unknown resistor. The formula used is simple:

$$R_r = \frac{(R_{2M} \times R_u)}{(R_{2M} + R_u)}$$

where:

R_r is the meter reading

$R_{2M} = 2M\Omega$

R_u is the unknown resistor value.

To reverse the process and find the value of any unknown resistor more than $2M\Omega$ from the meter reading, use the formula:

$$R_u = \frac{(R_{2M} \times R_r)}{(R_{2M} - R_r)}$$

In this case R_{2M} is always $2M\Omega$, so this reduces to:

$$R_u = \frac{(2 \times R_r)}{(2 - R_r)}$$

Here's an example: An unknown resistor is connected across the $2M\Omega$ resistor, which is in parallel with the ohmmeter leads. What is its value? (The reading is 1.5.)

$$\begin{aligned} R_u &= \frac{(2 \times R_r)}{(2 - R_r)} \\ &= \frac{(2 \times 1.5)}{(2 - 1.5)} \\ &= 3/0.5 = 6M\Omega \end{aligned}$$

A graphic solution

Figure 2 shows a graph that can be used to find more accurate readings than is possible with the chart in Table 1. However, the greatest accuracy will be achieved by use of the formula for R_u . This is very simple with any calculator.

Extending readings on the $20M\Omega$ scale

The same approach can be used to extend values on a $20M\Omega$ scale of a DVM. Simply shunt the leads with a $20M\Omega$ resistor and proceed as before. Values above $20M\Omega$ are generally found in high-voltage TV sections. The same chart and graph in Table 1 and Figure 2 can be used. Simply multiply all values by 10.

Using the formula, higher values of resistance than shown on the graph or chart can be determined. For example, assume a reading of $19.5M\Omega$. What is the value of resistance?

$$\begin{aligned} R_u &= \frac{(20 \times R_r)}{(20 - R_r)} \\ &= \frac{(20 \times 19.5)}{(20 - 19.5)} \\ &= 390/0.5 = 780M\Omega \end{aligned}$$

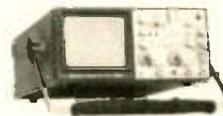
By the same token, the $2M\Omega$ range can be extended to more than $100M\Omega$.

Table 1
Resultant resistive readings

value	reading
3	1.2
4	1.333
5	1.429
6	1.5
7	1.556
8	1.6
9	1.636
10	1.667
11	1.692
12	1.714
13	1.733
14	1.75
15	1.765
16	1.778
17	1.789
18	1.8
19	1.81
20	1.818
22	1.833
24	1.846
26	1.857
28	1.867
30	1.875
32	1.882
34	1.889
36	1.895
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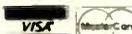
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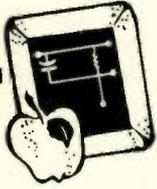
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Circle (30) on Reply Card



Troubleshooting the op-amp

By Christopher H. Fenton

Since the first op-amps appeared 20 years ago, their performance characteristics have improved dramatically. Because of their overall versatility, low cost and ease of use, op-amps—which are basically very efficient, high-gain dc amplifiers—have become one of the most widely used linear integrated circuits available today. When combined with other microchips and discrete components, they have become one of the fundamental building blocks of the computer age. A casual look through a VCR service manual revealed several op-amps: one in the capstan motor control circuit, one in the servo system and a

Fenton is the circuit fabrication consultant for ES&T.

couple in the cylinder control system.

Op-amps originally were high-gain amplifiers designed to perform mathematical computations such as addition, subtraction, multiplication and division. They could economically solve calculus problems, but they were extremely large, and they operated at high voltages, sometimes in excess of 300V. Modern op-amps inherit the name, but they work at lower voltages and are smaller and easier to use than their dinosaur ancestors.

Basic principles

An op-amp is basically a high-gain, direct-coupled inverting amplifier. (See Figure 1.) The triangle is used to repre-

sent the inverting amplifier and is defined by the equation $e_{out} = -Ae$. The equation means that the output voltage between the output terminal and summing junction will be A times as large as e. A is typically between 80dB and 160dB. In a micro-chip package, e_{out} will rarely be more than $\pm 10V$. As a result, e cannot be greater or less than $\pm 10V/10^8$ (160dB) or $\pm 0.1\mu V$.

Because this voltage is so slight, the full input voltage, e_{in} , is applied through the input impedance Z_{in} , while the total amplifier output voltage e_{out} will be applied through the feedback impedance of Z_{out} . The input current, I_{in} , is expressed as $I_{in} = e_{in}/Z_{in}$. The feedback current, I_f , is expressed by the

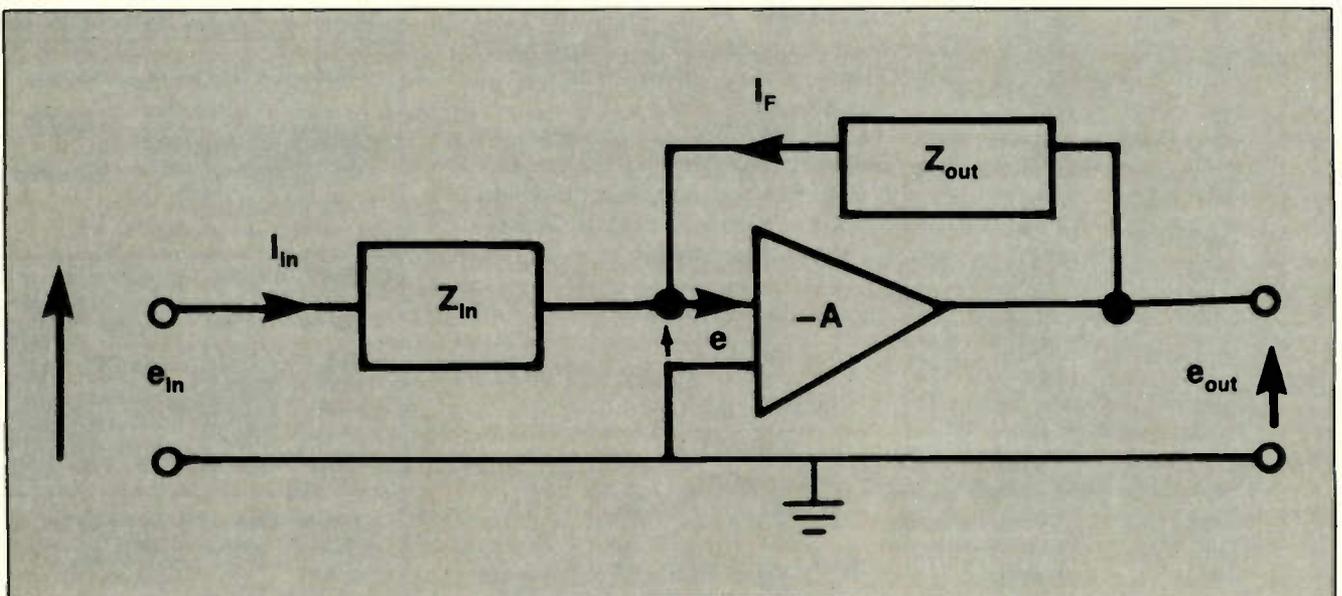


Figure 1. An op-amp basically is a high-gain, direct-coupled inverting amplifier. The gain of the amplifier, which is represented by the triangle, is defined as $e_{out}/e_{in} = Z_{out}/Z_{in}$.

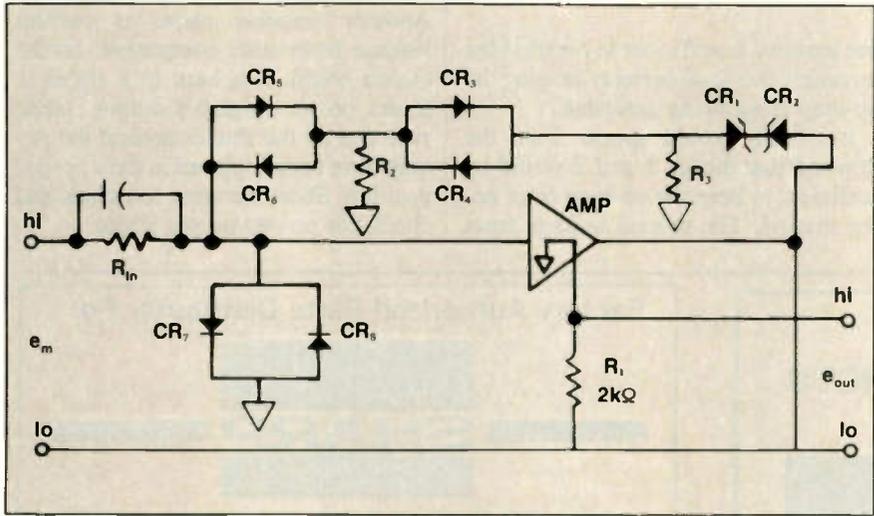
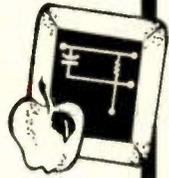


Figure 2. In a typical overload protection circuit, CR1 and CR2 prevent the input voltage from exceeding preset limits. Diodes CR3, CR4, CR5 and CR6 channel the reverse leakage to ground.

equation $I_f = e_{out}/Z_{out}$. The op-amp circuit's gain is therefore determined by the following equation:

$$\text{Gain} = \frac{e_{out}}{e_{in}} = \frac{-Z_{out}}{Z_{in}}$$

The gain of an op-amp can be changed or stabilized by varying either the input or feedback resistance. To make an op-amp with a precise gain, it is necessary to attach stable resistors to the input and feedback terminals. Gain is independent of the op-amp's open-loop gain, $-A$, and is determined by the ratio of R_f and R_{in} . A variable gain op-amp can be created simply by varying either the input or feedback resistance. Gain stability is determined by the

stability of the input and feedback resistors.

Overload protection

Op-amps are designed with ample overload protection to prevent transistor damage that could occur when the amp overloads because of saturation. Overload protection prevents the ac coupling capacitors from charging, keeping the transient recovery time of the device to a minimum of about 20 μ s.

In a typical overload protection circuit (Figure 2), input diodes 1 and 2 prevent the input voltage from exceeding preset limits, protecting the input transistors. Both diodes 1 and 2 are Zener diodes and have nominal breakdown voltages. Therefore, whenever the input

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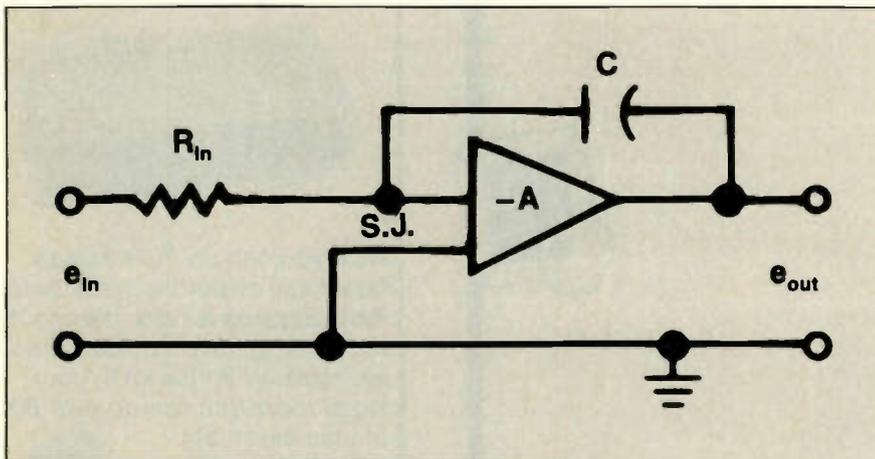


Figure 3. To track down hum, drift and noise, replace the feedback capacitor between the output terminal and the ground with a stable resistor (R_f) that has a value about 10 times greater than R_{in} .

signal exceeds the preset parameters, either diode will breakdown. Feedback current from the output terminal can't flow back to ground unless either diode 3 or 4 and either 5 or 6 are turned on. When the output current reaches its preset level, the current from the out-

put terminal is sufficient to override the incoming overload current, keeping the op-amp from being saturated.

It initially would appear from the drawing that diodes 1 and 2 would be sufficient to keep the op-amp from being toasted. The reverse leakage from

diodes 1 and 2 inputs directly into the summing junction of the op-amp. The four remaining diodes channel the reverse leakage directly to ground.

Troubleshooting

A total failure of a well-designed op-amp is rare because input overloads never saturate the circuit. However, the most common problems associated with an op-amp are hum, drift and noise. The primary cause of hum and ripple problems is the dc power supply providing the power to the op-amp. Another possible cause is current leakage from other components on the circuit board. If a hum or a ripple is found on an op-amp's output, make sure that all the shields around the op-amp have been replaced in their proper position. Short the input terminals and check for power supply ripple.

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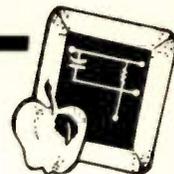
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Drift and noise problems are the most common sources of trouble. There are several possible causes of this kind of trouble—unstable power supplies are the most likely cause. Op-amps are extremely sensitive to an unstable power supply. A power supply should not drift more than $\pm 1\text{mV}/\text{min}$ on a typical dual power-supply voltage of $\pm 15\text{V}$. A digital voltmeter that registers to five or six places should be used to measure the stability of a power supply.

Another source of output noise in an op-amp is the zero-correction circuit. This circuit takes voltage from both the positive and negative power supplies and inputs a small dc current to compensate for the internally generated offset. Zener diodes, often used to regulate the zero-correction supply voltage, should be checked for drift and noise. Such adverse signals are input into the

op-amp at a point of high gain.

Because of their extremely high open-loop gain, op-amps can be difficult to troubleshoot. One way to track down hum, drift and noise is to replace the feedback capacitor between the output terminal and the ground (see Figure 3) with a stable resistor R_f that has a value of about 10 times greater than the input resistance R_{in} . The op-amp's output terminal can be checked with a digital voltmeter for dc drift. A high-gain scope can be used to check the output terminal waveform.

Another test that can be done while the feedback resistor is in place is a check of the zero-adjust circuit and the clipping level of the diode protection circuit. Short the amplifier input terminals and vary the coarse zero-control parameters while measuring the amp's output with a digital voltmeter. For each

change in the zero-control parameters, there is a corresponding change in the output voltage. Check the stability of the output voltage during each step.

The range of coarse zero control sometimes is not enough to limit the amp's output with just the protective overload circuitry. If it isn't, a highly stable current should be applied to the input terminals. Watch to see that limiting occurs within the required parameters for both polarities of the input voltage.

A discrepancy between the positive and negative overload breakdown voltage indicates either an open or a shorted diode in the overload protection circuit. In that case, replace the diode. If that doesn't cure the problem, saturation is taking place within the chip itself and the op-amp should be replaced.

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Circle (34) on Reply Card



Creating resistor values

You need a certain resistor value, but it's not on hand? Use this simple formula to find the correct parallel resistance.

By Art H. Meyerson

Every technician has encountered the problem of creating a resistance value that isn't on hand. Sometimes the resistor needed is a non-standard value. Another problem is that many of the new circuits call for close-tolerance values of 5% or better. These problems are now easily solved with the advent of the DVM. Even the lower priced DVMs have resistance scale readings that are accurate to 1% or better, and the DVM's numerical readings ensure high reading accuracy.

Sometimes the correct value can be achieved by series-connecting resistors. More often, the correct value can be more closely achieved by parallel connection of resistors. (See Figure 1.) Space considerations, particularly on a printed circuit board, also lend themselves more readily to parallel connection.

Finding parallel resistances

For a parallel connection, the applied formula is very simple:

$$R_p = \frac{R_s \times R_d}{R_s - R_d}$$

where

- R_p = the parallel resistance
- R_s = the stock resistance
- R_d = the desired resistance

Meyerson, a former high-school technical electronics instructor, has worked in electronics since 1925.

Because parallel resistances always combine to give a resistance less than either of the individual resistors, the stock resistor must always have a higher value than the desired resistor.

As an example, let's say you need a 500Ω resistor as a replacement, but the nearest resistor you have is a 680Ω resistor. What value of resistor do you have to find to place across it to get 500Ω?

$$\begin{aligned} R_p &= \frac{(680 \times 500)}{(680 - 500)} \\ &= 340,000/180 \\ &= 1.888\Omega \end{aligned}$$

There aren't any standard resistors

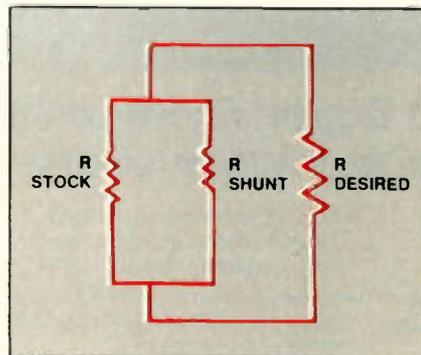


Figure 1. Connecting resistors in parallel allows the technician to create a non-standard resistor value or substitute for a value that is not on hand.

with a value of 1,888Ω, so if you used a 2,000Ω device, the error in resistance value would be (solving for R_d):

$$\begin{aligned} R_d &= \frac{(R_s \times R_p)}{(R_s + R_p)} \\ &= \frac{(680 \times 2,000)}{(680 + 2,000)} \\ &= 507\Omega \end{aligned}$$

This value is 7/500 or 1.4% higher than the specified value. Considering that the tolerance of most resistors is 5% (unless Murphy's law is operating here and both resistors are 5% over their nominal value), we probably have a parallel combination that will work very well.

Substituting for nonstandard resistors

This method is especially useful for resistor values that are not standard, such as those used in meters. For example, suppose the resistor value needed is 95Ω at 1% tolerance, or 95Ω ±0.95Ω. Let's say you have a 100Ω resistor in stock. The paralleling resistor needed is:

$$\begin{aligned} R_p &= \frac{(R_s \times R_d)}{(R_s - R_d)} \\ &= \frac{(100 \times 95)}{(100 - 95)} \end{aligned}$$

Rules for parallel connection

Whenever you create a parallel combination of resistors to replace a resistor, keep these things in mind:

- The stock resistor you start with must measure more than the desired resistance. For instance, in the example above we started with a 100Ω resistor to get a 95Ω combination.

- The actual *measured* resistance of the stock resistor should be used in the formula. For example, if the stock resistor measures 110Ω, use that value even if its nominal value as read on the color code is 100Ω.

- Use a value of stock resistance as close as possible to the desired value of resistance, but higher. For example, if the desired resistance is 95Ω, start with a stock resistance of 100Ω, if you have one, and determine from the formula what value of paralleling resistance you need.

$$= 9,500/5$$

$$= 1,900\Omega$$

A 2,000Ω resistor in parallel with the 100Ω resistor will give a resultant resistance of:

$$R_d = \frac{(2,000 \times 100)}{(2,000 + 100)}$$

$$= 95.24\Omega \pm 0.95\Omega$$

or a maximum value of 96.19Ω, which would be about 1.3% greater than the nominal value.

Again, assuming that the combination of resistors behaves as it should and that the tolerances don't add in the positive direction, the parallel combination will probably be within the required tolerance. If you check most resistors, you usually will find a wide variation from their nominal values. As an example, if you check 20% 100Ω resistors, you'll find values from 80Ω to 100Ω. This must be taken into account when you determine the value of paralleling

resistance in order to make up combinations.

One final bit of advice: If you don't have one, invest in a simple calculator. You'll find it invaluable in computing these formulas.

Editor's note:

Here's something else to keep in mind: When you're replacing resistors, always use a replacement of the same or closer tolerance. Some people think that if they find, say, a 20% 100Ω resistor that measures exactly 100Ω on the DMM, then they can use that to replace a 100Ω resistor of a tighter tolerance. Not so. That tolerance percentage tells you how far the resistor value will vary from its nominal value (the value on its color code) under normal operating conditions (unless it fails, of course).

That means the 20% resistor that you measured to be exactly 100Ω in March 1988 might read considerably more or less in March 1989. A 1% tolerance resistor under the same conditions won't read higher than 101Ω or lower than 99Ω.

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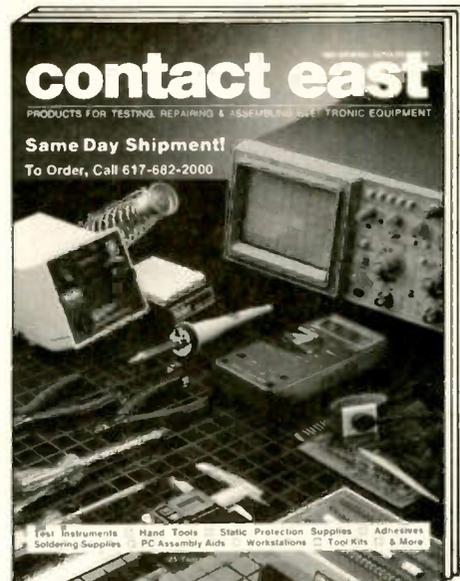
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Circle (36) on Reply Card

Servicing J.C. Penney vertical problems

By Homer L. Davidson

Although most of the vertical-output circuits in J.C. Penney televisions look alike, they are different in many vital areas. Transistors fail in all models, but some develop open resistors, others have shorted capacitors and a few develop leaky diodes that stop the vertical deflection. The circuits of each receiver are different, so the servicing of each cannot be exactly the same. That is why you should develop a sequence of tests; the hit-or-miss method is very inefficient. Becoming familiar with the symptoms of malfunctioning vertical systems in J.C. Penney models should give you helpful ideas for other models and brands.

Vertical sweep problems

Most of the malfunctions that occur in TV sets can be traced to the power supply and horizontal circuits. The next

Davidson is the TV servicing consultant for ES&T.

most common source of problems is the vertical system. Some symptoms of vertical malfunctioning:

- a TV picture that consists of nothing but one white horizontal line (zero vertical sweep);
- poor linearity, particularly at the top or extreme bottom;
- insufficient height;
- intermittent height;
- half of the picture missing.

Almost all vertical problems can be solved if you use an oscilloscope and a digital multimeter (DMM). The scope traces the signals and shows the waveforms; the DMM provides accurate voltage and resistance measurements, as well as a voltage-drop test for diode/transistor junctions. A capacitance tester is helpful, particularly if it is the digital type that has high accuracy.

In some cases, paralleling a capacitor suspected to be defective with a new one

of the same rating is a better test for capacitance and ESR; any improvement indicates that the old capacitor is open. However, the paralleling trick does not work with a leaky capacitor because its leakage is in parallel with the new capacitor. To check capacitor leakage, the suspected capacitor must be disconnected from the circuit during the leakage test.

Although many components in the vertical circuit can cause loss of height, transistors are responsible for most vertical problems. Resistors also produce many vertical-deflection defects. Capacitors and various voltage sources account for most of the other problems. Another class of defect includes broken or cracked circuit boards. Another symptom, erratic height or total loss of height, can be caused by poorly soldered connections.

Integrated circuits (ICs) rate a separate mention because they are difficult to test. ICs cannot be tested the way transistors are tested. With these devices, you are limited to using scope tests to detect the presence of proper output signals, and testing the B+ for voltage analysis.

Vertical background

The model 685-2060 color receiver includes the IC501 countdown IC, which (among other functions) supplies both vertical and horizontal low-level drive signals that replace the vertical- and horizontal-oscillator adjustable signals supplied in the older models. The countdown frequencies are extremely stable.

This countdown type is an excellent system. When the vertical is locked, the horizontal usually is also locked correctly. If the horizontal-output signal is normal but the vertical is not functioning (showing a white line), the IC usually is normal, and the problem is located somewhere else in the vertical circuit. Notice the word *usually*, but don't bet on it. There are exceptions.

One 685-2060 receiver showed only

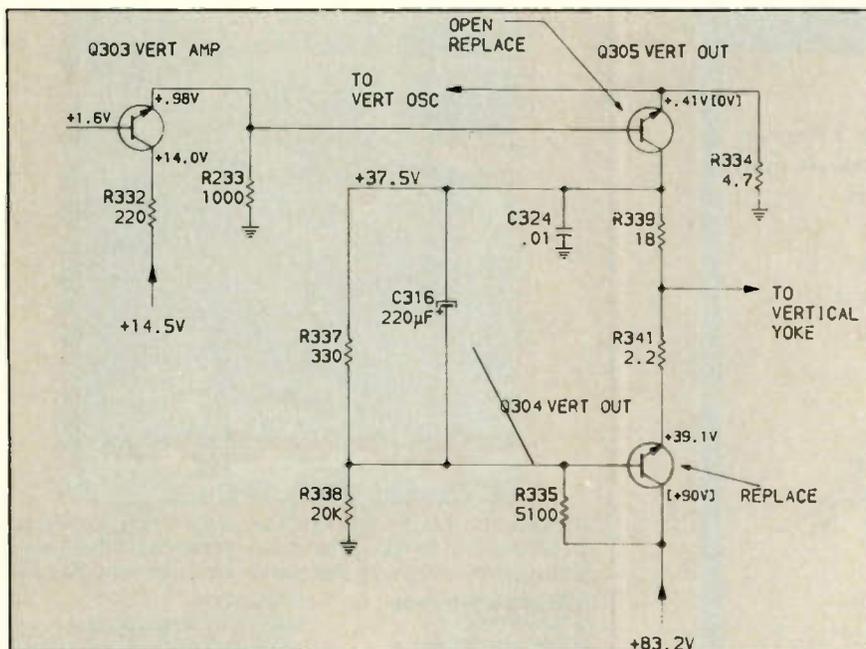


Figure 1. A simplified schematic for the model 685-2010 vertical-output stage. Although at a non-critical glance most of these models appear to have similar schematics, there are vast differences in the details. Note that the voltages shown in brackets are the readings that were obtained while the vertical was not working.

the classic single, bright horizontal line on the screen. All quick tests (such as voltage and resistance) were made on the output transistors of the vertical-deflection circuit, but no defects were discovered. Next, scope waveforms revealed normal horizontal-drive signals at IC501 pin 8, but zero vertical signal at pin 12. Of course, the vertical system cannot operate without an input signal.

The dc voltages at the IC501 terminals measured approximately the correct values. This usually indicates that the IC is not defective and should be working. After several additional fruitless tests, I replaced IC501 with a universal SK9248. When power was restored, the screen lighted with a full raster. A few minor adjustments finished that job.

Vertical sweep missing

In so many cases, a total lack of vertical deflection produces a single white horizontal line. The vertical system usually is arranged so one transistor deflects the top part of the raster and another transistor deflects the bottom. Without sweep, the vertical is not sweeping either the top or bottom areas of the screen. Most no-height symptoms are caused by open or shorted output transistors. Incorrect voltage or a lack of voltage from the power supply also can cause the loss of height. A loss of vertical-oscillator waveform or a defective feedback circuit also can cause a no-vertical symptom.

Try to scope vertical waveforms at the vertical oscillator and the driver circuit. Measure the collector voltage at the metal top of each power transistor. (See Figure 1.) Under normal operating conditions, one transistor will have a high

voltage, perhaps +83.2V, and the other will have a low +0.41V. If these voltages are measured in a receiver, the vertical-output stage is operating normally.

In a 685-2010 portable receiver, no voltage was measured at the collector of Q305, and higher-than-normal voltage was measured at the collector terminal of Q304 (+90V). These readings indicate that the vertical-output stage is malfunctioning. At this point, it is not clear how many transistors are defective.

A quick junction test of Q305 with the DMM indicated an open transistor. Q304 tested normal in circuit. However, whenever you locate a defective vertical-output transistor, whether open, shorted or leaky, even if the other transistor tests normal, always replace them both. You might save yourself from having to do the job over again later to replace the other transistor. In this case, both transistors were the same type and number and were replaced by two universal ECG-291 transistors. After they were installed, the picture covered the entire screen.

Another white line

On a model 685-2012A set, the symptom was again a single white, bright horizontal line in the center of the screen. (Figure 2 shows the schematic.)

Collector voltages of both power transistors were higher than usual. The transistors were tested in circuit for open or leaky conditions, but they tested normal. Next, they were removed and tested out of circuit. Again the test results were normal. Finally, I connected a DMM to one transistor with clip leads while alternately applying heat and coolant spray. Then I tested the

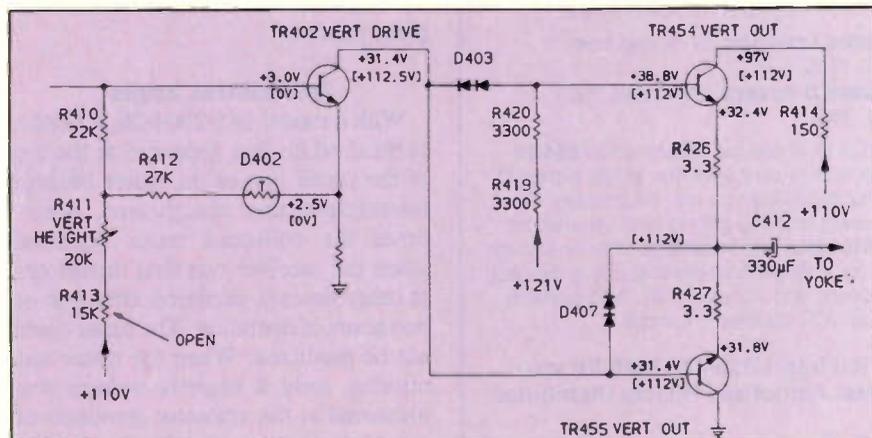


Figure 2. Although at first glance this 685-2012A schematic appears to be similar to the schematic in Figure 1, there are major differences. Trace the dc-current path through the two output transistors, for example, making note of the entrance of B+ and the emitter and collector connections. Each model is different.

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other transistor in the same way. Both showed normal reaction to temperature changes.

Because power transistors sometimes break down under full voltage, I replaced both. The horizontal line remained. Next, I tested the D403 and D407 bias diodes when TR454 and TR455 transistors were removed. Both diodes were in good condition. I measured the bias and base resistors, but that didn't reveal a defect.

I checked the vertical-driver transistor (TR402) in circuit again and performed accurate voltage measurements. The collector dc voltage was +112V instead of the specified +31.4V. Both the emitter and base of TR402 measured 0Vdc; the base should have measured about +3V and the emitter should have measured about +2.51V. In the output stage, TR454 had the same +112V reading at base, emitter and collector. This was beginning to sound like a

hopeless case. But the driver stage is direct-coupled to the two output transistors, so the driver stage is the one to begin testing and analyzing. Then the output stages may follow automatically.

Back at the driver stage, both base and emitter receive dc voltage from the same source (through R413, the height control, R410 or R412/T402) and to base or emitter. Then both share R418 to ground. A voltage measurement at the vertical-height control showed no voltage. Only two resistance readings were needed to prove that R413 was open. Installation of a new 15k Ω resistor and a few minor adjustments produced a good picture with full vertical deflection.

No vertical output

Incorrect dc voltages at the collector pins of Q603 and Q601 in a model 685-2067 with no vertical indicated that the problems were in the vertical-output circuits.

According to the schematic, both Q603 and Q601 collector voltages were much higher than normal. In fact, both were the same +37.5V, which is incorrect. Base and emitter voltages of Q601 measured too high. However, the IC501 apparently was supplying the vertical drive signal at pin 1.

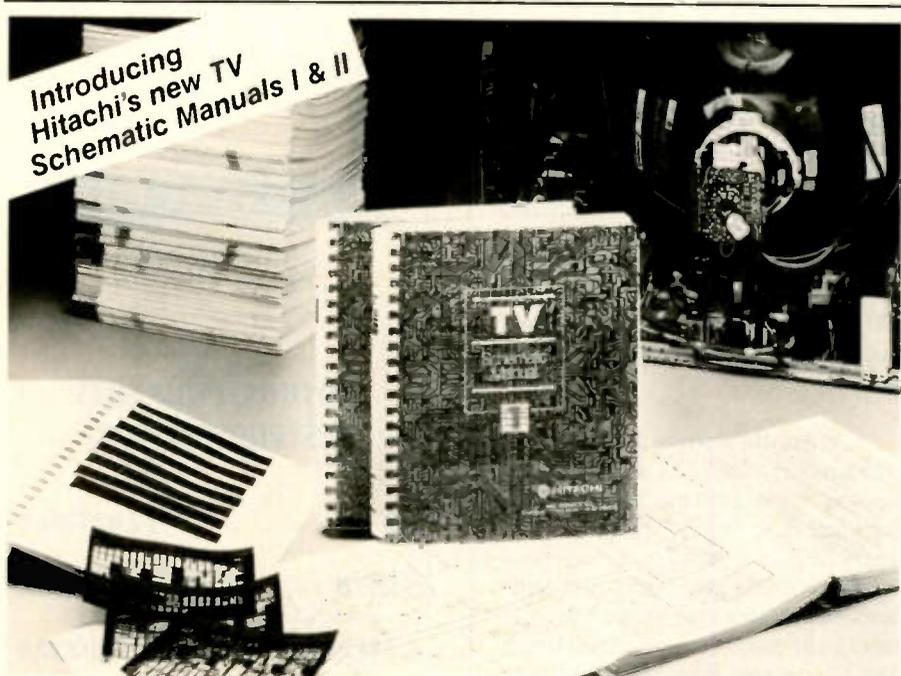
I tested Q601 and Q603 in circuit using the junction test of the DMM. Q601 appeared to be normal, but Q603 tested open. Both transistors were removed from the circuit and tested alone out of circuit. Q603 was open and Q601 was leaky. Both transistors were replaced with ECG375 universal types.

In this example, accurate voltage measurements helped locate the defective transistors and brought back a complete picture.

Intermittent height

With a model 685-2004-20, a bright, vertical white line appeared at the top of the raster just as the raster became intermittent, then disappeared. Sometimes the collapsed raster occurred when the receiver was first turned on; at other times it occurred after one or two hours of operation. The onset could not be predicted. When the raster was missing, only a negative voltage was measured at the collector terminals of the vertical-output transistors. (See the schematic in Figure 3.)

At IC530, both horizontal and vertical countdown waveforms were normal. All



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five transistors of the vertical system were checked in circuit with a DMM's junction-voltage-drop test and were found to be normal. Leakage was tested, as much as is possible in circuit.

Intermittent problems often can be triggered on or off by applications of canned coolant. This time it did not help.

Four different dc-voltage supplies provide power for these five vertical transistors: $-9.17V$, $+8.75V$, $+11.74V$ and $+145V$. Because these vertical stages are direct-coupled, any change of voltage anywhere probably will change the dc voltages in all the vertical stages. This makes voltage analysis very difficult. Nevertheless, try simple voltage analysis first. It can be helpful.

During normal operation, I checked and wrote down the dc voltage measured at the collectors of the two output transistors (and a few other transistors). After the raster collapsed, I measured those same points again, writing down the voltages. There was no $+8.75V$ supply at two points in the vertical sweep circuits. Because of the intermittent nature of the problem, it was difficult to test the $+8.75V$ supply. Finally, it became plain that $470\mu F$ filter capacitor C947 was intermittent. Horizontal power from the flyback pin 6 (with ground at pin 5) is rectified by diode Y946 and filtered by C947. Peak-reading by C947 also makes the horizontal power relatively constant. Therefore, an open C947 reduced the positive dc voltage to almost zero with some horizontal-sweep hash added. A new C947 capacitor solved the problem.

Top of picture missing

Only about 4 inches of picture (vertically) could be seen below the center line and nothing above the center of a 685-2020 portable (Photofact 1792-1). The principal loss of height usually is caused by transistors in the vertical-output channel labeled "top output" (for top of the picture) and "bottom output" (for height at the bottom 50% of the picture).

In this case, output transistors Q22 (bottom) and Q24 (top) tested good in circuit. (See Figure 4 for the schematic.)

Next, I checked Q19 (switch driver) and Q20 (retrace switch) for the top channel. Both tested leaky in circuit. They were removed, tested again to verify the leakage and then replaced.

Even with the new transistors,

however, the receiver operated normally for a few minutes and then the raster collapsed into the single horizontal line. The Q20 retrace switch was extremely hot. At first this indicated a flaw in the replacement, so another replacement was installed. Q20 continued to get extremely hot.

Accurate dc voltage measurements on a DMM were made at each transistor. The voltages deviated from the schematic by a volt or less; therefore,

some component must be breaking down under load.

Once again, I tested all six transistors in circuit, finding no defects. Diodes CR103, CR104 and CR105 were checked for opens and leakages next. Finally, I checked all resistors for opens or any increases of resistance. R117, specified to be $220k\Omega$, tested open. This was what was causing Q19 and Q20 to overheat and short. Because R116 is known to be a frequent cause of trouble in this set,

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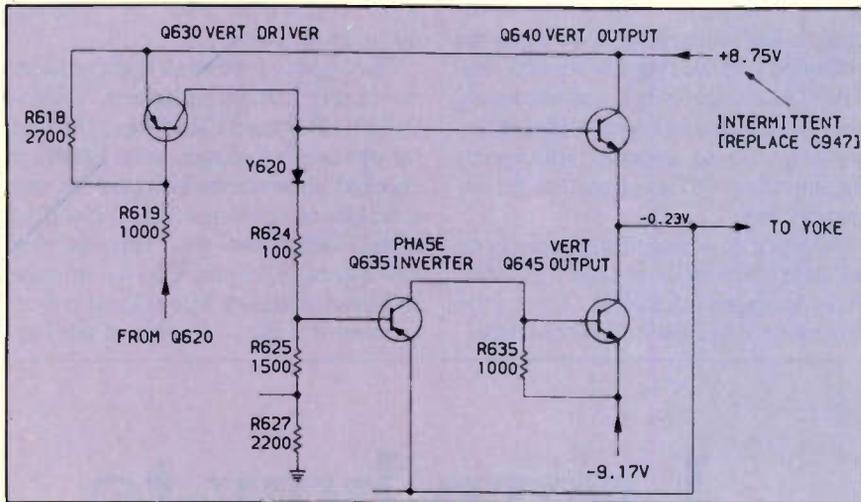


Figure 3. Here is another type of vertical-output circuit; it has a phase-inverter transistor. (The circuit is for model 685-2004-20, but the schematic has been greatly condensed.) After a routine test (including heating and cooling) of the transistors, the next step was to record changes of dc voltage that occurred when the raster disappeared.

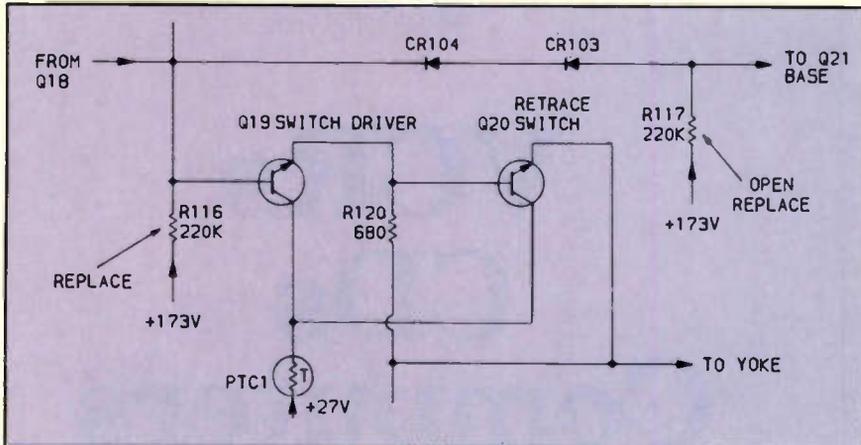


Figure 4. The defect was difficult to locate in this 685-2020. There was no picture above the center line and not much height below. A new retrace-switch circuit is included; its operation is not well understood. But Q20 should not run hot.

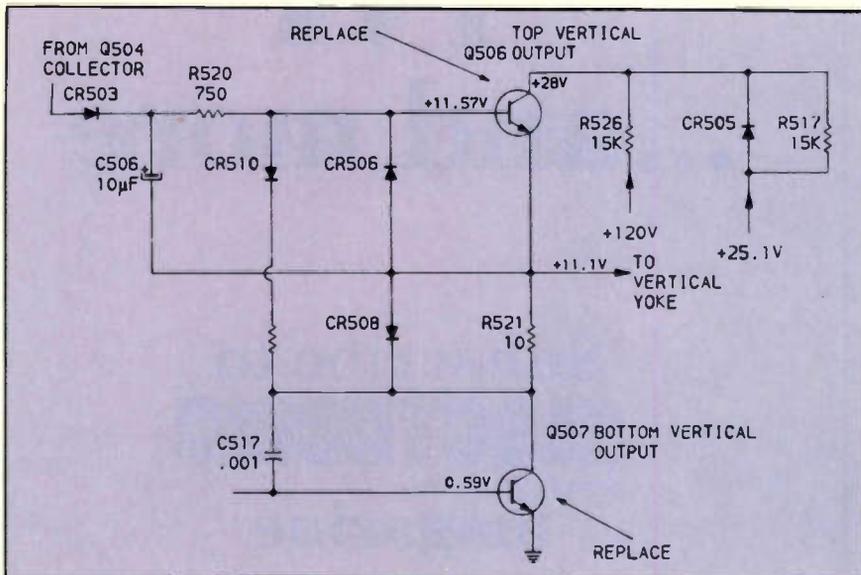


Figure 5. This circuit of the 685-2007E is slightly different from all the others. The two output transistors are designated top and bottom to show where each one makes its major contribution.

as is R117, replacing 220kΩ R116 any time you replace R117 is excellent insurance.

After a new Q19 and a new Q20 were installed and a new R117 resistor was soldered into place, the receiver operated correctly.

Erratic bottom of picture

After the bottom half of the raster collapsed in a model 685-2050E, excessive dc voltage was measured at the collector pin of Q507. (See Figure 5.) At first, Q507 tested open during an in-circuit check. Later it tested normal.

This erratic operation is common. When a transistor is intermittent, it often will operate normally after the test probes have touched the terminals. The chassis was powered-up again, and this time it operated for about an hour before the vertical height malfunctioned. High dc voltages were measured at all terminals of Q506 top vertical output. Although Q506 passed the tests I gave it (it had probably changed to normal again this time), I replaced Q507 bottom vertical output and Q506 transistors with GE-241 universal replacements. When the set was turned on, it operated correctly.

Replacing those two transistors without positive proof was servicing by parts replacement. In this case, it probably was the best technique because the symptoms pointed so strongly to those transistors. You have to weigh the value of the repair against the total technician's time and the components cost.

Retrace lines at the top

Although the raster was complete, several retrace lines appeared at the top of the raster of a model 685-2007E. These retrace lines would expand and move downward when the height was increased with the vertical-height control.

The two vertical bottom transistors and two top transistors apparently were operating correctly. Therefore, the suspects were the Q19 switch driver and the Q20 retrace switch because the extreme top of the raster is where they help the vertical sweep. (See Figure 6.) In fact, with Q19 and Q20 removed from the circuit, retrace lines and poor linearity at the top inevitably occur.

The dc voltages measured higher than the schematic called for at the base and emitter pins, but the dc voltages were lower than normal at the collector pins. Each switch transistor was checked in

circuit for junction conditions and leakages. Both tested normal.

The +27V source tested within tolerance at one end of R156, but the other end measured only +13.3V. Either one of the transistors was drawing too much current or R156 had increased in resistance. Only one test was needed to show that R156 was open. Installation of a new R156 eliminated the retrace lines.

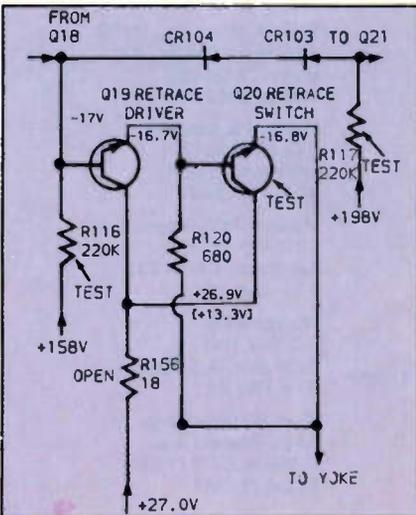


Figure 6. Retrace lines at the top of the picture on this 685-2007E receiver were something different than anything seen with the previous examples.

Mechanical board problems

The chassis in a new model 685-2067 was completely dead. After I removed the back cover and gave the circuit board a careful visual inspection, I found some major breakage on the circuit board and its wiring. The entire circuit board was cracked or broken in front of the flyback and across both horizontal-sweep and vertical-sweep sections.

When any board is broken beyond normal repair, the TV chassis usually should be considered a total loss. But because this was a brand new portable television that had just been taken out of the box, I decided to repair it.

All broken printed wiring was repaired with bare hook-up wire spanning the gaps. After I had visually checked the chassis twice, making repairs each time, I powered up the set. The raster showed only a horizontal white line when ac power was applied. This indicated that a vertical component or a section of etched wiring was open. No broken parts were discovered during a careful visual search.

Next, the voltage sources used in the
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Suggestions and recommendations

- When one vertical output transistor is proven to be defective, always replace both.

- Inspect the circuit board sockets if the output transistors are socketed.

- Don't forget to replace the mica insulator between transistor and metal heat sink. When vertical power-type transistors are mounted on separate metal heat sinks, the heat sink metal usually is not grounded to the chassis. Most transistors are bolted to the metal heat sinks directly without insulators. When you install or re-install a power transistor, apply generous amounts of silicone grease to both transistor and insulator.

- Accurate dc voltage tests at the metal collector terminals of the output transistors might indicate that one or both transistors are defective. For example, a lower collector voltage could indicate a leaky transistor. A very high collector voltage might indicate an open transistor.

- To conserve valuable servicing time, always obtain the correct schematic or wiring diagram and use it.

vertical circuits were measured where they entered the vertical circuits. The +44.8V source was missing. This voltage source was traced back to the flyback, the source of the ac power. I tested each wire for normal continuity by using the low range of the DMM.

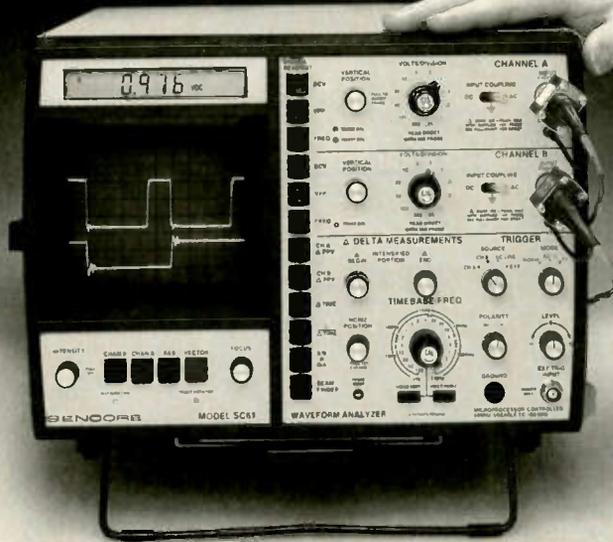
Using a magnifying light, I found a crack around the negative or ground pin of C931. Connecting a bare tie wire between the ground (negative) terminal of C931 and across the broken board section to common ground brought back the normal vertical raster.

Although the vertical-output circuits in J.C. Penney televisions can be very different, developing a sequence of tests can help trim down troubleshooting time for models you are unfamiliar with. Studying the symptoms carefully should give you a better starting point than a hit-or-miss method.

Editor's note: If a certain vertical problem does not respond to the various methods shown in this article, try to locate vertical circuit and vertical troubleshooting articles from past issues of *ES&T*. In most years, the index is found in the January issue. The experience of other technicians often is valuable as well.

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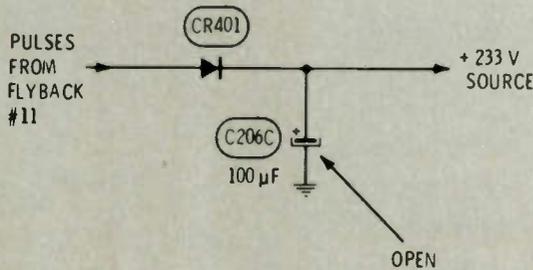
Circle (40) on Reply Card

March 1988 *Electronic Servicing & Technology* 75

This SYMCURE is reprinted from *Electronic Servicing* magazine.

Chassis—RCA CTC81
PHOTOFACT—1615-2

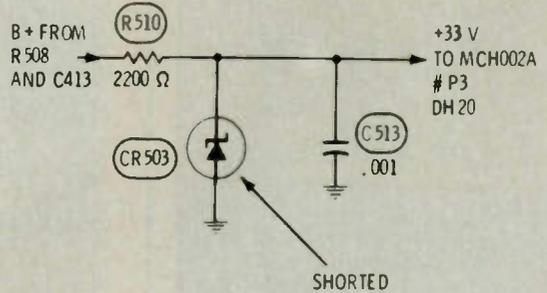
1



Symptom—No video, and excessive brightness with retrace lines
Cure—Check C206C, and replace it if open or low in value

Chassis—RCA CTC81
PHOTOFACT—1615-2

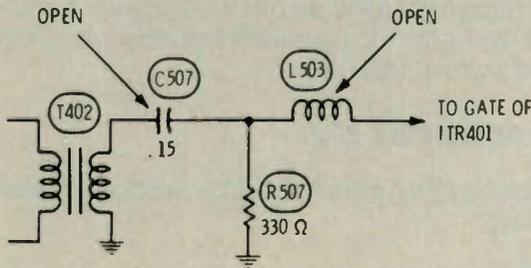
4



Symptom—No vertical sweep
Cure—Check CR503, and replace it if leaky or shorted

Chassis—RCA CTC81
PHOTOFACT—1615-2

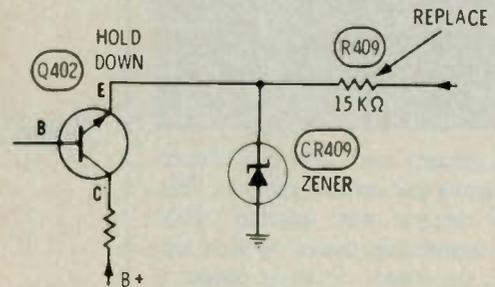
2



Symptom—Not locked horizontally, has squeal, and perhaps foldover with low HV
Cure—Check C507 and L503, and replace either if open

Chassis—RCA CTC58
PHOTOFACT—1365-1

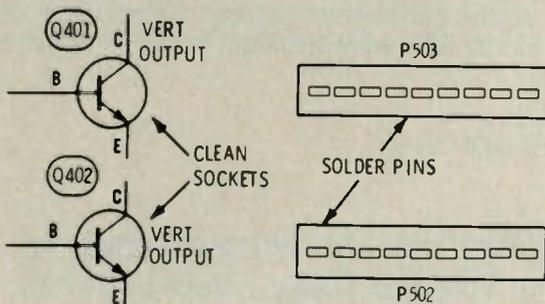
5



Symptom—Vertical lines at the edges are crooked
Cure—Check R409, and replace it if out of tolerance

Chassis—RCA CTC74
PHOTOFACT—1588-1

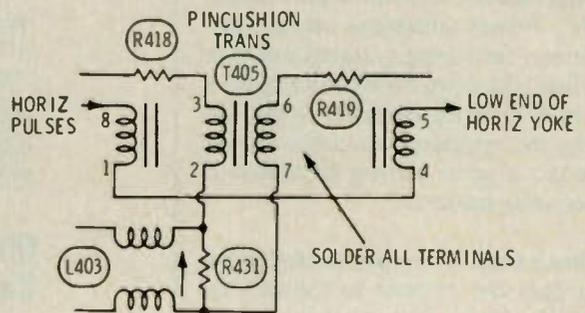
3



Symptom—Intermittent height, intermittent roll, or intermittent loss of vertical sweep
Cure—Clean socket contacts of Q401 and Q402; also, solder pins to spring contacts in P502 and P503 on PW500.

Chassis—RCA CTC68
PHOTOFACT—1437-2

6



Symptom—Vertical at right side is compressed, similar to a distorted trapezoid
Cure—Check and resolder all joints at terminals of T405

SYMCURE/ Troubleshooting Tips guidelines

ES&T is now paying \$60 per page (six different cases of symptoms and their solutions) for accepted Sycmure submissions.

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competent technician.

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- It should describe how the repair was performed and any precautions about the possibility of damage to the set or injury to the servicer.

For Sycmures and Troubleshooting Tips, please also include:

- the manufacturer's name;
- the model and chassis number;
- the Sams Photofact number; and
- a sketch of the schematic area where the fault was found. (Include a major component such as a transformer or transistor to provide a landmark for the ES&T staff.)

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That dreaded drift

By Joseph J. Carr, CET

Few customer complaints are less welcomed by the radio servicer than drift. This problem is characterized by the radio receiver changing frequency *not* under the influence of the operator. There are actually two different problems that are seemingly related: *drift* and *shift*. Drift is a gradual change of frequency, usually as a function of temperature. Shift, on the other hand, is an abrupt change of frequency. The causes of these two related phenomena are different, but they often are confused with each other.

Frequency shift problems

Resonant circuits in modern electronic equipment might be LC-tuned by a combination of inductance and capacitance, or they might be tuned by a piezoelectric resonator element (crystal). In either case, the cause of a sudden, unwanted shift of operating frequency usually is some form of mechanical trauma somewhere in the circuit. In other words, a component is either broken or has an intermittent connection.

Carr is an electronics engineer who has contributed frequently to *ES&T* and has published many books on electronics.

Figure 1 shows a partial circuit of an oscillator. The resonance of this circuit is determined by the combination of $C1/C2/C3/L1$. If any of these components fail, change value or become disconnected, the resonant frequency of the circuit will shift. If coil $L1$ fails, the circuit will probably cease oscillating, so the fault becomes obvious. But what if one of the capacitors fails? In that case, the circuit may well continue oscillating, but at a different frequency than before.

The trimmer capacitor was selected as an example in Figure 1 because that component seems especially failure-prone. After many years of experience, I can attest that trimmers seem to have a high casualty rate. Perhaps the worst offenders are the half-turn type that use silver deposited on a pair of ceramic surfaces. The mica compression types also fail, but seem less prone than the other types.

The mechanism of failure seems to be looseness in the adjustment screw. One way to determine if one of these components is faulty is to tap the capacitor gently with an insulated probe and note whether the shift occurs.

Don't make the mistake of assuming

that the other kinds of capacitors are fault-free—far from it. Every form of fixed capacitor has at least a small failure rate, usually caused by disconnected leads inside the body of the capacitor.

Also, don't overlook the possibility that the problem is caused by the solder connections connecting the capacitor to the circuit board, especially when the capacitor is mounted on a board that is easy to flex. Although some bad joints

Don't overlook the possibility that the problem is caused by the solder connections connecting the capacitor to the circuit board, especially when the capacitor is mounted on a board that is easy to flex.

escape the factory quality-assurance inspector and subsequently last for years in service before failing, others die an early death because of trauma or flexure of the board. A frequency shift problem may also be caused by a cracked printed wiring track. In either case, a little solder and a hot iron will solve the problem.

On older receivers, be sure to examine the main tuning capacitor for problems. I once had a terrible problem with a piece of equipment that exhibited both shift and drift in magnificent proportions. Although I was employed in a communications shop at the time, I did not get around to fixing the receiver for several months (Cobbler's kid's shoes syndrome).

When I looked into the problem, it turned out to be crud under the rotor grounding spring on the main tuning capacitor. That capacitor rotor is normally grounded to the chassis through its own frame. But because the rotor must move, a brass or steel grounding leaf spring or *spider clip* usually is placed around the rotor at the front bearing. The spring or clip grounds the

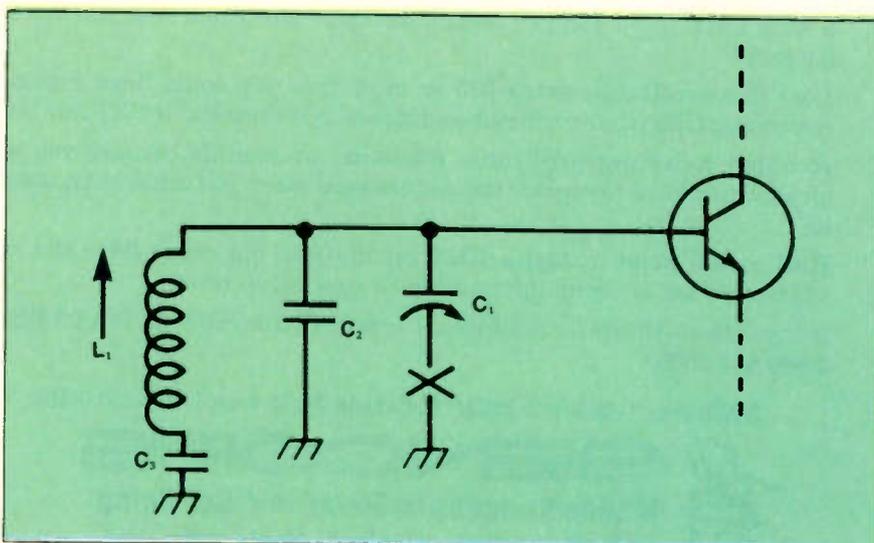
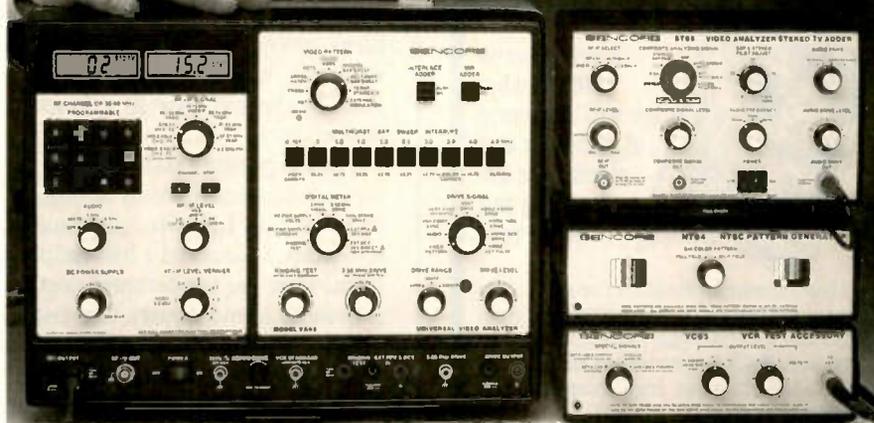


Figure 1. The resonance of this circuit is determined by the combination of $C1/C2/C3/L1$. If any of these components fail, change value or become disconnected, the resonant frequency of the circuit will shift.

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rotor to the frame. In this particular case, a lot of dirty grease had built up under the spring. Rather than causing operation to cease, the grease produced massive frequency shifts, drift when the device wasn't shifting and a sad tendency toward microphonics.

Poor grounding may be the cause

Another cause of drift in older receivers is poor grounding. Many car radios, 2-way radios and other RF equipment exhibit frequency-shift problems caused by poor grounding or cracked ground tracks on the printed circuit board. In one infamous FM model, the FM front end was grounded at only two points on the printed circuit. If that wasn't bad enough, the ground ran around the edge of the card, which was stressed at one point—where cracks tend to develop.

Although the circuit would not cease oscillating, the extra several inches of ground line on a flexing board caused operating frequency shifts. I suspect that the cause of the frequency shift was the added inductance of the printed circuit ground path. At VHF frequencies, the effect of distributed inductance and/or capacitance is more profound than at low frequencies. Again, judicious use of a soldering iron not only repaired the break, but also added strength to the weak point.

Drift problems

The other frequency-changing problem is old-fashioned drift. Unfortunately, most electronic components exhibit some temperature sensitivity. This sensitivity usually is measured in terms of a *temperature coefficient*, which specifies a certain shift of value in parts per million (ppm) per degree Celsius of temperature shift. The temperature coefficient can be either positive or negative. A positive temperature coefficient (PTC) indicates that the value increases with increases in temperature, and vice versa. A negative temperature coefficient (NTC) indicates that the value tends to decrease with increases in temperature (and vice versa).

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Most inductors used in oscillator circuits have a PTC problem. The value of inductance (microhenrys— μH) is determined by the coil dimensions and the number of turns of wire. Although the turns count remains constant, the diameter, length and size of the wire used in the inductor is a function of temperature.

The temperature coefficient of inductors can be minimized by design. If the inductor uses Litz wire (or some other low-tempco wire) and a low-tempco coil form, then the temperature coefficient is reduced tremendously. Old-fashioned cardboard forms are terrible sources of drift. According to the old "standard wisdom," the best forms are ceramic,

but that is no longer true. There are fiberglass and other synthetic materials that provide better tempco characteristics.

Capacitors are also sources of temperature coefficient problems. Ceramic capacitors are available in either PTC, NTC or no-TC versions. Markings of "Nxxx" and "Pxxx" indicate the direction and amount of temperature coefficient. For example, an "N750" is an NTC device with a tempco of 750ppm. The capacitor marked "NPO" has a low tempco, but not precisely zero—as some people find out, to their chagrin, when subbing really low-tempco caps with NPO ceramic units. In general, silver mica and

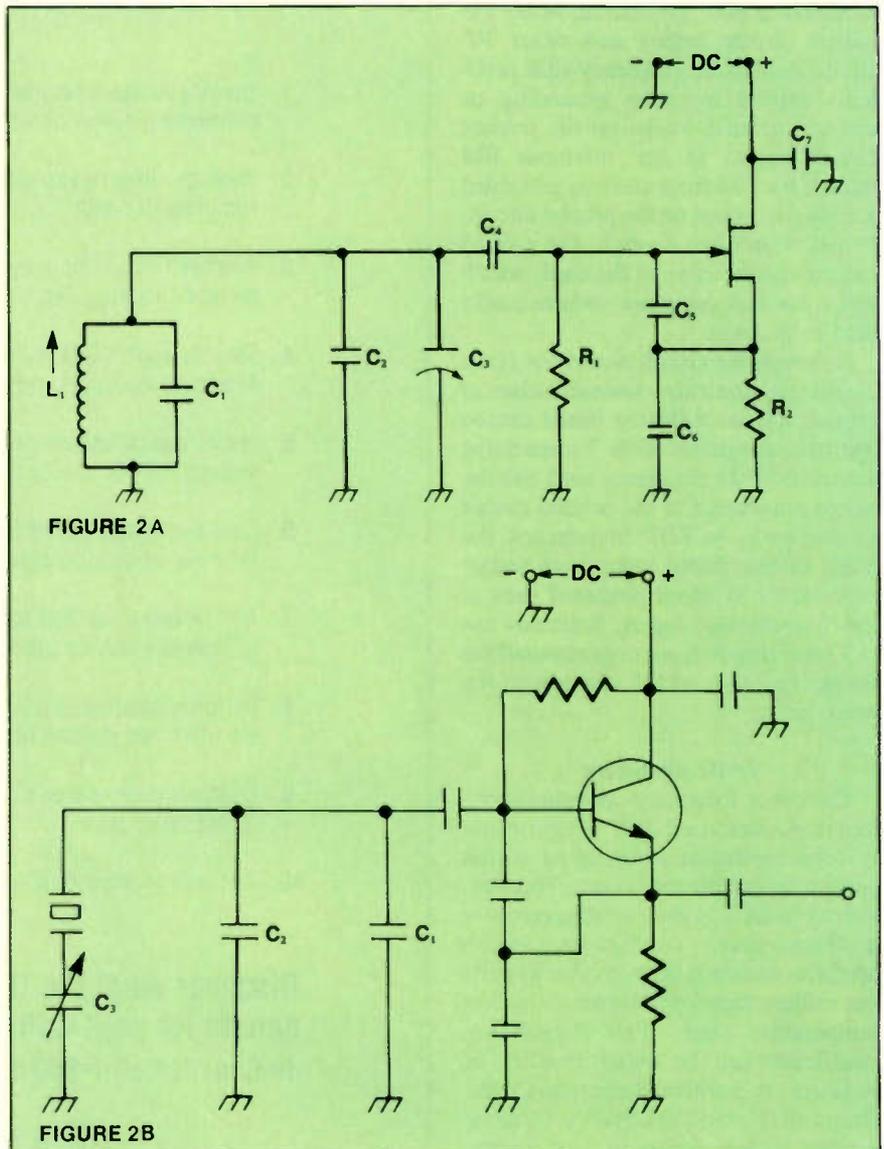


Figure 2. Here are two forms of oscillator, one LC-tuned (Figure 2A), the other crystal-tuned (Figure 2B). Both of these oscillators seem to have "extra" capacitors in the circuit (for example, C2 in Figure 2A and C1/C2 in Figure 2B). The extra capacitors are for temperature compensation.

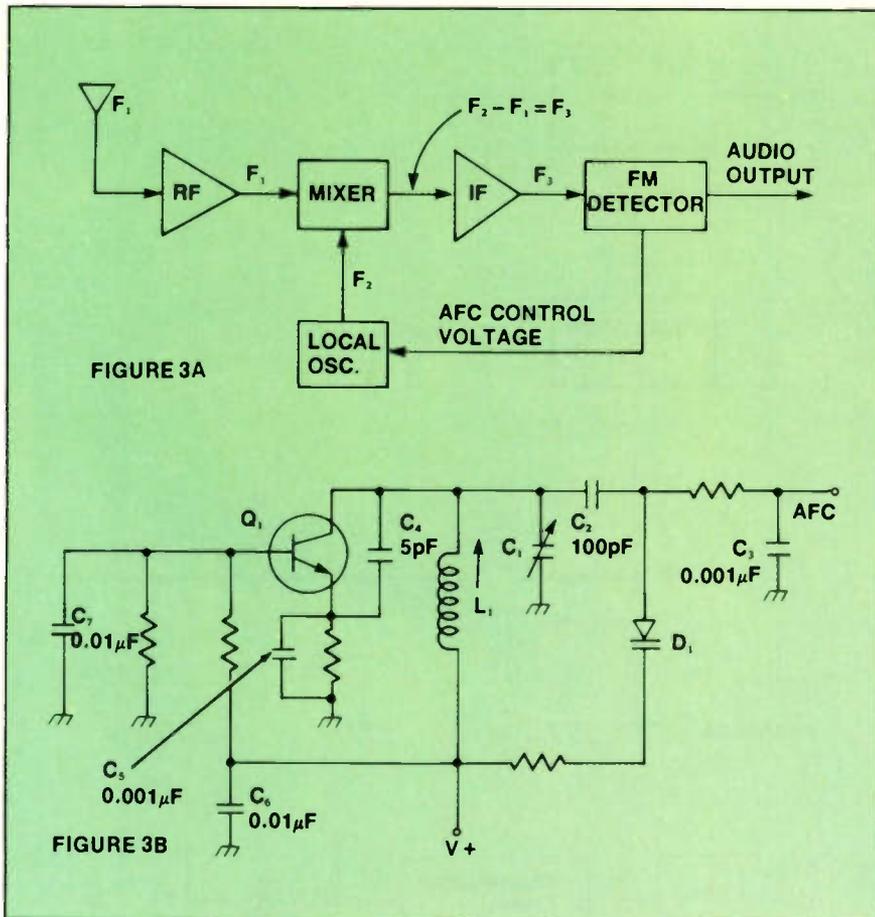


Figure 3. The block diagram of an FM receiver is shown in Figure 3A. The local oscillator (Figure 3B) is kept on channel by a dc control voltage from the automatic frequency control (AFC) output of the FM detector stage. The actual mechanism of frequency control is the variable capacitance (varactor) diode in the oscillator circuit (D1 in Figure 3B).

polystyrene capacitors are the lowest-tempco units available.

So why not make all capacitors with low or nearly zero tempcos? The reason is that they are sometimes used in temperature compensation circuits. Figure 2 shows two forms of oscillator, one LC-tuned and the other crystal-tuned.

Both of these oscillators seem to have "extra" capacitors in the circuit (for example, C2 in Figure 2A and C1/C2 in Figure 2B). In these cases, the extra capacitors are for temperature compensation. They are typically small value compared with other circuit capacitors, but have precalculated temperature coefficients that will cause the capacitance to change a predictable amount with changes in temperature.

Both circuits, even the crystal oscillator, will change frequency with changes in circuit capacitance, so the tempco of the compensation capacitors forces the frequency to change in a predictable manner. The idea is to

counter the positive temperature coefficient of the inductor with an equal and opposite direction temperature coefficient of the capacitors.

Varactor diode as frequency compensation

Figure 3A shows the block diagram of an FM receiver. The local oscillator (see Figure 3B) is kept on channel by a dc control voltage from the automatic frequency control (AFC) output of the FM detector stage. The actual mechanism of frequency control is the variable capacitance (varactor) diode in the oscillator circuit (D1 in Figure 3B). This type of diode is used in both LC-tuned circuits, as used in broadcast receivers, and the crystal-controlled units used in communications equipment.

If the varactor becomes defective, it will cause a frequency shift. Alternatively, if the diode is intermittent, the circuit will jump on and off channel as the diode opens and closes the circuit.

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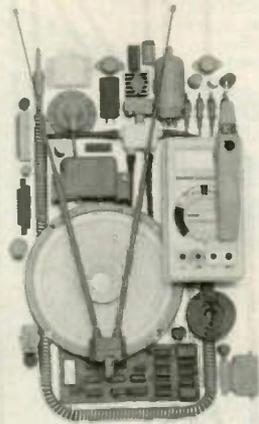
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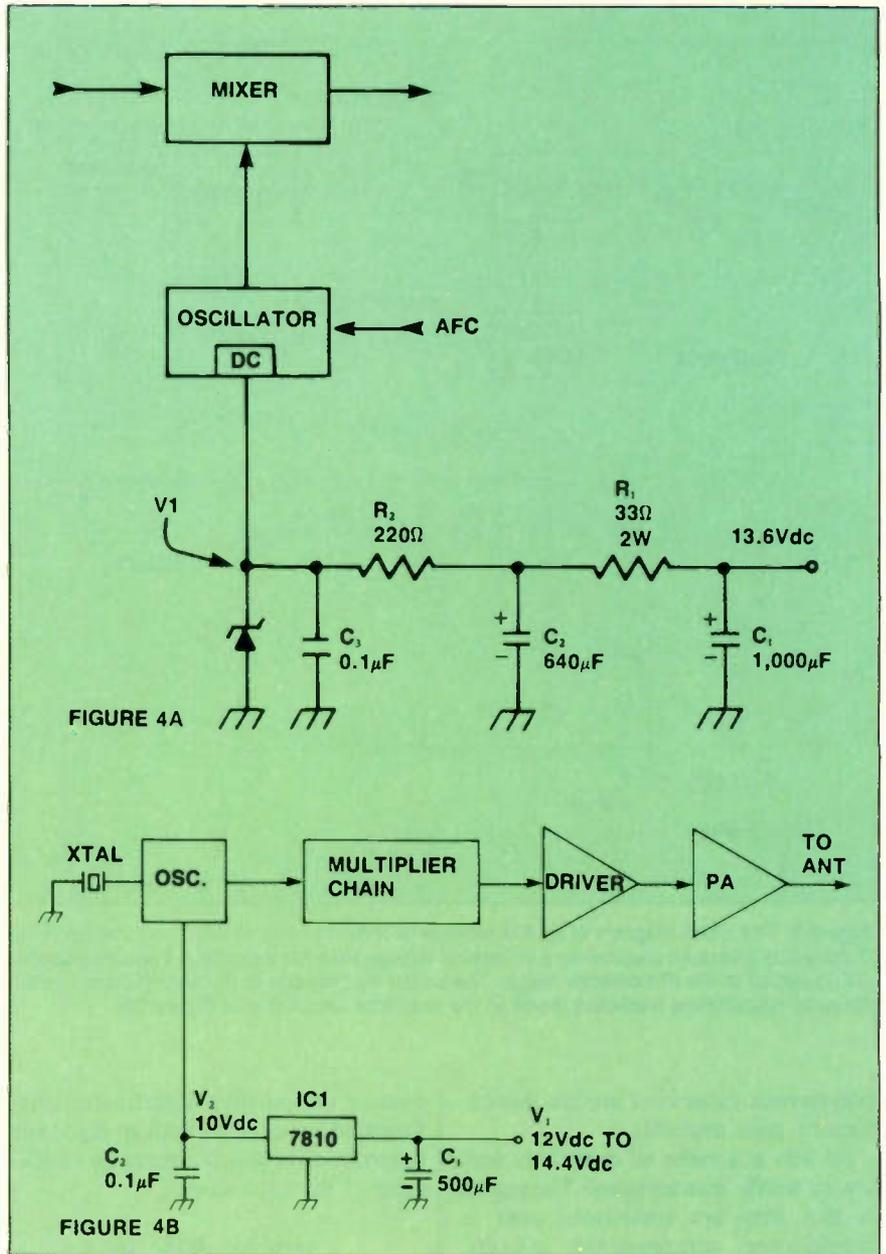


Figure 4. The zener diode regulator typically used in many car radio circuits is shown in Figure 4A; the 3-terminal IC voltage regulator that keeps the oscillator voltage to +10V in a certain mobile transmitter master oscillator is shown in Figure 4B. If any of these components faults, shift or drift will result.

I have, however, seen quite a number of sets over the years in which a newly developed (as opposed to inherent) drift problem was caused by a defective diode. For some reason, the diode capacitance was a function of temperature. Although it was not a scientific experiment, I once measured about five diodes that showed this phenomenon and found that all had excessive leakage resistance in the reverse bias direction.

Drift problems caused by dc supply
Don't overlook the dc power supply

as a potential source of drift problems. Oscillators typically require fixed, all-regulated dc operating potential for best stability. That dictum applies equally well to both LC-tuned and crystal oscillators. If the dc voltage or bias voltages change, expect an oscillator frequency shift.

The problem with dc voltage is especially acute in mobile equipment, whether it is used in communications or broadcast. In the early '60s, I worked in a car radio shop that dealt with Blaupunkt receivers (the German-made set in Porsche cars). One customer came

in with an oddball problem: The radio changed frequency with changes of engine speed.

That set, which used vacuum tubes, had a germanium diode across the resonant circuit to limit oscillation amplitude. A gas-regulator tube supposedly kept the potentials applied to the circuit, but it was defective. Because the car power supply varies markedly with engine speed, the now-unregulated power supply voltage applied to the oscillator also varied. One lesson: Although I frequently chuckled at customer diagnoses, I never again doubted the customer's description of the symptom ("...changes station when I pull away from a light...").

Modern mobile electronic equipment is probably more prone than some of the older equipment to this type of fault. In communications equipment and FM broadcast receivers, the oscillator voltage usually is regulated. Figure 4A shows the zener diode regulator typically used in many car radio circuits. Figure 4B shows the 3-terminal IC voltage regulator that keeps the oscillator voltage to +10V in a certain mobile transmitter master oscillator.

If any of these components faults, shift or drift will result. The nominal "12V" vehicle power supply is actually quite variable. With the engine off, my own car measured 11.8Vdc on one meter and 12.05Vdc on my DMM. When the engine is started, however, the voltage varies from 12.3Vdc at an idle to 14.5Vdc as the engine speed is increased. To an oscillator inside of electronic equipment, that range might be intolerable.

Crystal oscillators are not immune to drift problems, even when they previously worked well. In addition to the problems with dc power supplies mentioned above, it is also possible for the crystal to become defective. I have seen several sets over the years in which a terrible drift problem resulted from defective crystal elements. Replacing the crystal solved the problem.

Frequency shift and drift problems are not easily found in many cases, but understanding the causes and potential solutions of these problems goes a long way toward finding the fault in any particular case.

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Computer Corner

Basic flip-flop design

By Christopher H. Fenton

This is the first in a 2-part series on flip-flops. Part I will discuss the different types of these devices, while Part II will cover the different types of a particular flip-flop, the ripple counter.

Recent advances in microchip technology have revolutionized the face of nearly every electronic device manufactured today. Circuits, which only a few years ago required a separate circuit board, are now available in single-chip packages that are smaller, lower in cost, easier to use and more reliable than their discrete component counterparts.

One of the major advances that have made this revolution possible is bistable latches. Otherwise known as flip-flops, they are used in a wide range of applica-

tions, including counters, dividers, shift registers, data latches and many other devices. Flip-flops are the basis of nearly all digital circuits, and they have become one of the building blocks of the computer age.

A basic CMOS set/reset (S-R) flip-flop consists of two cross-coupled NOR gates, two input terminals and two out-of-phase outputs. (See Figure 1.) When a signal is input into the SET terminal, the A output swings to the maximum output voltage defined by the chip configuration, while the -A output voltage swings to the maximum low.

When the input signal ceases, the cross-coupling of the gates causes the output signal to lock itself or "latch" into the maximum mode until a signal is applied to the RESET terminal. This makes the outputs return to their normal state. The flip-flop remembers the

current state of the outputs and switches them according to which terminal receives an input signal.

The clocked flip-flop

To enhance the versatility of the S-R flip-flop, an AND gate, in series (Figure 2), is wired to each input terminal. This is called a *clocked* or *gated* S-R flip-flop. An input signal can only reach the flip-flop when the clock signal is at its preset high. When the clock signal is low, only one input of each AND gate has a signal, so no signal reaches the flip-flop inputs, and the outputs remain in their original state. The state of the set and reset inputs are irrelevant, and the flip-flop functions as a permanent memory. When the input signal is applied to the high clock, the circuit operates as a standard set/reset flip-flop. As a result, data is not latched in

Fenton is the circuit fabrication consultant for ES&T.

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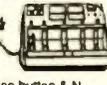
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automatically to the output, but is switched in via the clock.

The master/slave flip-flop

Two clocked S-R flip-flops can be combined to form a master/slave flip-flop. Clocked out of phase via an inverter in the clock line, this flip-flop is one of the most widely used. When the

clock input is low, the inputs are triggered by the inverter. Set/reset data is then accepted and the slave flip-flop is switched off with no data passing from its output terminals.

When the clock input is high, the master flip-flop's inputs are disabled. Input data is then latched into the output at the same time the slave flip-flop is

enabled. The latched data is then passed to the master flip-flop's output terminals.

By cross-coupling the input and the output terminals, the SET and A terminals are at logic levels opposite to those at the -A and RESET terminals. When the clock is low, the master flip-flop's outputs change state. When the

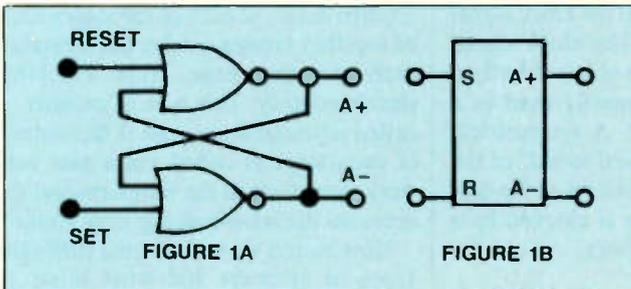


Figure 1. The S-R flip-flop is built from two NOR gates, as shown in A. Its symbol is shown in B.

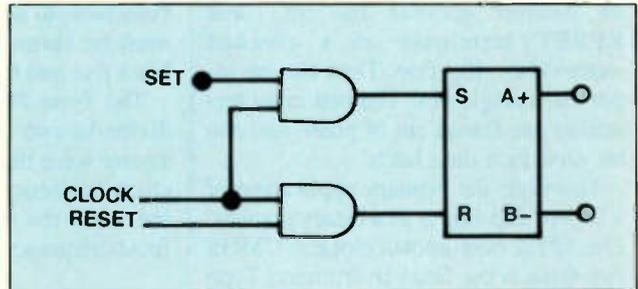
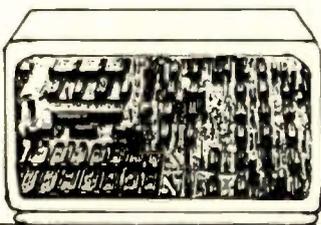


Figure 2. A clocked S-R flip-flop is built from two AND gates in addition to the S-R flip-flop.

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clock goes high, the slave's outputs change. The state of the outputs is dependent on each new clock pulse. Because it takes two clock pulses to change the output state and then return, the frequency of the output is half the frequency of the clock. This type of device is a *T* or *toggle* type of flip-flop.

The data flip-flop

A device that is more versatile than the T-type flip-flop is the data or D-type flip-flop, which is made by configuring an inverter between the SET and RESET terminals of a clocked master/slave flip-flop. Data can be input via a single pin. The two input terminals are always out of phase and can be used as a data latch.

However, the primary application of a D-type flip-flop is as a binary counter. One of the best-known clocked CMOS flip-flops is the Texas Instruments Type 74, which incorporates two independent flip-flops that share power and ground

connections in a single-chip package. Each flip-flop has independent SET and RESET terminals, and the clocked action can be overridden by directly inputting a signal to either terminal. When the device has been overridden, it then functions as a standard S-R flip-flop. For the device to operate as a counter/divider, the direct inputs must be grounded.

The Type 74 clocks *on* on the positive transition of the clock signal. The high-speed operation of the device makes it vulnerable to noise, and the clock signal must be bounceless. The clock signal has a rise and fall time of less than 5 μ s.

The Type 74 is primarily used as a divide-by-two counter. A symmetrical square wave that is equal to half of the clock frequency is produced as the output when the flip-flop is clocked by a fixed-frequency waveform.

The ripple counter

Several Type 74s can be configured

to form a ripple counter. A ripple counter is a series of D-type flip-flops. Several flip-flops can be cascaded to successively divide the output of a digital circuit by powers of two. Any number of flip-flops can be cascaded to provide a division ratio of 2ⁿth power.

Each successive output is clocked by the output of the previous stage instead of being timed by the master clock signal. The end result is that the clock signal "ripples" from stage to stage in the counter chain. However, the synchopated delays at each of the stages added together creates a delay that prevents each counter stage from clocking simultaneously. This type of counter is called *asynchronous*, and if the output of each stage is coded via a gate network, variations in the waveform and inaccurate decision-making may result.

Next month we will discuss different types of counters and what kinds of problems you may encounter with them.

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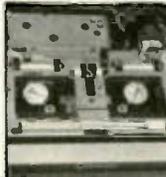
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Audio Corner

The CD data structure

By Kirk Vistain

In examining the past year's Audio Corner topics, I couldn't help but notice that the word "servo" shows up quite a bit, so let's change the subject. How about something pertinent but unusual? I know—CD players! But, you say, Audio Corner is crammed full of references to these machines. OK, so we'll discuss another aspect of them. After all, the CD player is about the only piece of audio gear that consistently provides servicing challenges. Most everything else just gets a new belt, an output IC or a trip to the wastebasket. But compact disc players make you think.

In the past, I've purposely avoided a discussion of the data structure used by compact discs. You almost never need to know anything about it to fix a player.

Note the qualifier "almost." You almost never need a triple coronary bypass either, but when you do, it's the only thing that will work. We have to be careful to remember that "almost" doesn't mean "never," or we'll certainly go to the dogs sooner or later. This won't be a methodical or comprehensive treatment of the subject. Let's simply discuss the concepts for a column or two. (See the glossary for more help.)

The basic concepts of changing analog information to digital bits and bytes is relatively simple. Sample the analog signal level, assign a digital value to it and repeat. For CDs this process is repeated at a rate of 44.1kHz, or every 22.7µs. Each complete sample is represented by a 16-bit word. Left and right channels are recorded alternately.

straightforward concepts actually work. Of course, those of us who have been on the bench a while know that "simple," as applied to electronic theory, means "understandable but impractical." You won't be surprised to discover that about 75% of the circuitry in the CD signal chain is there to overcome hardware limitations. But you may wonder at the fact that around 60% of the actual information on a compact disc is there for the same reason. Less than half of it is actual program material (music).

Why? First, the laser beam has a finite width, in the area of 1.7 microns, which is large compared to the 0.5-micron track width and 1.6-micron spacing between tracks. Second, to cram as much data as possible onto the disc, engineers opted for a NRZ (non-return-to-zero) data format (see Figure 1), which I'll try to explain later. For

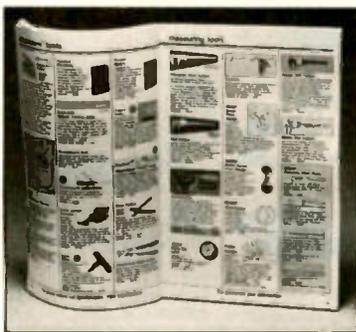
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Vistain is the audio consultant for ES&T.

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now all you need to know is that this can result in pits that the laser can't read because they're the wrong size. This creates the need for a further level of complication—EFM.

EFM encoding

Eight-to-fourteen modulation (EFM) ensures that all the little pits on the compact disc will be within the right size range for the laser to read. We can't have any that are too small because the laser

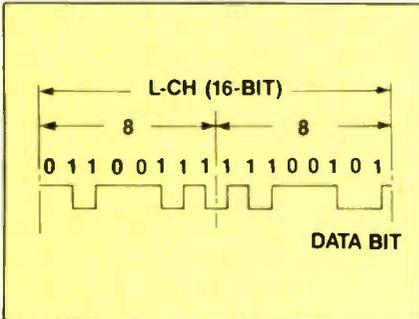


Figure 1. With the NRZ (non-return-to-zero) data format, the binary value of the data stream only changes to the opposite state when a 1 is encountered.

won't be able to resolve them. If the pits are too big, the output of the photodetectors will veer toward dc and disturb the data clock. (See Figure 2.)

So, take the 16-bit words derived from the sampling process and split them into two 8-bit bytes. Take these and look them up in a table of 14-bit values,

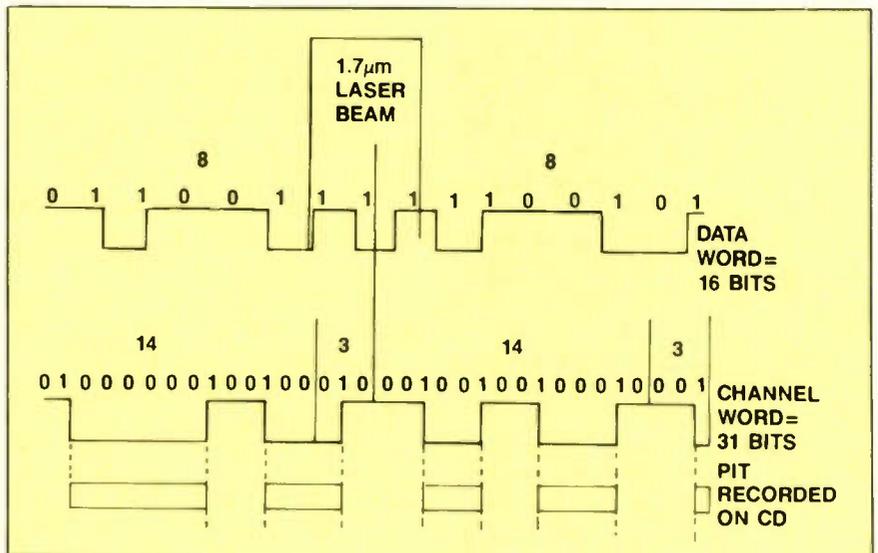


Figure 2. EFM is necessary because of the NRZ format. The beam is too wide to resolve rapid transitions in a straight 16-bit system, so specially selected 14-bit patterns are substituted for each 8-bit byte. They are separated by three merging bits.

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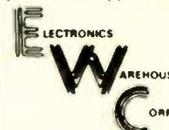
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selected from among the 16,384 total possibilities, on the basis of what pit size they produce. The laser basically doesn't want to see any digital signal with more than 10, or less than two, zeros between any two 1 values. The 14-bit model offers 267 of these.

To summarize, the recording system breaks each 16-bit word, representing one sample of the audio input, into two 8-bit bytes. Then the EFM encoder substitutes an appropriate 14-bit value for each one and sends the result off for more processing. At this stage, then, we have taken the original 16-bit word and derived two 14-bit patterns from it for a total of 28 bits.

As you can see, this increases the number of bits per sample from 16 to 28, a 75% increase. In other words, the actual music data is really only about 57% of the EFM signal. And we still haven't added merging, sync, parity or control bits. If this seems a tad confusing, just wait until next time.

ES&T

GLOSSARY:

Bit: The smallest unit of binary digital information. It is either high or low, also termed 1 or 0.

Byte: An assemblage of eight bits.

Channel bit: One bit of the EFM signal.

Data bit: One bit of digitized audio before EFM coding.

EFM: Eight-to-fourteen modulation, whereby an 8-bit data byte is represented by a 14-bit channel word, all in the interest of keeping the pit size within certain limits dictated by the size of the tracking beam.

Merging bits: A set of three bits interposed between 14-bit words to ensure that there are always at least two, but no more than 10, zeros between each pair of 1s. You thought the EFM process took care of this? It does, on a word-by-word basis, but when you start stringing 14-bit words together, you could get the wrong spac-

ing between 1's. The merging bits are adjusted to eliminate the problem.

NRZ: A digital coding scheme in which the binary value of the data stream only changes when a 1 is encountered. The signal does not return to 0V after each high, the purpose being to reduce a signal's high-frequency components and thus the bandwidth requirement of the processing circuitry.

Pit: A small dot burned into a CD to represent the value of one bit of recorded information.

Sample: As a verb, to convert the instantaneous voltage of an input waveform into a digital word.

Sync: Digital information recorded onto a CD to mark the beginning of a particular collection of bits.

Word: Usually an assemblage of 16 bits or two bytes.

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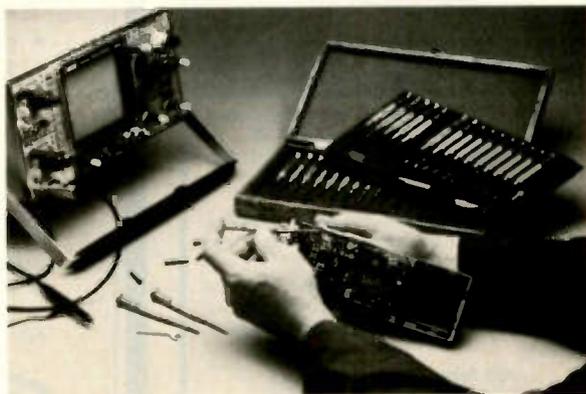
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Video Corner

Audio high fidelity in VCRs

By Conrad Persson

When VCRs first became available as consumer electronics products, the picture quality was at least as good as broadcast TV quality at its best. So was the sound. There was no problem with that, except that consumer electronics technology had already provided homes with sound systems that could rival the concert hall, and the fine sound systems in movie theaters had accustomed viewers to having spine-tingling audio along with their visual delights. VCR manufacturers knew that if they could offer great sound with their good video, people would respond by buying their products in greater numbers.

Beta VCRs were the first to add hi-fi sound, with VHS close on their heels. Now homes resound to the rich sounds of today's movies, which is great, except that it's another technological

development that needs to be studied by electronics servicing technicians.

How it works

Here's a synopsis of what the GE technical training manual, *VCRs and Video Cameras, 1985 Line*, has to say about the model IVCR5018. This information also applies to many similar models.

The unit actually contains two separate audio systems: a conventional or linear track-recorded audio that is virtually identical to that used in the unit with standard audio; and a high-fidelity unit that features a helically scan-recorded audio system.

In the VHS High Fidelity system, the audio heads are located on the video-head cylinder. This greatly increases relative head-to-tape speed and results in an audio system that has truly remarkable specifications. The frequen-

cy range is 20Hz to 20kHz; noise immunity is rated at 80dB. The system compares so favorably with audiotape recorders that it is designed to be switched into an *audio-only* mode and used as a hi-fi audiotape recorder.

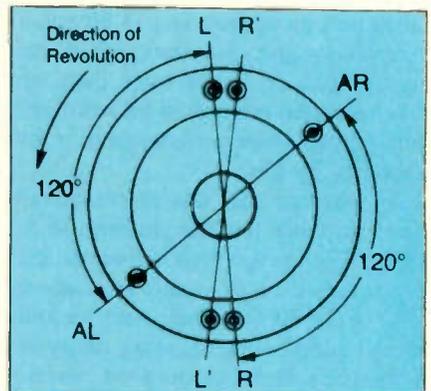


Figure 1. The audio heads are mounted on the video-head cylinder, 120° from the adjacent video head. Their azimuth angle is ±30°.

Persson is editor of ES&T.

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Another plus is that wow and flutter, undesirable phenomena that result from tape-speed variations in normal audio-tape systems, are not factors.

In this system, the audio signal is frequency-modulated and recorded on the tape by audio heads that are mounted on the video-head cylinder. (See Figure

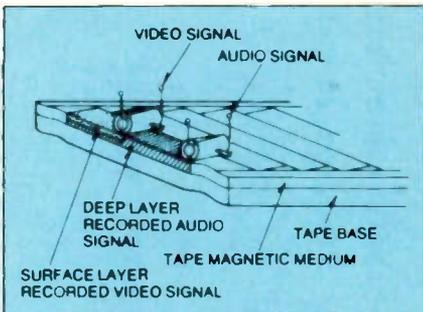


Figure 2. With depth multiplexing, the large head gaps of the audio heads record deeply in the tape. The video heads record over the audio signal, but to a more shallow depth.

1.) The audio heads are positioned 120° apart from the adjacent video head and their azimuth angle is $\pm 30^\circ$.

And you thought recording tape was thin

The audio signals are recorded onto the tape first. The video signals are then recorded over the top of them. This is called *depth multiplexing*. (See Figure 2.) The idea here is that the large head gaps of the audio heads record deeply into the tape. The video heads then

record over the audio signal, but to a more shallow depth. Thus, the signals are, in effect, recorded in layers with the video on top of the audio.

During playback, the video heads only pick up the surface-layer video, while the audio heads reject the surface-layer video by virtue of their $\pm 30^\circ$ azimuth and bandpass filtering. Figure 3 shows the recorded signal spectrum of this audio system.

Next month's installment will discuss the circuits themselves in more detail.

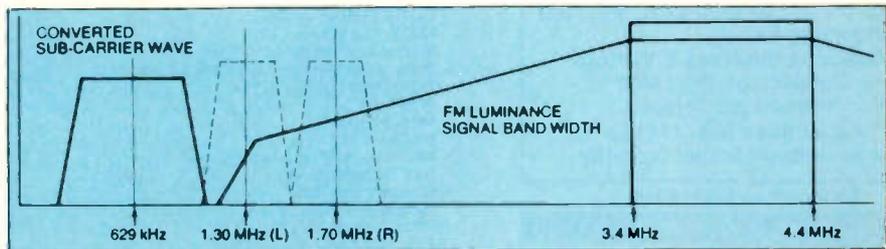


Figure 3. The recorded signal spectrum of the audio system.



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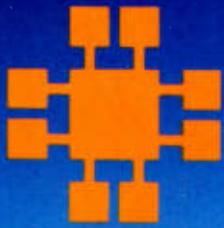
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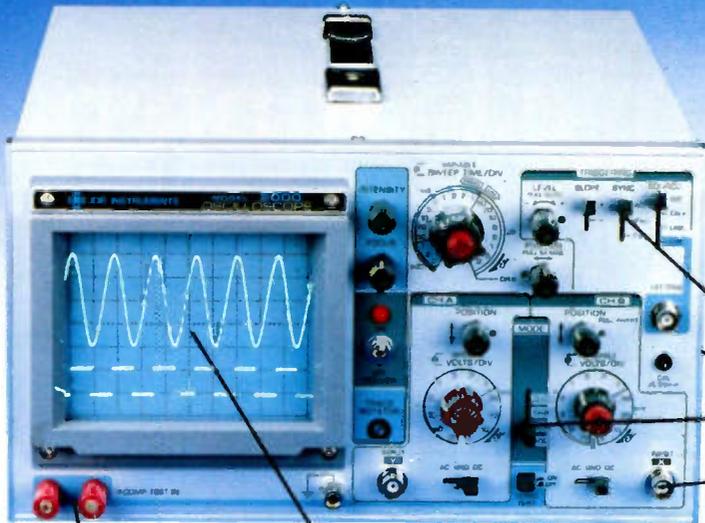
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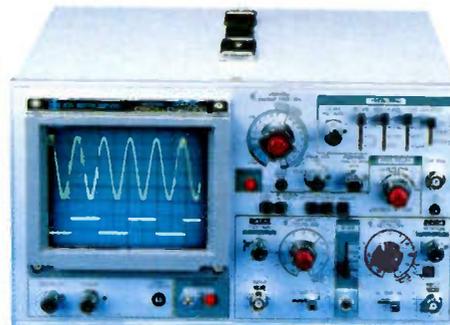
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