The how-to magazine of electronics...

AN INTERTEC PUBLICATION

ELECTRONIC Servicing & Technology

JUNE 1987/$2.25

Locating. . .the defective flyback • Digital audio tape on the way

Circuit analysis, troubleshooting quiz

IC tester

More Functions. Smaller Budget.

Beckman Industrial Circuitmate™ DMMs put hFE, Logic, Capacitance, Frequency and True RMS In Your Hand. For Less.

Get more, for less. It's a simple definition of value. For DMMs, value means finding the combination of capabilities that meets your needs at the right price. Without losing sight of accuracy and reliability.
If you want more functions at a low price, Beckman Industrial's Circuitmate™ Digital Multimeters are the best value around.

From the pocket-sized DM20L to the DM850, with true RMS capability and accuracy to 0.05% ±1 digit, Circuitmate DMMs give you the functions you need.

For instance, the DM20L puts both a Logic Probe, a transistor gain function (hFE), and a full range of DMM functions in the palm of your hand. For only $69.95.

Then there's the DM25L. Where else does $89.95 buy you a Logic Probe, capacitance measurement, transistor gain function (hFE), and 24 DMM ranges including resistance to 2000 megohms? Nowhere else.

When high accuracy counts, there's the DM800 with a 4 ½ digit display. The DM800 also gives you frequency counting. A full-function DMM, and more, doesn't have to cost over $169.95. If it's a Circuitmate DM800.

Or, for a few dollars more, get true RMS (AC coupled) to let you accurately measure non-sinusoidal AC waveforms, and all the capability of the DM800, in the DM850.

Of course, there's a whole range of Circuitmate DMMs and service test instruments, including the DM78 autoranger that fits in a shirt pocket, yet gives you a full size 3 ½ digit, ⅜" readout. Not to mention a complete line of accessories like test leads, current clamps, even probes that can extend your DMMs range and sensitivity. All designed to work flawlessly with your Beckman Industrial Circuitmate DMM.

EMERSON

DM20L Pocket-Size w/Logic $69.95*

- TTL Logic Probe: 20MHz Hi/lo/off indications Detects 25nS pulse widths
- hFE (NPN or PNP): 1 range (1000)
- DMM: Input Impedance—10 Megohms DCA/ACA-5 ranges (200μA to 2A)
- Ohms-8 ranges (200 ohms to 2000 Megohms)
- Continuity beeper

DM850 True RMS

- 4½ digits. DCV accuracy is .05% +3 digits
- True RMS
- Frequency counter to 200KHz
- Data Hold display capability
- Continuity beeper
- Built-in bail
- Anti-skid pads
- Price: DM850 (True RMS)....$219.95*
  DM800 (Average) $169.95*

DM25L Capacitance, Logic, hFE $89.95*

- TTL Logic Probe: 20MHz Hi/lo/off indications Detects 25nS pulse widths
- Capacitance: 5 ranges (2nF to 20μF)
- hFE (NPN or PNP): 1 range (1000)
- Continuity beeper
- Built-in bail
- Anti-skid pads

See your Beckman Industrial distributor and discover more DMM performance. For less.

*Suggested list price ($US) with battery, test leads and manual.

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Circle (1) on Reply Card

IMPORTANT ANNOUNCEMENT FOR ALL READERS

Because of the information we obtained from ES&T readers through questionnaires like the one below, we can tailor ES&T's editorial package to fit your unique needs.

As proof, ES&T recently added new monthly columns on:

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Type of Business

21☐ Consumer Electronics Equipment Independent Or Franchised Service Business
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35☐ Wholesaler, Jobber, Distributor
37☐ Electronics Equipment Or Components Manufacturer
38☐ Government and Military: Federal, State, Municipal
09 Education
(a)☐ College, Library, School, Including Instructors
(b)☐ Student
30☐ Other ______________________

Position

EE☐ **Company Management**
Such as General Manager, Owner, Partner, President, Vice President, Director And Other Corporate Personnel
FF☐ **Operations Management**
Such as Service Manager, Operations Manager, Production Manager, Customer Service Manager, Marketing/Sales Manager, Purchasing Manager, Credit/Accounts Manager and Other Operations/Administrative Personnel
GG☐ **Engineering/Technical & Other Personnel** Such as Engineer, Technician, Field Service Engineer, Specialist, Engineering Associate and Other Engineering And Technical Support Personnel
KK☐ **Other** ______________________

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A☐ 1-5
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C☐ 11-25
D☐ 26-50
E☐ Over 50
F☐ Not applicable

Check the statement that best describes your role in the purchase of major electronics servicing equipment and servicing components, accessories and services.

1☐ Make final decision to buy a specific make or model.
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3☐ Have no part in specifying or buying.

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INTEGRATED CIRCUITS

7400 TTL

Part	Price
7400N	.48
7401N	.48
7402N	.48
7403N	.48
7404N	.50
7405N	.53
7406N	.75
7407N	.75
7408N	.50
7409N	.50
7410N	.48
7411N	.48
7413N	.60
7414N	.68
7416N	.58
7417N	.58
7420N	.48
7423N	.38
7425N	.53
7426N	.53
7427N	.53
7430N	.48
7432N	.48
7437N	.53
7438N	.58
7440N	.58
7441AN	1.50
7442N	.68
7445N	1.18
7446N	1.25
7447N	1.25
7450N	.55
7451N	.48
7453N	.55
7454N	.55
7459N	.25
7460N	.35
7473N	.58
7474N	.58
7475N	.73
7476N	.58
7483N	.83
7485N	.88
7486N	.60
7489N	3.75
7490N	.60
7491N	2.63
7493N	.70
7495N	.70
7496N	.83
74107N	.43
74109N	.63
74121N	.63
74123N	.80
74125N	.78
74132N	.83
74141N	1.63
74145N	1.10
74148N	1.38
74150N	2.03
74151N	.73
74153N	.73
74154N	1.50
74155N	.73
74156N	.88
74157N	.75
74160N	.98
74161N	.98
74163N	.98
74164N	.98
74165N	1.03
74166N	1.13
74170N	2.63
74173N	1.38
74174N	.88
74175N	.88
74176N	1.20
74177N	1.20
74180N	1.13
74181N	[illegible]
74182N	1.15
74184N	3.63
74185N	3.63
74190N	1.08
74191N	1.08
74192N	1.08
74193N	1.08
74194N	1.08
74195N	.75
74197N	[illegible]
74198N	1.88
74199N	1.88
[illegible]	[illegible]
74365N	.83
74366N	.83
74367N	.83
74368N	.83
8093N	[illegible]
[illegible]	[illegible]
8097N	.88
8098N	.88
9334N	[illegible]

74LS00 TTL

Part	Price
74LS00N	[illegible]
74LS01N	[illegible]
74LS02N	[illegible]
74LS03N	[illegible]
74LS04N	[illegible]
74LS05N	[illegible]
74LS08N	[illegible]
74LS09N	[illegible]
74LS10N	[illegible]
74LS11N	[illegible]
74LS12N	[illegible]
74LS13N	[illegible]
74LS14N	[illegible]
74LS15N	[illegible]
74LS20N	[illegible]
74LS21N	[illegible]
74LS22N	[illegible]
74LS26N	[illegible]
74LS27N	[illegible]
74LS30N	[illegible]
74LS32N	[illegible]
74LS37N	[illegible]
74LS38N	[illegible]
74LS40N	[illegible]
74LS42N	[illegible]
74LS47N	[illegible]
74LS51N	[illegible]
74LS54N	[illegible]
74LS55N	[illegible]
74LS73N	[illegible]
74LS74N	[illegible]
74LS75N	[illegible]
74LS76N	[illegible]
74LS78N	[illegible]
74LS83AN	[illegible]
74LS85N	[illegible]
74LS86N	[illegible]
74LS90N	[illegible]
74LS92N	[illegible]
74LS93N	[illegible]
74LS95N	[illegible]
74LS107N	[illegible]
74LS109N	[illegible]
74LS112N	[illegible]
74LS113N	[illegible]
74LS114N	[illegible]
74LS122N	[illegible]
74LS123N	[illegible]
74LS125N	[illegible]
74LS126N	.88
74LS132N	1.03
74LS136N	.56
74LS138N	.83
74LS139N	.83
74LS151N	.75
74LS153N	.75
74LS154N	1.5[illegible]
74LS155N	.88
74LS156N	1.00
74LS157N	.88
74LS158N	.75
74LS160N	1.10
74LS161N	1.10
74LS162N	1.10
74LS163N	1.10
74LS164N	1.05

Part	Price
74LS168N	1.6[illegible]
74LS169N	1.60
74LS170N	2.25
74LS173N	.98
74LS174N	.80
74LS175N	.80
74LS190N	1.13
74LS191N	1.13
74LS193N	1.08
74LS195AN	.98
74LS196N	1.38
74LS197N	1.38
74LS221N	1.45
74LS240N	1.45
74LS241N	1.45
74LS243N	1.45
74LS244N	1.50
74LS249N	1.60
74LS251N	.78
[illegible]	.78
[illegible]	[illegible]
[illegible]	1.18
[illegible]	1.18
[illegible]	1.33
[illegible]	1.80
[illegible]	1.80
[illegible]	.68
[illegible]	.68
[illegible]	.80
[illegible]	.80
74LS374N	[illegible]
[illegible]	[illegible]
81LS95N	2.13
81LS97N	2.13
81LS98N	2.13

74S00 TTL

Part	Price
74S00N	.80
74S02N	.80
74S03N	.80
74S04N	.80
74S05N	.80
74S08N	.80
74S09N	.60
74S10N	.60
74S11N	.80
74S15N	.80
74S20N	.80
74S22N	.60
74S30N	.80
74S32N	.80
74S40N	.80
74S51N	.60
74S64N	.60
74S65N	.60
74S74N	.80
74S86N	.85
74S112N	.83
74S113N	.83
74S114N	.83
74S133N	[illegible]
74S134N	.73
[illegible]	1.25
[illegible]	1.80
[illegible]	1.50
[illegible]	1.50
[illegible]	.80
74S151N	1.50
74S153N	1.50
74S157N	1.50
74S158N	[illegible]
[illegible]	[illegible]
74S174N	[illegible]
74S175N	[illegible]
[illegible]	[illegible]
74S188N	[illegible]
74S189N	[illegible]
[illegible]	[illegible]
74S194N	[illegible]
74S195N	[illegible]
74S196N	2.38
74S197N	[illegible]
74S240N	[illegible]
74S241N	[illegible]
74S243N	[illegible]
74S244N	[illegible]
74S251N	[illegible]
74S253N	[illegible]
[illegible]	[illegible]
74S283N	[illegible]
74S287N	[illegible]
74S288N	[illegible]
[illegible]	[illegible]
74S373N	[illegible]
74S374N	[illegible]
74S387N	[illegible]
74S412N	[illegible]
74S472AN	7.50
74S473AN	7.50
74S474AN	8.25
74S475AN	8.25
74S571N	[illegible]
74S572N	7.88
74S573N	7.88
74S940N	3.60
74S941N	3.60

74C00 CMOS

Part	Price
74C00N	[illegible]
74C02N	[illegible]
74C04N	[illegible]
74C08N	[illegible]
74C10N	[illegible]
74C14N	[illegible]
74C20N	[illegible]
74C30N	[illegible]
74C32N	[illegible]
74C42N	[illegible]
74C48N	2.50
74C73N	1.13
74C74N	[illegible]
74C76N	1.13
74C83N	2.25
74C85N	[illegible]
74C86N	[illegible]
74C89N	[illegible]
74C90N	[illegible]
74C93N	[illegible]
74C95N	[illegible]
74C107N	[illegible]
74C150N	[illegible]
74C151N	3.13
74C154N	[illegible]
74C157N	[illegible]
74C160N	[illegible]
74C161N	[illegible]
74C162N	[illegible]
74C163N	[illegible]
74C164N	[illegible]
74C165N	[illegible]
74C173N	[illegible]
74C174N	1.33
74C175N	1.45
74C192N	2.00
74C193N	2.00
74C195N	1.75
74C200N	13.88
74C221N	2.00
74C240N	2.50
74C244N	2.50
74C373N	3.13
74C374N	3.13
74C801N	[illegible]
74C902N	.88
74C903N	.88
74C904N	.88
74C905N	12.00
74C906N	.88

Part	Price
74C907N	.88
74C908N	1.88
74C909N	3.18
74C910N	13.88
74C911N	13.00
74C912N	13.00
74C914N	2.50
74C915N	2.00
74C917N	13.00
74C918N	2.06
74C922N	6.93
74C923N	6.25
74C925N	8.75
74C926N	8.75
74C927N	8.75
74C928N	8.75
74C932N	1.63
74C941N	2.52
74C945N	11.25
74C947N	11.25
80C95N	1.00
80C96N	1.00
80C97N	.95
80C98N	1.00
82C19N	4.53
88C29N	3.50
88C30N	3.50

74HC00 CMOS

Part	Price
74HC00N	.68
74HC02N	.68
74HC04N	.68
74HC08N	.68
74HC10N	.68
74HC11N	.68
74HC14N	1.23
74HC20N	.68
74HC27N	.68
74HC30N	.68
74HC32N	.68
74HC42N	1.29
74HC73N	.85
74HC74N	.95
74HC75N	.95
74HC76N	.95
74HC85N	1.93
74HC86N	.88
74HC107N	.95
74HC112N	.95
74HC113N	.95
74HC123N	2.70
74HC125N	2.05
74HC126N	2.05
74HC133N	.68
74HC138N	1.35
74HC139N	1.23
74HC147N	1.75
74HC151N	1.13
74HC153N	1.15
74HC154N	3.50
74HC157N	1.13
74HC158N	1.13
74HC160N	1.63
74HC161N	1.63
74HC162N	1.63
74HC163N	1.63
74HC164N	1.58
74HC165N	2.46
74HC174N	1.29
74HC175N	1.25
74HC193N	2.03
74HC194N	1.10
74HC195N	1.35
74HC221N	3.05
74HC240N	3.10
74HC241N	3.10
74HC242N	2.45
74HC243N	2.45
74HC244N	3.10
74HC245N	3.45
[illegible]	[illegible]
74HC4002N	[illegible]
[illegible]	[illegible]
74HC4075N	[illegible]
74HC4078N	[illegible]
74HC4511N	[illegible]
74HC4538N	[illegible]
74HC4543N	[illegible]

Signetics

Part	Price
[illegible]	9.00
AM8012F	16.88
DAC08CN	2.36
MC1408 8N	1.40
MC1408 6N	1.67
NE5018N	7.90
NE5020N	14.96
NE5034FE	5.63
NE5036N	2.66
NE5037N	2.86
NE5410N	13.75
NE5537N	3.13
[illegible]	1.24
NE5614N	1.60
NE5532N	[illegible]
NE5534N	1.28
NE5534AN	5.74
NE542N	.82
TDA1510U	3.60
TDA1010U	1.76
TDA1015U	1.63
[illegible]	5.02
TDA1010AU	1.51
NE587N	3.62
NE589N	3.69
PCE2100N	5.49
PCE2110N	6.39
NE5090N	2.48
NE592N	2.21
NE591N	2.64
NE5044N	2.45
NE5045N	2.45
NE555N	1.87
NE556N	1.58
ULN2003	1.46
ULN2004	1.48
TDA280A	2.70
TDA1023	2.68
TDA1024	2.21
TDA1010	3.83
TDA1029	3.33
TDA1074	6.41
LM339N	.88
SG3524N	2.81
NE532	.77
NE5535N	3.88
NE555N	.65
NE556N	1.20
NE566N	1.64
UA723N	.64

4000 CMOS

Part	Price
4000	[illegible]
4001B	[illegible]
4002B	[illegible]
4006A	[illegible]
4007A	[illegible]
4008B	[illegible]
4009A	[illegible]
4010A	[illegible]
4011B	[illegible]
4012B	[illegible]
4013B	[illegible]
4014B	[illegible]
4015B	[illegible]
4016B	[illegible]
4017B	[illegible]
4018B	[illegible]
4019B	[illegible]
4020B	[illegible]
4021B	[illegible]
4022B	[illegible]
4023B	[illegible]
4024B	[illegible]
4025B	[illegible]
4027B	[illegible]
4028B	[illegible]
4029B	[illegible]
4030A	[illegible]
4031B	[illegible]
4034B	[illegible]
4035B	[illegible]
4040B	[illegible]
4041A	[illegible]
4042B	[illegible]
4043B	[illegible]
4044B	[illegible]
4046B	[illegible]
4047B	[illegible]
4048B	[illegible]
4049A	[illegible]
4050B	[illegible]
4051B	[illegible]
4052B	[illegible]
4053B	[illegible]
4060B	[illegible]
4066B	[illegible]
4068A	[illegible]
4070B	[illegible]
4071B	[illegible]
4073B	[illegible]
4075B	[illegible]
4076B	[illegible]
4081B	[illegible]
4082B	[illegible]
4089B	[illegible]
4093B	[illegible]
4099B	[illegible]
40106B	[illegible]
40160B	[illegible]
40161B	[illegible]
40162B	[illegible]
40163B	[illegible]
40174B	[illegible]
40175B	[illegible]
40192B	[illegible]
40193B	[illegible]
40195B	[illegible]
4503B	[illegible]
4510B	[illegible]
4511B	[illegible]
4512	[illegible]
4514B	[illegible]
4516B	[illegible]
4518B	[illegible]
4519B	[illegible]
4520B	[illegible]
4522B	[illegible]
[illegible]	[illegible]

Linear

Part	Price
LF347N	2.34
LF351N	[illegible]
LF353N	[illegible]
[illegible]	[illegible]
LF356N	[illegible]
[illegible]	[illegible]
LF411CN	[illegible]
LF412CN	[illegible]
LF441CN	[illegible]
LF444CN	2.75
[illegible]	[illegible]
LM301AN	[illegible]
LM307N	[illegible]
LM308N	[illegible]
LM309K	[illegible]
LM310N	[illegible]
LM311N	[illegible]
LM317K	[illegible]
LM317LZ	[illegible]
LM317MP	1.51
LM317T	1.93
LM318N	1.88
LM319N	3.18
LM320LZ 5.0	1.38
LM320LZ 12	1.38
LM320LZ-15	1.38
LM320MP-5	2.61
LM320MP-6	1.79
LM320MP-12	2.61
LM320MP-15	2.61
LM322N	2.20

Part	Price
LM323K	[illegible]
LM324N	[illegible]
[illegible]	[illegible]
LM331N	[illegible]
LM334Z	[illegible]
[illegible]	[illegible]
LM337K	[illegible]
LM337MP	[illegible]
LM337T	2.61
LM338K	[illegible]
LM339N	[illegible]
LM340KC-5	[illegible]
LM340KC-12	[illegible]
LM340KC-15	[illegible]
[illegible]	[illegible]
LM348N	[illegible]
LM349N	[illegible]
LM350K	[illegible]
LM358N	[illegible]
LM359N	[illegible]
[illegible]	[illegible]
LM380N	[illegible]
LM380N-8	[illegible]
[illegible]	[illegible]
LM386N	[illegible]
[illegible]	[illegible]
LM3914N	[illegible]
LM3915N	[illegible]
LM3916N	[illegible]
[illegible]	[illegible]
AN7805	[illegible]
AN7806	[illegible]
AN7808	[illegible]
AN7810	.75
AN7812	.75
AN7815	.75
AN7818	.75
AN7820	.75
AN7824	.75
LM7805CK	3.03
LM7812CK	3.03
LM7815CK	3.03
LM7805CT	.96
LM7812CT	.96
LM7815CT	.96

Part	Price
LM78L05ACZ	.55
LM78L12ACZ	.55
LM78L15ACZ	.55
LM7905CT	1.38
LM7912CT	1.38
LM7915CT	1.38
LM79L05ACZ	1.38
LM79L12ACZ	1.38
LM34CZ	4.81
LM35CZ	4.81

Memory

Part	Price
MM2114N	3.38
MM2114N-3L	3.63
MM2114N-3L	3.50
MM2147N	17.50
MM2716Q	7.38
MM2716Q-5	6.98
4116N-200	1.88
4116N-200	1.95
5280N-200	[illegible]
MM5257N	6.43
74C200N	13.88
74C910N	13.88
74S188N	2.48
74S189N	3.75
74S287N	2.63
74S288N	2.48
74S387N	3.75
74S472AN	7.90
74S473AN	7.90
74S474AN	8.25
74S475AN	8.25
74S570N	4.38
74S571N	4.88
74S572N	7.88
74S573N	7.88

Micro.

Part	Price
COP402N	7.38
COP444LR	75.00
COP470N	4.13
COP498N	5.38
COP499N	5.38
DP8212N	3.78
DP8216N	3.60
DP8224N	4.50
DP8226N	3.50
DP8228N	8.13
DP8303N	5.00
DP8304BN	4.63
DP8307N	5.00
DP8308N	5.00
DP8310N	5.88
DP8311N	5.88
INS8035LN-6	7.50
INS8039N-11	7.50
INS8039N-6	9.60
INS8039N-11	10.50
INS8154N	17.50
INS8255N	9.38
ISP-8P/352	25.00
MM5314	3.25
MM58167AN	15.00
MM58174AN	13.75
MSM5832	9.38
NSC800N-1	21.25
NSC800N-1	12.48
DM8334N	4.60

A/D & D/A

Part	Price
ADC0803LCN	7.75
ADC0804LCN	5.00
ADC0805LCN	[illegible]
ADC0808CCN	[illegible]
[illegible]	[illegible]
DAC1022LCN	7[illegible]
[illegible]	2.50

Interface

Part	Price
DS1488N	1.25
DS1489AN	1.25
DS1489N	1.25
75450N	.90
75451N	.88
75452N	.88
75453N	.88
75454N	.88
75491N	.85
75492N	1.13
75493N	1.80
75494N	1.42

4116 200 nsec 16,384x1 D Ram

Part No.	Price Per Pak Of 8	32	128	512	1024
4116N-ND	15.12	57.12	215.00	806.40	1397.[illegible]
5280N-ND	15.12	57.12	215.00	806.40	1397.[illegible]
Price Each	1.89	1.785	1.68	1.575	1.365

MN4164-15 64K DRAM 150NS $2.96/1 $17.50/9

NEC Memory Chips

Digi-Key Part No.	Description		Price
D4164C-20	Dynamic RAM	16-Dip	$ 2.70
D41416C-15	Dynamic RAM	18-Dip	2.70
D41254C-20	Dynamic RAM	18-Dip	16.43
D2147AD-25	Static RAM	18-Dip	9.23
D2167D3	16,384 x 1-Bit Static N MOS Ram	20-Dip	7.76
D4016C-3	Static RAM	24-Dip	3.94
D446C-2	Static RAM	24-Dip	4.60
D4361C70	Static RAM	22-Dip	46.00
D4364C 20L	Static RAM	28-Dip	7.31
D2764C	EPROM (One-Time Programmable)	28-Dip	9.23
D2764D-2	EPROM (Ultra-Violet Erasable)	28-Dip	11.48
D27128D	16,384 x 8-Bit N-MOS UV EPROM	28-Dip	12.49
D27128C-3	EPROM (One-Time Programmable)	28-Dip	6.08
D27256D	EPROM (Ultra-Violet Erasable)	28-Dip	19.68
D27C64D-25	EPROM (Ultra-Violet Erasable)	28-Dip	13.05

NEC Microprocessor Chips

Digi Key Part No	Description		Price Each
D8748HC	8-Bit Microcomputer	40-Dip	$15.75
D8748HD	8-Bit Microcomputer	40-Dip	18.56
D8749HC	High Performance Single Chip 8-Bit Microcomputer	40-Dip	18.56
D8085AC	Single Chip 8-Bit N Channel Microprocessor	40-Dip	3.38
D8086D	16-Bit Microprocessor	40-Dip	16.88
V30	8086 Replacement	40-Dip	16.85
D8088	High Performance 8-Bit Microprocessor	40-Dip	14.06
V20	8088 Replacement	40-Dip	14.65
D780C-1	High Performance CP/M Compatible NMOS 8-Bit Microprocessor	40-Dip	3.38
D70008C	8-Bit CMOS Microprocessor	40-Dip	5.63

TI I.C. SOCKETS

SOLDER TAIL DIP SOCKETS

- Single beam
- Low profile
- YOUR CHOICE: TIN OR GOLD* (Minimum 30 microinch gold inlay on gold sockets)

TIN PLATED SOLDER TAIL Min. 200 Microinches Tin, -40° to +70°C

Part No.	Description	1	10	100
C8808	8 pin solder tail, tin	.13	1.15	10.50
C8814	14 pin solder tail, tin	.15	1.45	12.00
C8816	16 pin solder tail, tin	.17	1.60	13.00
C8818	18 pin solder tail, tin	.20	1.90	17.00
C8820	20 pin solder tail, tin	.23	2.10	20.00
C8822	22 pin solder tail, tin	.25	2.25	21.00
C8824	24 pin solder tail, tin	.28	2.50	24.00
C8828	28 pin solder tail, tin	.32	2.90	27.00
C8840	40 pin solder tail, tin	.46	4.20	39.00

GOLD INLAY SOLDER TAIL Min. 30 Microinches Gold, -40° to +105°C

Part No.	Description	1	10	100
C9808	8 pin solder tail, gold	.34	3.20	30.00
C9814	14 pin solder tail, gold	.44	4.20	40.00
C9816	16 pin solder tail, gold	.50	4.70	45.00
C9818	18 pin solder tail, gold	.57	5.40	52.00
C9820	20 pin solder tail, gold	.63	5.90	57.00
C9822	22 pin solder tail, gold	.70	6.60	64.00
C9824	24 pin solder tail, gold	.76	7.20	70.00
C9828	28 pin solder tail, gold	.79	7.50	73.00
C9840	40 pin solder tail, gold	1.12	9.90	97.00

WIRE WRAP DIP SOCKETS

- Standard profile
- Universal mounting and packaging capabilities
- Contacts accommodate .015" through .021" rec. or round dual-in-line leads.
- Wire wrap posts held to true position of .015" providing a true position of .020" on boards for efficient automatic wire wrapping*
- YOUR CHOICE: TIN OR GOLD* (Minimum 30 microinch gold inlay on gold sockets)
- TEXAS INSTRUMENTS QUALITY

TIN PLATED WIRE WRAP Min. 200 Microinches Tin

Part No.	Description	1	10	100
C8108	8 pin wire wrap, tin	.38	3.60	34.00
C8114	14 pin wire wrap, tin	.50	4.90	48.00
C8116	16 pin wire wrap, tin	.57	5.60	56.00
C8118	18 pin wire wrap, tin	.69	6.70	65.00
C8120	20 pin wire wrap, tin	.76	7.60	74.00
C8122	22 pin wire wrap, tin	.83	8.20	81.00
C8124	24 pin wire wrap, tin	.91	8.90	88.00
C8128	28 pin wire wrap, tin	1.04	10.30	102.00
C8140	40 pin wire wrap, tin	1.42	13.80	138.00

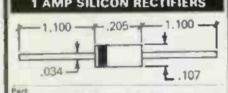
GOLD INLAY WIRE WRAP Min. 30 Microinches Gold

Part No.	Description	1	10	100
C9108	8 pin wire wrap, gold	.59	5.80	57.00
C9114	14 pin wire wrap, gold	.79	7.80	77.0
C9116	16 pin wire wrap, gold	.85	8.40	83.00
C9118	18 pin wire wrap, gold	.99	9.80	97.00
C9120	20 pin wire wrap, gold	1.19	11.80	117.00
C9122	22 pin wire wrap, gold	1.29	12.80	127.00
C9124	24 pin wire wrap, gold	1.39	13.80	137.00
C9128	28 pin wire wrap, gold	1.69	16.80	167.00
C9140	40 pin wire wrap, gold	2.29	22.80	227.00

Silicon Transistors

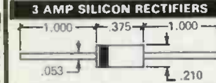
DIGI-KEY Part No	1	10	100	1,000
2N3055	2.02	16.80	151.20	1344.00
2N3904	.23	2.20	18.90	173.25
2N3906	.23	2.20	18.90	173.25
2N4124	.24	2.27	19.50	178.75
2N4126	.24	2.27	19.50	178.75
2N4401	.23	2.20	18.90	173.25
2N4403	.23	2.20	18.90	173.25
2N4410	.33	3.15	27.00	247.50
2N5087	.24	2.20	20.00	180.00
2N5210	.23	2.20	18.90	173.25
2N5457	.67	6.30	54.00	495.00
[illegible]01A	.48	4.20	36.00	330.00
[illegible]	.48	4.20	36.00	330.00
[illegible]U10	.45	4.20	38.00	330.00
[illegible]U51A	.45	4.20	36.00	330.00
[illegible]	.45	4.20	38.00	330.00
[illegible]	.67	6.30	54.00	495.00
[illegible]	.71	6.65	57.00	522.50
[illegible]	.97	9.10	78.00	715.00
[illegible]	.88	8.05	69.00	632.50
[illegible]	.88	8.05	69.00	632.50
[illegible]	.97	9.10	78.00	715.00
[illegible]	.56	5.25	45.00	412.50
[illegible]	.23	2.20	18.90	173.25
[illegible]	.23	2.20	18.90	173.25
[illegible]	.23	2.20	18.90	173.25
[illegible]	.23	2.20	18.90	173.25
[illegible]	.23	2.20	18.90	173.25
[illegible]	.23	2.20	18.90	173.25
MPS3643	.23	2.20	18.90	173.25
MPS918	.28	2.62	22.50	206.25
MPSA13	.33	3.15	27.00	247.50
TIP29	.60	5.25	45.00	375.00
TIP29A	.64	5.60	48.00	400.00
TIP29B	.68	5.88	51.00	425.00
TIP29C	.72	6.30	54.00	450.00
TIP30	.68	5.95	51.00	425.00
TIP30A	.72	6.30	54.00	450.00
TIP30B	.76	6.65	57.00	475.00
TIP30C	.80	7.00	60.00	500.00
TIP31	.64	5.60	48.00	400.00
TIP31A	.68	5.95	51.00	425.00
TIP31B	.72	6.30	54.00	450.00
TIP31C	.76	6.65	57.00	475.00
TIP32	.80	7.00	60.00	500.00
TIP32A	.84	7.35	63.00	525.00
TIP32B	.88	7.70	66.00	550.00
TIP32C	.92	8.05	69.00	575.00
TIP41	.88	7.70	66.00	550.00
TIP41A	.92	8.05	69.00	575.00
TIP41B	.96	8.40	72.00	600.00
TIP41C	1.00	8.75	75.00	625.00
TIP42	1.08	9.45	81.00	675.00
TIP42A	1.12	9.80	84.00	700.00
TIP42B	1.16	10.15	87.00	725.00
TIP42C	1.20	10.50	90.00	750.00
[illegible]	.76	7.00	60.00	560.00
[illegible]	.76	7.00	60.00	550.00
TIP110	.76	6.65	57.00	475.00
TIP111	.80	7.00	60.00	500.00
TIP112	.84	7.35	63.00	525.00
TIP115	.96	8.40	72.00	600.00
TIP116	1.00	8.75	75.00	625.00

1 AMP SILICON RECTIFIERS



Part No.	Description	Pkg.	10	100	1,000	10,000
1N4001	50 PIV	DO-41	.80	7.00	60.00	515.00
1N4002	100 PIV	DO-41	.80	7.00	60.00	540.00
1N4003	200 PIV	DO-41	.80	7.50	64.00	563.00
1N4004	400 PIV	DO-41	.80	7.90	68.00	588.00
1N4005	600 PIV	DO-41	1.00	9.00	74.00	625.00
1N4006	800 PIV	DO-41	1.00	9.00	80.00	661.00
1N4007	1000 PIV	DO-41	1.50	12.00	100.00	710.00
1N4148	Ultra Fast Switching Diode	DO-41	.60	5.00	29.58	211.25

3 AMP SILICON RECTIFIERS



Part No.	Description	Pkg.	1	10	100	1,000
1N5400	3 Amp 50PIV	Plastic	.28	2.56	22.80	199.50
1N5401	3 Amp 100PIV	Plastic	.30	2.70	24.00	210.00
1N5402	3 Amp 200PIV	Plastic	.31	2.83	25.20	220.50
1N5404	3 Amp 400PIV	Plastic	.33	2.97	26.40	231.00
1N5406	3 Amp 600PIV	Plastic	.35	3.15	28.00	245.00
1N5407	3 Amp 800PIV	Plastic	.40	3.60	32.00	280.00
1N5408	3 Amp 1000PIV	Plastic	.50	4.50	40.00	350.00

5% Carbon Film Resistors

Available in 1/8, 1/4 & 1/2 Watt

Wattage Rating	1/8W	1/4W	1/2W
Max. Working Voltage	200V	250V	350V
Rated Ambient Temp.	70°C		
Operating Temp. Range	-55°C to +155°C		
Dimension "L"	3.80	6.50	9.50
Dimension "D"	1.80	2.30	3.20
Dimension "d"	0.46	0.60	0.60

5% Carbon Film Resistor Values in Ohms - 1.0Ω to 4.7M

How To Order: Take any standard resistor value (i.e. 3.2) and add an "E" for 1/8 watt, or a "Q" for 1/4 watt, or an "H" for 1/2 watt (i.e. 3.2Q for 3.2Ω 1/4 watt); this is the Digi-Key part number.

Pricing	5	200	1000
1/8 Watt	.25	5.40	25.00
1/4 Watt	.25	3.40	13.00
1/2 Watt	.25	3.60	15.00

For large quantities and prices as low as $9.95/M call Digi-Key

1/8 Watt Carbon Film Assortments

RS112	5 each of the 73 standard values in series 1.0, 1.2, 1.5, 1.8, 2.2, etc. through 1.0M (365 total pcs.)	$9.90
RS212	5 each of the 72 standard values in series 1.1, 1.3, 1.6, 2.0, 2.4, etc. through 910K (360 total pcs.)	$9.90

1/4 Watt Carbon Film Assortments

RS125	5 each of the 73 standard values in series 1.0, 1.2, 1.5, 1.8, 2.2, etc. through 1.0M (365 total pcs.)	$9.90
RS225	5 each of the 72 standard values in series 1.1, 1.3, 1.6, 2.0, 2.4, etc. through 910K (360 total pcs.)	$9.90

1/2 Watt Carbon Film Assortments

RS150	5 each of the standard values in series 1.0, 1.2, 1.5, 1.8, 2.2, etc. through 1.0M (365 total pcs.)	$9.90
RS250	5 each of the standard values in series 1.1, 1.3, 1.6, 2.0, 2.4, etc. through 910K (360 total pcs.)	$9.90

1% Metal Film Fixed Resistors

Available in 1/4 Watt

Wattage Rating	1/4 Watt
Max. Working Voltage	160V
Rated Ambient Temp.	70°C
Operating Temp. Range	-55°C to +155°C
Dimension "L"	6.5
Dimension "D"	2.3
Dimension "d"	0.6

1% Metal Film Values in Ohms - 10.0 to 1.00M

How To Order: Take any standard resistor value (i.e. 1.69K) and add an "X" (i.e. 1.69KX); this is the Digi-Key part number.

Pricing	5	10	1000
1/4 Watt	.50	3.90	30.00

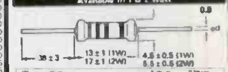
For large quantities and prices as low as $8.15/M call Digi-Key.

1/4 Watt Metal Film Assortments

RSX1	5 each of values 10Ω to 97.6Ω (480 total pcs.)	$29.95
RSX2	5 each of values 100Ω to 976Ω (480 total pcs.)	$29.95
RSX3	5 each of values 1.00KΩ to 9.76KΩ (480 total pcs.)	$29.95
RSX4	5 each of values 10.0KΩ to 97.6KΩ (480 total pcs.)	$29.95
RSX5	5 each of values 100KΩ to 1.00MΩ (480 total pcs.)	$29.95

5% Metal Oxide Film Resistors

Available in 1 & 2 Watt



Wattage Rating	1 Watt	2 Watt
Max. Working Voltage	350V	350V
Rated Ambient Temp.	70°C	70°C
Operating Temp. Range	-55°C to +200°C	
Dimension "L"	13.0	17.0
Dimension "D"	4.5	5.5
Dimension "d"	0.8	0.8

5% Metal Oxide Film Values in Ohms — 0.47 to 1.0M

How To Order: Take any standard value (i.e. 1.5K) and add a "W1" for 1 watt, or add a "W2" for 2 watt (i.e. 1.5KW1 for 1.5KΩ 1 watt); this is the Digi-Key part number.

Pricing	1	5	100	500	1,000
1 Watt	.15	.70	9.00	40.00	72.50
2 Watt	.18	.85	10.50	47.50	87.80

For large quantities and prices as low as $27.75/M call Digi-Key.

1 Watt Resistor Assortments

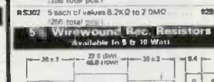
RS101	5 each of values 0.47Ω to 56Ω (256 total pcs.)	$29.95
RS201	5 each of values 62Ω to 7.5KΩ (256 total pcs.)	$29.95
RS301	5 each of values 8.2KΩ to 2.0MΩ (256 total pcs.)	$29.95

2 Watt Resistor Assortments

RS102	5 each of values 0.47Ω to 56Ω (256 total pcs.)	$29.95
RS202	5 each of values 62Ω to 7.5KΩ (256 total pcs.)	$29.95
RS302	5 each of values 8.2KΩ to 2.0MΩ (256 total pcs.)	$29.95

5% Wirewound Rec. Resistors

Available in 5 & 10 Watt



Wattage Rating	5 Watt	10 Watt
Operating Temp. Range	-55°C to +250°C	
Temp. Coefficient	±300 PPM/°C	
Dimension "L"	22.0	48.0

5% Wirewound Rectangular Resistors — 5 Watt Values: 0.30Ω to 2.0KΩ; 10 Watt Values: 1.0Ω to 3.0KΩ

How To Order: Take any standard value (i.e. 7.5) and add "W5" for 5 watt, or add "W10" for 10 watt (i.e. 7.5W5 for 7.5Ω 5 watt); this is the Digi-Key part number.

Pricing	1	10	100	500	1,000
5 Watt	.32	2.90	24.00	90.00	180.00
10 Watt	.35	3.20	27.00	100.00	180.00

For large quantities and prices as low as $92.00 call Digi-Key.

5 Watt Resistor Assortments

RS105	6 each of values 0.30Ω to 0.91Ω (60 total pcs.)	$17.95
RS205	4 each of values 1.0Ω to 9.1Ω (96 total pcs.)	$27.95
RS305	4 each of values 10Ω to 91Ω (96 total pcs.)	$27.95
RS405	3 each of values 100Ω to 2.0KΩ (96 total pcs.)	$27.95

10 Watt Resistor Assortment

R110	2 each of all standard values (168 total pcs.)	$49.95

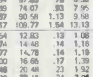
DISC CAPACITORS

Part No.	Cap.	Volt.	10	100	1,000
P4000	10 pf	500	.75	6.49	48.71
P4002	15 pf	500	.75	6.49	48.71
P4003	18 pf	500	.75	6.49	48.71
P4004	22 pf	500	.75	6.49	48.71
P4005	27 pf	500	.75	6.49	48.71
P4006	33 pf	500	.75	6.49	48.71
P4007	39 pf	500	.75	6.49	48.71
P4008	47 pf	500	.75	6.49	48.71
P4009	56 pf	500	.75	6.49	48.71
P4010	68 pf	500	.75	6.49	48.71
P4011	82 pf	500	.84	7.23	54.22
P4100	100 pf	500	.84	7.23	54.22
P4102	150 pf	500	.63	5.43	40.72
P4103	180 pf	500	.63	5.43	40.72
P4104	220 pf	500	.63	5.43	40.72
P4105	270 pf	500	.63	5.43	40.72
P4106	330 pf	500	.63	5.43	40.72
P4107	390 pf	500	.63	5.43	40.72
P4108	470 pf	500	.80	6.91	51.86
P4109	560 pf	500	.80	6.91	51.86
P4110	680 pf	500	.80	6.91	51.86
P4111	820 pf	500	.80	6.91	51.86
P4112	1000 pf	500	1.00	8.58	64.35
P4114	1500 pf	500	1.00	8.58	64.35
P4115	1800 pf	500	1.31	11.25	84.37
P4202	1600 pf	100	.58	5.01	37.57
P4203	2200 pf	100	.58	5.01	37.57
P4205	3300 pf	100	.58	5.01	37.57
P4206	4700 pf	100	.58	5.01	37.57
P4209	6800 pf	100	.70	6.00	45.00
P4300	.01 uf	25	.58	4.83	36.23
P4302	.022 uf	25	.68	5.91	44.32
P4305	.033 uf	25	.82	7.08	53.90
P4307	.047 uf	25	.88	7.68	57.60
P4311	.1 uf	25	1.79	15.37	115.31

NPO NPO NPO NPO NPO NPO NPO NPO

Part No.	Cap.	Volt.	10	100	1,000
P4400	10 pf	500	.73	6.28	47.13
P4402	15 pf	500	.81	6.97	52.31
P4403	18 pf	500	.81	6.97	52.31
P4404	22 pf	500	.81	6.97	52.31
P4405	33 pf	500	1.03	8.89	66.71
P4406	39 pf	500	1.03	8.89	66.71
P4407	39 pf	500	1.37	11.80	88.53
P4408	56 pf	500	1.37	11.80	88.53
P4410	68 pf	500	1.56	13.38	100.35
P4411	82 pf	500	2.05	17.59	131.98

For Complete Specs on Physical Size and Electrical Characteristics, consult your FREE DIGI-KEY Catalog.



ASSORTMENT OF 10 POPULAR VALUES PANASONIC QUALITY — 310 DISC CAPACITORS — CAT. NO. DH-KIT ONLY $24.95

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Miniature Aluminum Electrolytic Capacitors

Value UF	WV D.C.	Axial 1	Axial 10	Axial 100	Radial 1	Radial 10	Radial 100
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

150 CAPACITORS — ASSORTMENT OF 15 POPULAR CAPACITORS — Cat. No. P6200-Kit ONLY $39.95

TANTALUM CAPACITORS

DIGI-KEY Part No.	Cap. (uF)	Volt DC	1	10	100	1000
P2000	3.3	3.15	.31	2.70	22.50	202.50
P2001	6.8	3.15	.31	2.70	22.50	202.50
P2003	15	3.15	.35	3.66	30.56	276.08
P2004	22	3.15	.52	4.46	37.22	335.02
P2005	33	3.15	.63	5.40	45.00	405.00
P2006	47	3.15	.56	5.67	47.25	425.25
P2007	68	3.15	.75	6.75	56.25	506.25
P2008	150	3.15	2.27	19.50	162.50	1462.50
P2011	4.7	6	.31	2.70	22.50	202.50
P2012	6.8	6	.37	3.21	26.81	241.31
P2013	10	6	.50	4.29	35.81	322.31
P2014	15	6	.52	4.53	37.75	339.75
P2015	22	6	.55	5.67	47.25	425.25
P2016	33	6	.68	5.85	48.75	438.75
P2017	47	6	.72	6.21	51.76	465.75
P2018	68	6	1.14	9.80	81.72	735.52
P2019	100	6	2.55	21.88	182.36	1641.26
P2020	150	6	2.74	23.48	195.81	1762.31
P2081	220	6.3	4.34	37.20	310.00	2790.00
P2022	2.2	10	.31	2.70	22.50	202.50
P2023	3.3	10	.31	2.70	22.50	202.50
P2024	4.7	10	.34	2.94	24.50	220.50
P2025	6.8	10	.39	3.36	28.00	252.00
P2026	10	10	.47	4.05	33.75	303.75
P2027	15	10	.59	5.10	42.50	382.50
P2028	22	10	.66	5.70	47.50	427.50
P2029	33	10	.83	7.14	59.50	535.50
P2030	47	10	1.29	11.06	92.17	829.57
P2031	68	10	2.27	19.50	162.50	1462.50
P2032	100	10	2.76	23.70	197.50	1777.50
P2083	150	10	4.56	39.00	325.00	2925.00
P2084	220	10	5.81	49.80	415.00	3735.00
P2033	1.5	16	.31	2.70	22.50	202.50
P2034	2.2	16	.31	2.70	22.50	202.50
P2035	3.3	16	.34	2.94	24.50	220.50
P2036	4.7	16	.39	3.36	28.00	252.00
P2037	6.8	16	.45	3.90	32.50	292.50
P2038	10	16	.61	5.31	44.25	398.25
P2039	15	16	.68	5.85	48.75	438.75
P2040	22	16	.82	7.06	58.75	528.75
P2041	33	16	1.54	13.20	110.00	990.00
P2042	47	16	2.27	19.50	162.50	1462.50
P2043	68	16	2.76	23.70	197.50	1777.50
P7086	150	16	5.81	49.80	415.00	3735.00
P2044	1.5	25	.31	2.70	22.50	202.50
P2045	2.2	25	.34	2.94	24.50	220.50
P2046	3.3	25	.39	3.38	28.00	252.00
P2047	4.7	25	.47	4.05	33.75	303.75
P2048	6.8	25	.59	5.10	42.50	382.50
P2049	10	25	.82	7.06	58.75	528.75
P2050	15	25	1.29	11.10	92.50	832.50
P2051	22	25	1.80	15.45	128.75	1158.75
P2052	33	25	2.56	21.90	182.50	1642.50
P2053	0.1	35	.29	2.55	21.25	191.25
P2054	0.15	35	.31	2.70	22.50	202.50
P2055	0.22	35	.31	2.70	22.50	202.50
P2056	0.33	35	.31	2.70	22.50	202.50
P2057	0.47	35	.31	2.70	22.50	202.50
P2058	0.68	35	.31	2.70	22.50	202.50
P2059	1.0	35	.31	2.70	22.50	202.50
P2060	1.5	35	.44	3.82	31.87	286.87
P2061	2.2	35	.47	4.05	33.75	303.75
P2062	3.3	35	.52	4.50	37.50	337.50
P2063	4.7	35	.56	4.80	40.00	360.00
P2064	6.8	35	.79	6.78	56.50	508.50
P2065	10	35	1.05	9.00	75.00	675.00
P2066	15	35	2.38	20.40	170.00	1530.00
P2067	0.1	50	.32	2.70	22.50	202.50
P2068	0.15	50	.32	2.70	22.50	202.50
P2069	0.22	50	.32	2.70	22.50	202.50
P2070	0.33	50	.32	2.70	22.50	202.50
P2071	0.47	50	.40	3.39	28.32	254.82
P2072	0.68	50	.44	3.78	31.50	283.50
P2073	1.0	50	.45	3.84	32.00	288.00
P2074	1.5	50	.67	5.78	48.00	432.00
P2075	2.2	50	.85	7.26	60.50	544.50
P2076	3.3	50	1.18	10.08	84.00	756.00
P2077	4.7	50	1.55	13.32	111.00	999.00
P2078	6.8	50	3.21	27.48	229.00	2061.00
P2093	15	50	5.88	49.80	490.00	4410.00

ASSORTMENT OF 15 POPULAR VALUES — PANASONIC QUALITY — CAT. NO. F-KIT $54.95

Metallized Polyester Capacitors

DIGI-KEY Part No.	Working Voltage	µF	Pak Of 1	Pak Of 10	Pak Of 100	Pak Of 1,000
E2103	250	.01	.19	1.64	13.68	123.08
E2123	250	.012	.19	1.64	13.68	123.08
E2153	250	.015	.19	1.64	13.68	123.08
E2[illegible]	250	.018	.19	1.64	13.68	123.08
[illegible]	250	.022	.19	1.64	13.68	123.08
[illegible]	250	.027	.19	1.64	13.68	123.08
[illegible]	250	.033	.19	1.64	13.68	123.08
[illegible]	250	.039	.19	1.64	13.68	123.08
[illegible]	250	.047	.19	1.64	13.68	123.08
E2563	250	.056	.22	1.85	15.43	138.83
E2683	250	.068	.22	1.85	15.43	138.83
E2823	250	.082	.22	1.85	15.43	138.83
E2104	250	.10	.23	1.94	16.13	145.13
E2124	250	.12	.25	2.12	17.63	158.63
E2154	250	.15	.27	2.28	18.95	170.55
E2184	250	.18	.29	2.49	20.73	186.53
E2224	250	.22	.32	2.68	22.28	200.48
E2274	250	.27	.34	2.91	24.25	218.25
E2334	250	.33	.37	3.18	26.47	238.17
E2394	250	.39	.41	3.44	28.65	257.85
E2474	250	.47	.43	3.68	30.65	275.85
E2564	250	.56	.47	4.02	33.45	301.05
E2684	250	.68	.52	4.43	36.93	332.33
E2824	250	.82	.58	4.94	41.13	370.13
E2105	250	1.0	.63	5.36	44.62	400.62
E2125	250	1.2	.68	5.82	48.50	436.50
E2155	250	1.5	.86	7.32	60.97	548.67
E2185	250	1.8	1.01	8.64	72.00	648.00
E2225	250	2.2	1.03	8.85	73.68	663.08

ASSORTMENT of 15 POPULAR VALUES — CAT. NO. E-KIT $54.95

PANASONIC V-SERIES

Stacked Metallized Film Capacitors

- **Operating Temperature Range:** -40°C to +85°C
- **Capacity Range:** 0.01µF to 1.0µF
- **Temperature Coefficient** ΔC/C: ±2.5%
- **Standard Capacity Tolerance:** ±5%
- **Dissipation Factor (max.):** 1.0%
- **Insulation Resistance (20°C):** 1000MΩ-µF
- **Voltage Coefficient (DC):** Negligible
- **Aging Rate:** Negligible
- **Electrodes:** Metallized film
- **Lead Spacing:** .200, .300
- **Self-Healing:** Yes
- **WVdc:** 50V

V-SERIES

DIGI-KEY Part No.	Cap. µf	Price 1	10	100	1,000
P4509	0.0047	.11	.91	7.89	57.40
P4510	0.0056	.11	.91	7.89	57.40
P4513	0.01	.11	.91	7.89	57.40
P4514	0.012	.11	.94	8.08	58.90
P4515	0.015	.11	.98	8.47	61.60
P4516	0.018	.11	1.01	8.75	63.70
P4517	0.022	.12	1.06	9.15	66.60
P4518	0.027	.12	1.12	9.66	70.20
P4519	0.033	.13	1.18	10.23	74.40
P4520	0.039	.14	1.24	10.71	77.90
P4521	0.047	.15	1.32	11.39	82.90
P4522	0.056	.16	1.42	12.26	89.20
P4523	0.068	.17	1.53	13.19	95.90
P4524	0.082	.18	1.63	14.03	102.10
P4525	0.1	.18	1.68	14.49	105.40
P4526	0.12	.20	1.81	15.62	113.80
P4527	0.15	.24	2.21	19.00	138.20
P4528	0.18	.24	2.21	19.00	138.20
P4529	0.22	.27	2.42	20.83	151.50
P4530	0.27	.30	2.70	23.23	169.00
P4531	0.33	.33	3.00	25.79	187.60
P4532	0.39	.38	3.33	28.62	208.20
P4533	0.47	.41	3.75	32.29	234.90
P4534	0.56	.46	4.21	36.24	263.60
P4535	0.68	.52	4.72	40.56	295.00
P4536	0.82	.58	5.32	45.78	333.00
P4537	1.0	.66	6.02	51.75	376.00

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Circle (3) on Reply Card

The how-to magazine of electronics...

ELECTRONIC
Servicing & Technology

Volume 7, No. 6 June 1987

page 11
An IC tester can be a wise investment for anyone who tests a lot of digital circuitry. *(Photo courtesy of B&K Precision)*

page 7
Consumer high-tech. *(Photo courtesy Toshiba)*

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Problems finding information?

You're not alone

One of the most frequent requests we get from our readers is for information: "Where can I find a schematic for an xyz 19-inch color TV?" or, "Where can I find a course on servicing VHS VCRs?"

The other side of that coin is the information that flows from the manufacturers, from the book publishers, from the associations, from, well, from this magazine. There is no shortage of information.

Just the other day, for example, I received five books from one publisher for review. That's in addition to the 20 or so assorted books from a number of publishers that are still waiting to be reviewed in ***ES&T***.

The five books I just received, which are still cluttering my desk, are all different in information content and purpose. One is a textbookish book that covers components, circuits and systems. It starts out with an excursion into the physics of semiconductors, goes into the method of growing a silicon crystal, describes how semiconductor devices are fabricated, then goes into a very mathematical treatment of the operation of the devices, using idealized models to develop the formulas.

Two of the books have "troubleshooting" in the title: one specifically aimed at microprocessors, and providing detailed, specific instructions on troubleshooting microprocessor circuit segments, the other more slanted toward the human aspects of developing generalized troubleshooting skills.

Another of the five books calls itself a "complete" guide to servicing television and the other is a "complete" electronics reference. They both look as though they contain some good information, but "complete"? Hardly.

One of the five books, the one on servicing of microprocessor-based equipment, seems to be packed with good information. It lists the kinds of test equipment available, from the simplest to the most complex and sophisticated. It mentions specific types of servicing equipment by manufacturer. It explores specific types of logic circuits, describes the theory of operation and explains how to go about troubleshooting the system.

The information problem faced by servicing technicians comes down to the fact that most of the information that's needed is available—somewhere, in some form. Sometimes it's very difficult to find. Other times it's almost incomprehensible even if you can find it. Of course, especially with new technology, on some occasions the information is either not available at all, or if it is, it's only sketchy.

Some of the books I've read remind me of a book I used in a course in statistics, probability and all that, as an introduction to statistical quality control. When I took the course I understood it pretty well. Later, when I got my first programmable calculator, I decided to review the course and to use the calculator's statistical functions.

What had seemed fairly understandable when I took the course was now totally incomprehensible. After a little reflection I realized why this was so. During the course we had used the instructor's notes and a workbook. We used the text only for the statistical tables in the back. No doubt the text was technically accurate. It was just almost impossible to read.

This problem is general. What one author makes clear, another obfuscates. The lesson is clear. When you're looking for information, as the old adage says, "if at first you don't succeed, try, try again."

It is indeed unfortunate that this problem exists. We wish we could do something to improve the situation. Any suggestions?

Nils Conrad Persson

Technology

Digital technology Double scanning Clearer TV pictures

TV receivers that use the double-scanning method for high-quality picture resolution now have been designed economically enough for home use. The Toshiba Corporation recently developed and marketed color TV sets that also employ a high-contrast, full-square picture tube for further enhancement of TV-broadcast reception, as well as videocassette and videodisc programming. The consumer's demand for better picture quality has kept pace with the trend toward larger screens.

Interlaced scanning and double scanning

A TV screen is made up of a collection of horizontal lines called scanning lines. One picture (or one frame) on a TV screen consists of 525 scanning lines. Conventionally, not all of the 525 scanning lines are sent at once, but they are sent in two chunks of images called fields, which consist of 262.5 scanning lines each. When these two fields are sent consecutively, they appear to be a single picture to the human eye. This scanning method is called interlaced scanning.

The interlaced scanning poses a problem in terms of resolution because the gap between the lines in each field is sometimes recognizable to the human eye. To solve this problem, the double-scanning method virtually doubles the scanning line density of each field by increasing the number of scanning lines from 262.5 to 525 lines, thereby filling the gap between scanning lines.

Principle of double scanning

Toshiba doubled the scanning lines by using two semiconductor chips called line memories in a digital memory circuit. In the double scanning method, each line is scanned twice to fill in the space that conventional television leaves between the scanning lines as a gap. (See Figure 1.)

Although the number of the scanning lines in one field is twice as great with double scanning, the number of scanning lines in one frame remains 525 because the two fields are overlapped to make one picture.

Because the scanning time for one field is predetermined, the scanning speed had to be made twice as fast. Toshiba developed a high-quality picture tube in conjunction with a new type of deflecting circuit that can handle a very high switching frequency. This maintains focus correctness and contrast at the same or higher level than that of conventional TV sets.

ES&T

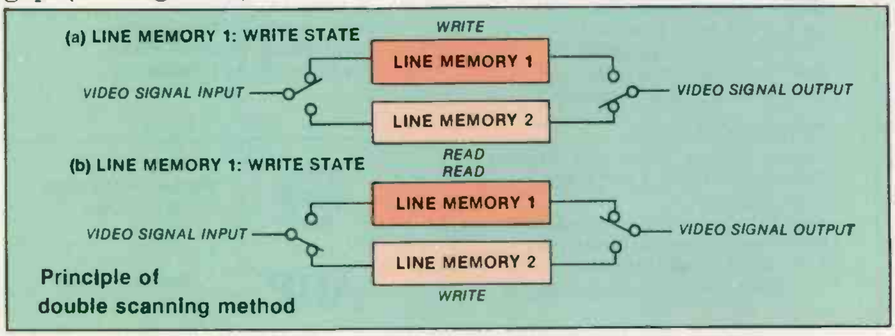

Figure 1. While the line memory 1 is reading *in* the video signal of the scanning line at a given moment, line memory 2 reads *out* the previous line (a). While line memory 1 reads *out* the scanning line (b), line memory 2 reads *in* the next line (b). These functions are then repeated. *(Photo courtesy of Toshiba Corporation.)*

News

VCR servicing workshops

The Electronic Industries Association sponsors a 5-day, basic VCR training program at United Electronics Institute, Tampa, FL, and Illinois Technical College, Chicago.

The workshops are conducted by EIA-trained instructors who supply state-of-the-art VCR instruction. The curriculum covers the basic functions of playback, recording, servo control for both the Beta and VHS systems as well as mechanical operation.

If you are just entering into VCR servicing, this resident VCR program presents an opportunity to upgrade your technicians and prepare them for further high-tech product training. To qualify for enrollment the technician must:

1. be working currently as a consumer electronics technician;
2. submit an application on company letterhead signed by the owner or a superior;
3. include the workshop location of preference.

Locations and dates include:

Illinois Technical College
506 S. Wabash Ave.
Chicago, IL 60605
Aug. 24-28, 1987

United Electronics Institute
4202 Spruce St.
Tampa, FL 33607
June 29-July 3, 1987
Sept. 28-Oct. 3, 1987
Mar. 28-April 1, 1988

Mail the letter of application on company letterhead signed by a supervisor to:

Don Hatton
Electronic Industries Assn.
2001 Eye St. NW
Washington, DC 20006
202-457-4919

A letter of confirmation will be sent to you upon acceptance requesting a $50 pre-registration fee (company check or money order), which will be refunded upon completion of the seminar or if you cancel at least two weeks prior to the class.

Due to the limited size of the class, only one technician from each organization may attend a particular session. It is suggested that applications for enrollment be mailed as early as possible.

The Nat'l Bureau of Standards invites you to participate in this 1987 survey ➤ ➤ ➤

Your responses will be of great help to NBS even if you answer only some of the questions.

For those less familiar with NBS sevices, "GOES" refers to Geostationary Operational Environmental Satellites that broadcast the NBS time code; "DUT1," to information included in broadcast formats providing the approximate difference between the UT1 astronomical time scale and the UTC atomic time scale; "Marine Weather," to marine storm warnings; "Geoalerts" relate to solar activity and solar-terrestrial conditions; "Omega" relates to the current status of the U.S. Coast Guard's Omega Navigation System; and "BCD Time Code," to time-of-day information in binary-coded-decimal form provided on 100Hz subcarriers on WWV and WWVH.

Please fold and mail the completed questionnaire or use the circle number if a separate form is desired.

Circle (124) on Reply Card

ELECTRONIC Servicing & Technology

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NBS-1220
(2-87)

1987 SURVEY OF NBS TIME AND FREQUENCY SERVICE USERS

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
OMB NUMBER 0652-0024
APPROVAL EXPIRES JUNE 30, 1987

My responses primarily reflect the view of: ☐ an individual ☐ an organization

Organization name ______________________ Approximate number of time and frequency users in this organization ______

USE OF CURRENT SERVICES	WWV (MHZ) 2.5	5	10	15	20	WWVH (MHZ) 2.5	5	10	15	WWVB 60 KHZ	GOES SATELLITE 469 MHZ	TELEPHONE WWV	WWVH
How often do you use each of these NBS services? (0=Never; 1=Rarely; 2=Sometimes; 3=Frequently)													
How often do you observe harmful interference when using these services? (0=Never; 1=Rarely; 2=Sometimes; 3=Frequently)													
How would you characterize your usual reception reliability? (0=Extremely poor; 1=Poor; 2=Generally adequate; 3=Excellent)													
Do you usually use these services during daytime or nighttime hours? (D=Day; N=Night; B=Both)													

ADEQUACY OF CURRENT SERVICES	WWV	WWVH	WWVB	GOES SATELLITE	TELEPHONE TIME-OF-DAY
Do the current NBS services satisfy your needs for accuracy? (0=No; 1=Marginally; 2=Generally yes; 3=Yes)					
Do the current NBS services satisfy your needs for reliability of reception and ease of use? (0=No; 1=Marginally; 2=Generally yes; 3=Yes)					

FOR USERS OF WWV AND WWVH	VOICE TIME OF DAY	BCD TIME CODE	1-SECOND TICKS	STANDARD FREQUENCY	DUTI VALUES	MARINE WEATHER	GEOALERTS	OMEGA STATUS
Which types of information on these broadcasts do you use at least occasionally? (Indicate by checking each appropriate box)								
How important is each type of information? (0=Not at all; 1=Marginal importance; 2=Important; 3=Very important)								

Is the present quality of the voice announcements of weather, geoalerts, and Omega System status adequate for your needs? (Yes or No) ☐ Yes ☐ No If no, why? ______________________

FOR USERS OF WWVB	STANDARD FREQUENCY	TIME CODE
How important to you or your organization is each of these aspects of WWVB? (0=Not at all; 1=Marginal importance; 2=Important; 3=Very important)		

FOR USERS OF THE GOES SATELLITE TIME CODE

Does interference in your area significantly hinder the usefulness of the satellite time code? (Yes or No) ☐ Yes ☐ No

Do you use the GOES time code status reports by accessing the "NBSGO" file in the U.S. Naval Observatory's Automated Data Service System? (Yes or No) ☐ Yes ☐ No

Do you use the full accuracy of the time code (100 microseconds) via a receiver that automatically corrects for path delay variations? (Yes or No) ☐ Yes ☐ No

Do the occasional time code shifts of more than 100 microseconds at times of satellite maneuvers cause serious problems for your application? (Yes or No) ☐ Yes ☐ No

FOR USERS OF THE WWV OR WWVH TELEPHONE TIME-OF-DAY SERVICES

How often do you encounter busy signals when calling (303) 499-7111 or (808) 335-4363? (0=Never; 1=Rarely; 2=Sometimes; 3=Frequently) ☐

Would the value of these services be decreased if only a high-quality voice time announcement were available without the weather, geoalert, or Omega status information? (Yes or No) ☐ Yes ☐ No

If yes, why? ______________________

(OVER)

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POSSIBLE FUTURE CHANGES IN NBS SERVICES	ACCURACY	RECEPTION RELIABILITY	COVERAGE AREA	EASE-OF-USE	USER COST
In the development of future time and frequency services which of the following aspects need the most improvement? (Check appropriate boxes)					

If the availability of new services in the future with improved capabilities in terms of accuracy, reliability, coverage, etc. required the payment of an annual user fee of less than $250/year, would you or your organization likely subscribe to such a service? (Yes or No) ☐ Yes ☐ No

Do you need NBS timing signals designed for direct interfacing to computers? If "Yes", what accuracy level is needed? ☐ Yes ☐ No

Accuracy Level ____________

What new or improved time and frequency services would you find useful? (Please describe briefly)

____

USER DATA

Please indicate which of the items below apply to you as a user of NBS services: (✓)

- ☐ Private Citizen
- ☐ Government/civilian
- ☐ Government/military
- ☐ Radio/TV Operations
- ☐ Standards Lab
- ☐ Electric Power Industry
- ☐ Telephone Industry
- ☐ Aviation/aerospace Industry
- ☐ Transportation Systems
- ☐ Communications Systems
- ☐ University
- ☐ Geophysics/seismology
- ☐ Health Care Industry
- ☐ Pleasure Boating
- ☐ Equipment Manufacturing
- ☐ Jeweler/watchmaker
- ☐ Amateur Radio

Other (Specify) ______________________________

Please indicate which of the items below describe the purposes for which you use the NBS time and frequency services: (✓)

- ☐ Frequency Calibrations
- ☐ Watch/clock Setting
- ☐ Master Clock
- ☐ Navigation/Position Location
- ☐ Time Base for Computers
- ☐ Time Base for Synchronizing or Controlling Operations
- ☐ Time Base for Data Monitoring
- ☐ Surveying
- ☐ Space/missile tracking
- ☐ Marine Weather
- ☐ Propagation Information
- ☐ Astronomy
- ☐ Hobby
- ☐ Geolart Information
- ☐ Omega System Information

Other (Specify) ______________________________

In what state of the United States or foreign country do you use the NBS time and frequency services? (Two-letter state abbreviation or country) ____________

Please estimate the annual economic value of the NBS time and frequency services to you or your organization, if possible. $ ________

Additional Comments:

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IC tester

By Conrad Persson

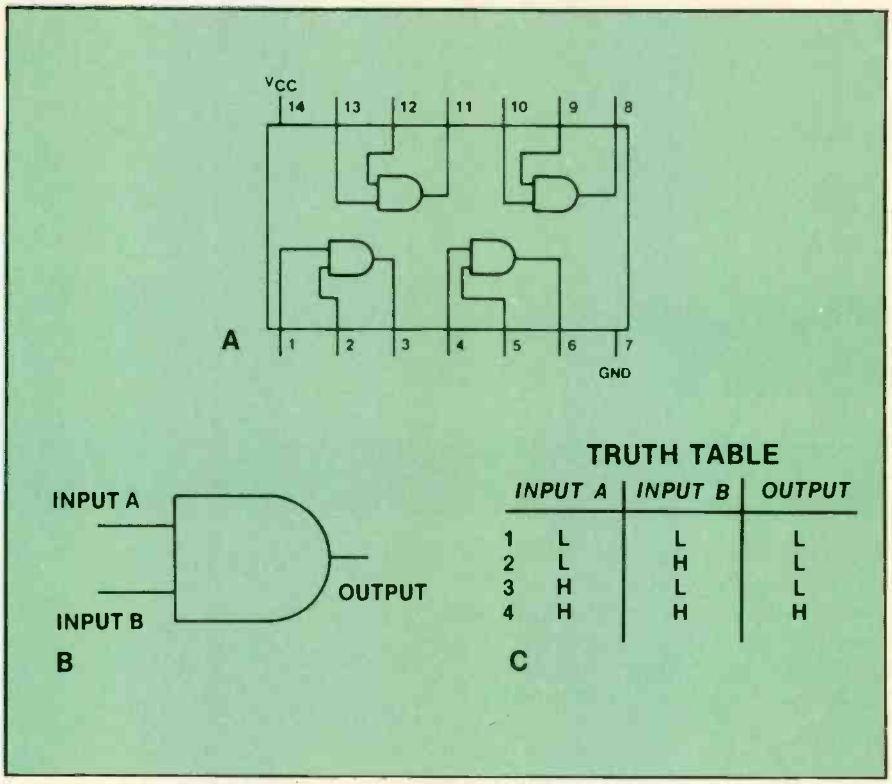
The introduction of integrated circuits a few years ago created a revolution in electronics. The immediate result was a reduction in the size of electronic products, an increase in their speed of operation and reduction of power consumption. That revolution has continued at breakneck speed since then, with the result of an array of products that couldn't even have been dreamed of before: laptop computers, Walkman-type stereo equipment, compact disc audio and laserdisc video, electronic watches, credit card calculators. The list could go on and on.

Besides the obvious effects on size and performance on every type of electronics equipment, the introduction of ICs had a number of other effects on the electronics world. Standard logic ICs, such as the 74 series, allowed circuit designers to begin designing by using functions rather than voltage/current relationships. For example, a circuit designer who wanted to include AND gates into a design didn't have to study how they worked and design them. He simply could go out and buy a 7408 quad 2-input AND gate and–as long as his circuit provided the gate with the proper source voltages and logic inputs–it would work.

The effect of ICs on servicing

The effects of ICs didn't stop at the design engineer and consumer levels. ICs also had a profound effect on servicing technicians. For instance, technicians often enhance their understanding of a circuit by tracing the circuit visually, taking voltage readings at strategic points in the circuit and following the logic of the design. Trying to do that in a circuit containing ICs can be an exercise in frustration. You can trace the circuit up to the IC's pins but if you want to know what's going on inside, you have to obtain the literature of the

Information, photos and illustrations on which this article was based were provided by B & K Precision.



TRUTH TABLE

	INPUT A	INPUT B	OUTPUT
1	L	L	L
2	L	H	L
3	H	L	L
4	H	H	H

Figure 1. Quad 2-Input AND gate, 7408, is simply an IC that contains, on a single chip, four AND gates, each with two inputs.

manufacturer and study it. And as often as not the circuitry will be shown as functions rather than actual electronic components.

This has introduced additional mystery into a subject that is already surrounded by mystery, making it increasingly difficult to comprehend.

Then comes the question of testing ICs, especially logic ICs. Because with logic ICs you're frequently dealing with data that's flowing at high rates, you can't just probe with the usual test equipment: DMM, oscilloscope and so forth. Some *specialized* equipment is needed: logic probes, logic pulsers, IC testers.

Testing ICs

You can proceed to test ICs in a number of ways. For starters there is the old standby, the DMM. It will reveal a lot of things about ICs. Of course, there are also a lot of things it will not reveal. For example, with power to the board under test turned *off,* if you suspect a specific IC, you can probe its pins with the meter set to the OHMS scale. This approach will reveal certain classes of problems like opens or shorts. With power applied to the device under test, the meter can be switched to DC VOLTS and used to probe dc levels.

An oscilloscope likewise can be used to diagnose certain types of faults in IC circuits.

For most effective troubleshooting of logic ICs, though, you need to use test equipment specifically made for the purpose. The specific types of IC test equipment you'll need will depend on the amount and complexity of the digital equipment you'll be servicing.

Here's a list of some of the IC test equipment that's readily available from test equipment manufacturers and distributors you're familiar with:

- Logic probe
- Logic pulser
- Logic test clip
- Logic timing analyzer
- Logic state analyzer
- IC tester

Logic ICs

Before proceeding with the theory and operation of the test equipment, let's take a look at some of the circuitry it's designed to test. Figure 1 is a logic representation of a quad 1-input AND gate. The standard semiconductor industry designation for one of these ICs is 7408. For those of you unfamiliar with the concept of design and operation of these devices, here's a review.

As you know, computers and computer-based equipment use a lot of logic gates. In the early days of integrated circuits, before an entire computer could be fabricated on a single IC chip, semiconductor manufacturers recognized that if they fabricated several gates on a single IC chip, computer designers could design their circuits based on these ICs. Given the state of the art of IC fabrication at the time, multiples of gates in a chip made sense.

A quad 2-input AND gate, then, is simply one IC package that contains four AND gates, each of which has two inputs.

Figure 1B shows a single AND gate. Its truth table is shown in Figure 1C. If no input signal is present at input A or B, there is no output. If there is an input signal present at either input A or input B, but not at both, again there is no output. Only if there is an input signal present at both A AND B is there an output. That's why it's called an AND gate.

With the right test equipment it's a piece of cake to test one of these devices during troubleshooting. First check to see that V_{DD} and V_{SS} are present. If not, there's a problem somewhere, but not necessarily in this IC. If those two supply voltages are present, it remains to check the operation of each of the four individual gates.

Note that one gate has as inputs Pins 1 and 2, and its output is Pin 3. Another gate has Pins 5 and 6 as inputs and Pin 4 as output. The third gate has Pins 8 and 9 as inputs and Pin 10 as output, and the fourth gate has Pins 12 and 13 as inputs and Pin 11 as output. To test this IC, once you have checked for the presence of the correct supply voltages, you simply need to check each gate to see if its characteristics correspond to its truth table. We'll discuss that in detail when we get into the IC testers portion of this article, but basically, it's just a matter of monitoring the output of each gate one at a time while you apply, first, no signal at both inputs, then a signal at each output alternately, then a signal at both inputs. If you get an output signal when there is a signal present at both inputs, but not signal otherwise, the gate is operating properly.

The OR gate

Logically enough, the 74 series of ICs also includes a quad 1-input OR gate, 7432 (see Figure 2). Not surprisingly, the source voltages are at the same pins as on the 7408, Pins 7 and 14. In addition, inputs and outputs to each of the gates are at the same pins.

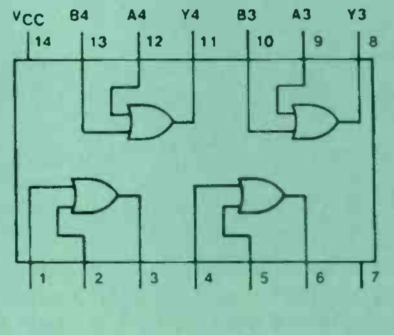
Testing the 7432 proceeds in a similar manner to testing the 7408. First, verify that the correct source voltages are present at Pins 7 and 14. Assuming that these signals are present, you can proceed to testing the individual gates. No signal at either input to any of the gates will result in no signal at the output of that gate if the gate is operating properly. A signal at either input or at both inputs to either gate should result in an output.

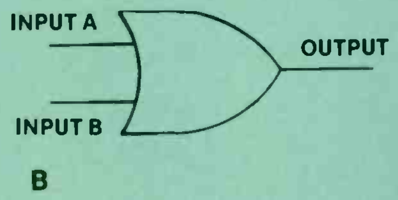
The logic probe

The logic probe, Figure 3, indicates the logic state of point being tested, whether it is at a logic HIGH or LOW. A sophisticated probe will have indicators to show if the test point is HIGH or LOW or exhibiting pulses. Some will even have a memory or pulse stretcher that will show the presence of a 1-shot pulse that is of duration so short that either it's insufficient even to light the indicator, or lights it too briefly to be recorded by the human eye.

The indicators used on these logic probes to show the logic state of the pin being tested are usually LEDs. In some cases a single LED is used to indicate any of the conditions: HIGH, LOW or pulsing, while in other cases, individual LEDs are used for each indication.

Let's say you're doing troubleshooting using a sophisticated logic probe that is capable of testing a number of different kinds of logic circuits: TTL, DTL, CMOS. You would connect the probe's power input to the power supply from which the circuitry being tested derives its power. Con-





TRUTH TABLE

	INPUT A	INPUT B	OUTPUT
1	L	L	L
2	L	H	H
3	H	L	H
4	H	H	H

C

Figure 2. Quad 2-Input OR gate, 7432, contains four OR gates, each with two inputs.

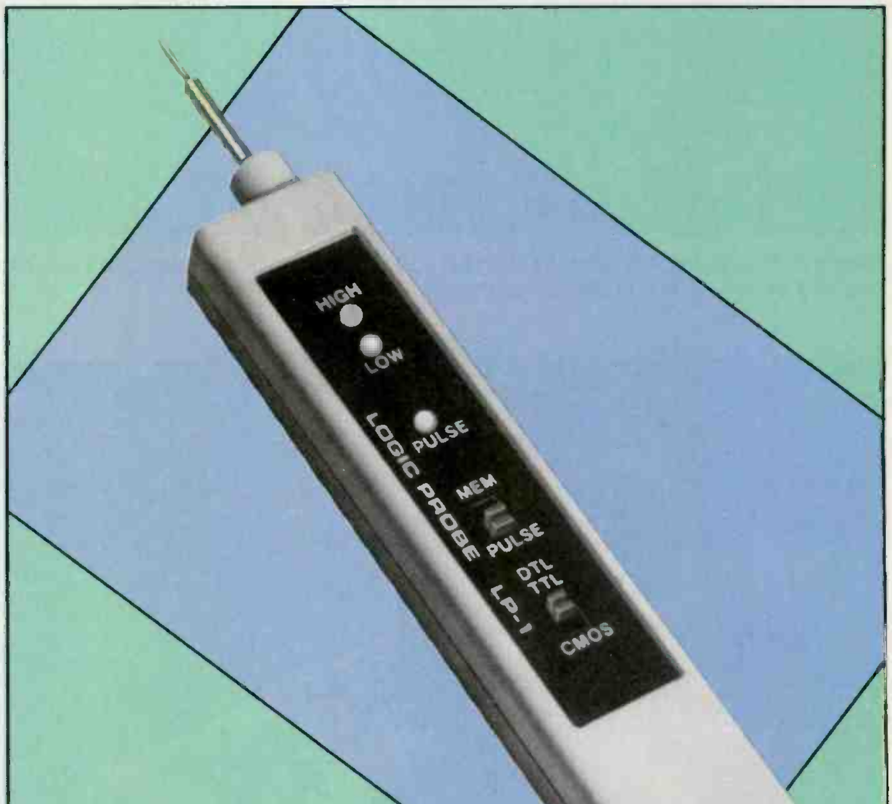


Figure 3. A logic probe can be used to determine if a given logic IC pin is at a HIGH logic level, a LOW logic level, or if it is pulsing.

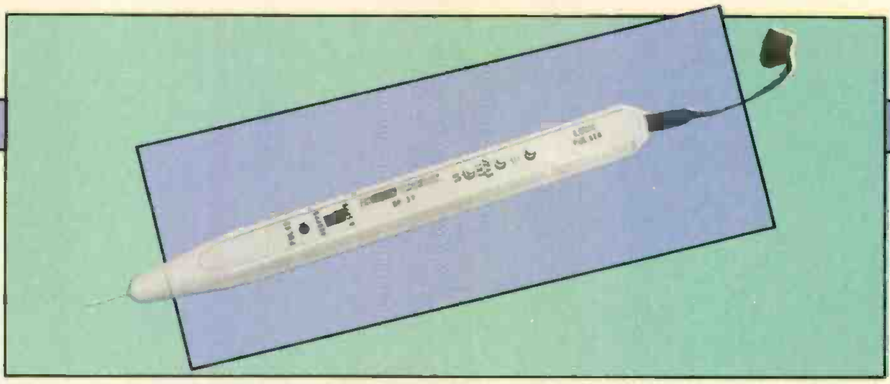


Figure 4. A logic pulser may be used to inject pulses, or trains of pulses, at inputs to logic ICs. Used in conjunction with a logic probe, it can help pinpoint problems.

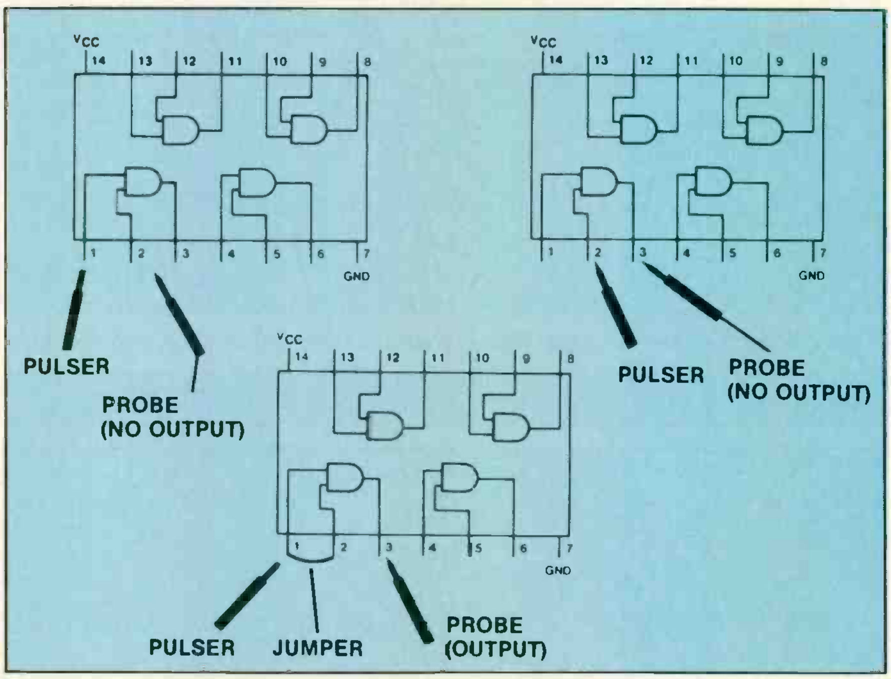


Figure 5. By pulsing and probing the appropriate inputs and outputs of a logic IC, you can determine if it is operating properly or if it's defective.

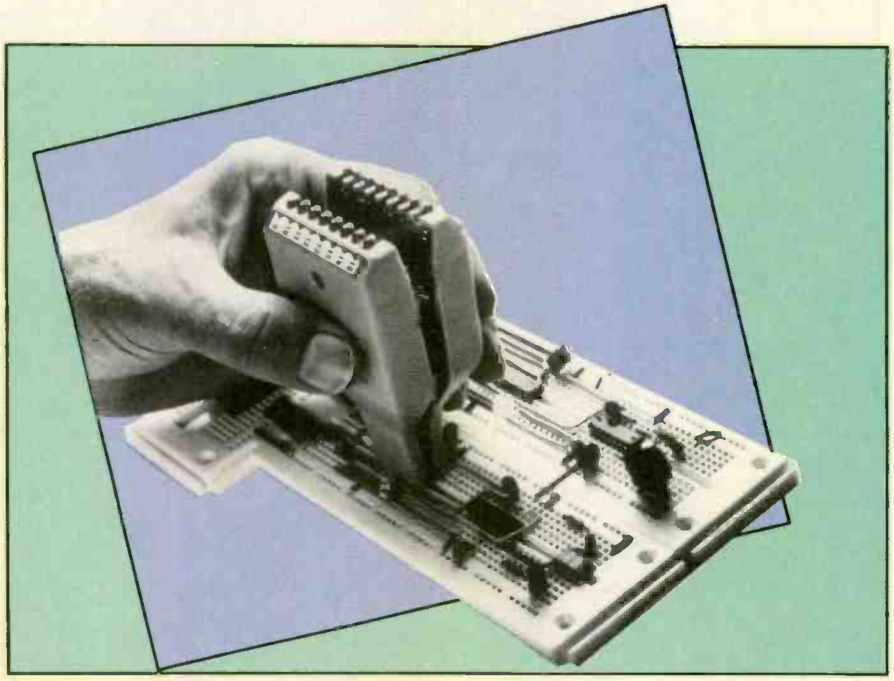


Figure 6. A logic monitor clips over the leads of an IC to be tested. LEDs read out the logic level of all pins simultaneously.

necting the probe in this manner will indicate the approximate value of signal voltage that constitutes a logic LOW or HIGH. For example, the power supply voltage for a CMOS logic circuit is 18V. A logic LOW in this circuit would be about 30% of that value or 5.4V. A logic HIGH in this circuit would be about 70% of 18V or approximately 12.6V.

If you suspect a specific IC, it would make sense once you have the logic probe connected into the circuit's power supply to go directly to that IC. Otherwise, use the time-tested method of starting approximately in the middle of the circuit, and let the results at that point guide you upstream or downstream a half-circuit at a time.

The logic pulser

The logic pulser, Figure 4, is the active counterpart to the logic probe. When its tip is placed against an IC pin and you push the button, it will inject a pulse, or a train of pulses, into the IC.

Here's how you might test a 7408 quad 2-input AND gate, using a pulser and probe (Refer to Figure 5). Starting with one of the gates, say the one with input Pins 1 and 2 and output Pin 3, connect the probe to Pin 3 for the duration of the test. Then apply a pulse, using the pulser at Pin 1. There should, of course, be no output. Then apply a pulse at Pin 2. Again, there should be no output. Then, observing precautions to avoid circuit damage, place a jumper across Pins 1 and 2 and apply a pulse to both pins simultaneously. If the gate is working properly, a pulse should appear at Pin 3 and be observed on the logic probe.

To make sure that the complete IC package is good, place the logic probe at Pins 4, 10 and 11 in turn and pulse input Pins 5 and 6, 8 and 9, and 12 and 13, just as you did Pins 1 and 2 to check each of the other gates.

By applying logic properly, or simply by following the circuit's truth table, you can use the logic pulser and probe in combination to test any other similar logic IC.

Figure 7. If you plan to troubleshoot a lot of digital logic circuitry, you might want to use an IC tester.

Logic monitors

Another inexpensive test device for logic ICs is the logic monitor, Figure 6. This a unit that clips right over the IC to be tested. The monitor features an LED for each of the pins on the IC that reads out at any time what the logic level is at that pin.

IC testers

If you don't test a lot of digital ICs, the logic probe and pulser and possibly the logic monitor will probably be all the logic test equipment you'll ever need. If, however, you plan to troubleshoot a lot of digital logic circuitry, you might want to have available an IC tester (See Figure 7), one that you can connect to an IC and receive an immediate display of that IC's condition. With one of these units, you don't have to pulse or probe, and you don't have to interpret the condition of one or more LEDs. You simply set the device up for the IC to be tested, plug the IC into the tester's socket and test it.

Conventional IC testers test chips by generating test patterns that exercise all possible input-state combinations of the chip being tested. For example, the NAND gate shown in Figure 8A has a maximum of four input-state combinations. These four possible input combinations yield four test patterns that the tester must carry out to completely test this device. When the four test patterns and the resulting output of the device for each of the test patterns and the resulting output of the device for each of the test patterns (1) through (4) (Figure 8B) are arranged in a table, a truth table is developed. As noted by the name, the truth table represents

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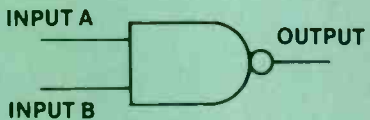
Circle (27) on Reply Card

response that should be obtained for test patterns (1) through (4).

IC testers produce each of the test patterns (1) through (4), apply one pattern at a time to the inputs; and check the output result for each test pattern. The correct results for a given chip are known and are held in memory. The tester checks the results obtained from the chip under test by executing each test pattern, and then decides if the results match the predetermined correct results. If all of the results agree, the chip is declared good. If any of the results do not match with the predetermined correct results, the tester declares the chip defective.

Figure 9 shows the truth tables and comparisons between a good device (chip No. 1) and a defective device (chip No. 2). Note how a chip No. 2 test pattern (4) does not match the predetermined result. The tester notices the error and declares the chip as defective.



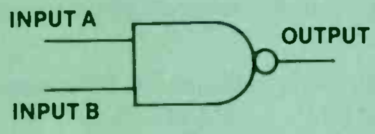
TRUTH TABLE

	INPUT A	INPUT B	OUTPUT
1	L	L	H
2	L	H	H
3	H	L	H
4	H	H	L

B

Figure 8. An IC tester applies a pattern of signals to the input pins of a logic IC and tests for the response. If the response is different from that expected, the IC is declared to be defective.

CHIP NO. 1: "GOOD" CHIP

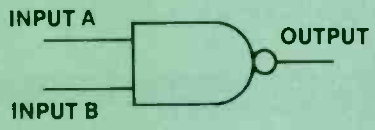


TRUTH TABLE

	INPUT A	INPUT B	GATE OUTPUT	TESTER REQUIRES:
1	L	L	H	H
2	L	H	H	H
3	H	L	H	H
4	H	H	L	L

H = +5V
L = 0V

CHIP NO. 2: "DEFECTIVE" CHIP



	INPUT A	INPUT B	GATE OUTPUT	TESTER REQUIRES:
1	L	L	H	H
2	L	H	H	H
3	H	L	H	H
4	H	H	H	L

H = +5V
L = 0V

Mismatch

Figure 9. The input/response pattern of chip No. 1 is the pattern expected, so chip No. 1 is labeled "good." The pattern for chip No. 2 does not match the expected pattern, so it is branded "defective."

Limitations to conventional testing

Conventional functional tests are perfectly suited for all out-of-circuit device tests. In out-of-circuit testing conditions, the tester is free to toggle each input of the chip HIGH or LOW, thereby executing all patterns of the chip's truth table.

For many in-circuit applications, inputs to the chip are wired in ways that prevent the tester from executing the predetermined test pattern that corresponds to the chip's truth table. Called *hard wiring*, this is commonly used.

Figure 10A shows again a 2-input NAND gate with its inputs free from imposed states. In this case, the expected customary truth table can be executed and, as expected, the gate output exactly matches the response required by the tester (designated "TESTER REQUIRES" in all truth tables shown).

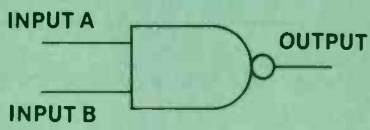
Figure 10B shows the same 2-input NAND gate wired with input A tied to Vcc (+5V). This is a very common *in-circuit* configuration. Assume that the gate is functional. Now we'll attempt conventional functional testing of the gate. Notice what has happened to the test patterns. During the execution of test patterns (1) and (2), input A of the chip was prevented from going to the LOW (0V) state. Most important, notice what happened during test pattern (2): The tester tried to pull input A low. However, input A is tied to +5V. During test pattern (2) this condition prevented the expected test pattern from being executed. Therefore, in this case the expected output was not produced. Instead of the chip outputting a HIGH during this test pattern, the chip outputted a LOW, causing the tester to declare the chip "defective" even though it is good.

Figure 10C shows the same 2-Input NAND gate wired as an inverter; both leads are tied together. This is another very common configuration that will be encountered during in-circuit testing. Again assume that the gate was previously checked and is known to be good. Here's what happens if you attempt conventional functional testing of the gate. Again, notice what has happened to the test patterns. During test pattern (2), input A is expected to go HIGH; but the jumper connecting the two inputs together make opposite states on each input impossible. During test pattern (3), the opposite input state orientation occurs; but again the jumper connecting the two inputs makes this impossible. During test patterns (2) and (3), an invalid result is outputted from the gate. The tester will certainly give a "defective" result during test pat-

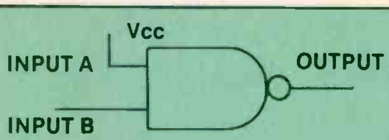
A

TRUTH TABLE

	INPUT A	INPUT B	GATE OUTPUT	TESTER REQUIRES:
1	L	L	H	H
2	L	H	H	H
3	H	L	H	H
4	H	H	L	L



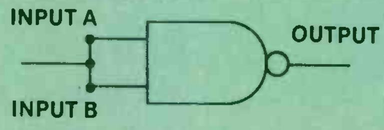
B



When one Input is wired to Vcc test patterns 1 and 2 are invalid because Input A cannot toggle "low."

	INPUT A	INPUT B	GATE OUTPUT	TESTER REQUIRES:
1	H	L	H	H
2	H	H	L	H
3	H	L	H	H
4	H	H	L	L

C



When both inputs are wired together, test patterns 2 and 3 are invalid because Input A and B cannot attain opposite logic states simultaneously.

	INPUT A	INPUT B	GATE OUTPUT	TESTER REQUIRES:
1	L	L	H	H
2	L	H	I	H
3	H	L	I	H
4	H	H	L	L

I = Invalid state; could result in random H or L gate output.

Figure 10. The Truth Table for the NAND gate in A, which has its inputs from imposed states, is the correct Truth Table. In B, Input A is tied to Vcc, and in B the inputs are hard-wired together. A NAND gate in either of these configurations will test "defective" on a conventional tester.

tern (2) or (3), or both. Again, due to the unexpected nonstandard input wiring, the tester will declare the chip as "defective" even though the chip is known to be good.

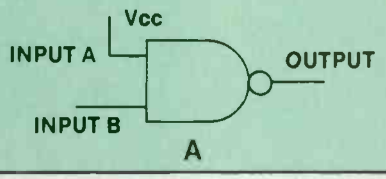
IC testers that can learn

Some IC testers are able to circumvent the problem of nonstandard configurations by including a learning or storage mode. Using this mode, the IC tester exercises the input of a gate that is known to be operating properly in a nonstandard configuration with the normal set of input signals, but instead of declaring the nonstandard output to signify a defective IC, it accepts the output to be proper for that configuration and stores it.

Take, for example, the configuration we've discussed before shown in Figure 11. Because one of the inputs of the NAND gate is tied back to Vcc, the repsonse of this circuit will not be that of a standard NAND gate. When the

TRUTH TABLE

	INPUT	INPUT	OUTPUT	REQUIRES:
1	X	L	I	I
2	X	H	I	I
3	H	L	H	H
4	H	H	L	L



	INPUT A	INPUT B	OUTPUT
1	L	L	I
2	L	H	I
3	H	L	H
4	H	H	L

Rejecting test patterns 1 and 2 , Compare Testing only considers...

the valid patterns 3 and 4 ...

	INPUT A	INPUT B	TESTER NOW REQUIRES:
1	H	L	H
2	H	H	L

These patterns yield the "new" Truth Table. The "new" patterns 1 and 2 will be used by the Model 560 Compare Mode to test additional "Figure 7" circuits.

B

Figure 11. An IC tester with COMPARE mode can store the Truth Table input/output patterns of a hard-wired IC and use this "new" pattern as a criterion for testing similarly wired ICs.

IC tester is placed in the compare mode, now the obtained gate output represents the "new" function of the NAND gate as wired in this example. This new gate output (response) develops a new truth table for the NAND gate. The new truth table, shown beside the circuit of Figure 11, becomes the criterion against which other circuits wired in the same way will be tested.

Testing ICs, the same only different

Troubleshooting methods for electronic circuits have changed considerably since the advent of ICs, yet the object of the exercise is the same: stimulate a circuit segment with a known signal and observe the response. If the response is different from what was expected, you strongly suspect that the defect lies there and test some more.

The broad range of IC test equipment sophistication allows the servicing technician to choose between spending more time with relatively simple, inexpensive test devices, or to save time with more sophisticated, but more expensive, test equipment.

It's important also to keep in mind that because of the huge numbers of different kinds of ICs being manufactured, no programmed tester could possibly test them all. So even if it makes sense to own one of the sophisticated testers, it still will be necessary to maintain skills with logic pulsers, probes and similar testers to test the logic ICs that haven't been programmed into the high-dollar testers. ES&T

Locating and Replacing The Defective Flyback

Some flyback defects not only stop the television operation but also leave a trail of burned and destroyed components. This article describes a method of applying reduced line voltage to protect most components while extended testing can be performed. Several case histories are presented.

By Homer L. Davidson

A defective flyback transformer instantly can destroy any or all of these components: the horizontal-output transistor; the low-voltage regulator transistor; various zener and regular silicone diodes; and several power resistors. All might be ruined before a fuse can blow.

Most flybacks are mounted near a corner (as this one) or at an edge with the horizontal circuitry around them. Most new flybacks are called Integrated High-Voltage Transformer (IHVT) because the HV diodes are inside the flyback.

Flybacks can develop many types of defect. One might have shorted turns in a winding, and this could not be detected by resistance measurements. If you service a lot of televisions you should have some piece of equipment that includes a *ringer*, an impedence tester or some other item that is capable of checking inductances. A short from some winding to ground can be formed when the flyback forms a leakage path between winding and core, where it cannot be seen. Many models take a voltage sample from the *cold* end of the high-voltage winding, using it in the automatic-brightness circuit, and often to trigger the safety shutdown circuit from excessive HV current. Occasionally, a *flyback* will produce this excessive current in the HV winding's cold end, which sometimes activates shutdown. Of course, excessive HV amplitude also will activate the shutdown, and flybacks sometimes produce excessive HV.

Integrated flybacks in the later models might have internal arcing between windings and the high-

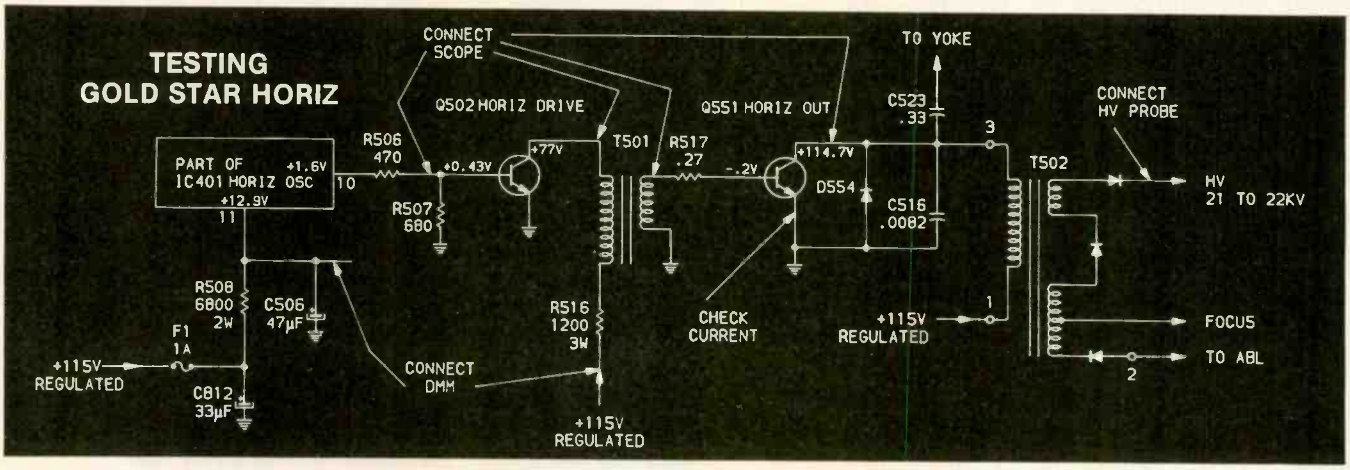


Figure 1. All three horizontal stages of the Gold Star CNR-405 (Photofact 1993-1) are supplied from the regulated +115V supply that comes from rectification of 60Hz line voltage plus transistor regulation. Therefore, testing can be done on the oscillator and driver stages even when the output stage is not operating. Some likely points to connect DMM, scope and HV probes when troubleshooting this circuitry are marked by arrows.

voltage diodes. This arcing can be accompanied by loud popping and cracking noises. During power-on operation, watch the flyback carefully, looking for signs of smoke, bubbles in the plastic covering, or any arcovers between a winding and chassis. After a short time of operation, uplug the machine and with caution feel the flyback, searching for hot spots or an abnormally warm body.

Flybacks are susceptible to being destroyed by any large overload, such as a shorted yoke and pincushion wiring or serious leakages of one or more of the dc-voltage pulses that are rectified from flyback pulses. A flyback horizontal-output transformer can be destroyed by excessive high voltage produced by an open retrace-tuning capacitor (the largest capacitor in parallel with the damper diode), although the output transistor is even more likely to be shorted from those higher peak voltages. A leaky tripler rectifier or yoke might overload the flyback, tripping the circuit breaker (or blowing the fuse, whichever is provided) or causing a shutdown from excessive HV rectifier current.

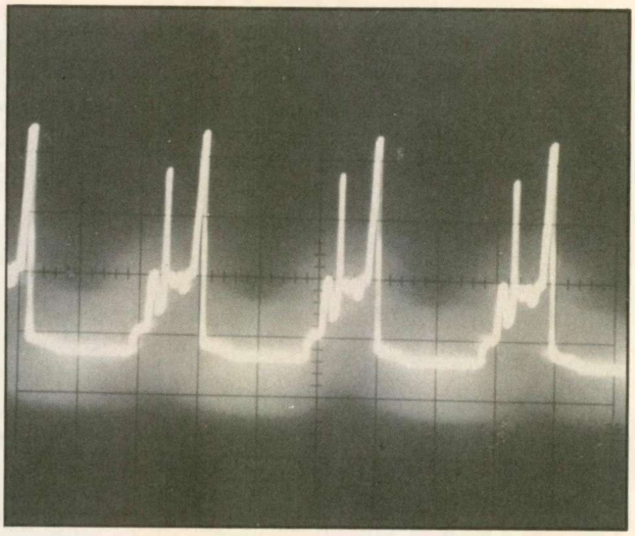
Test equipment needed

For finding defective flybacks, the absolute minimum includes a wideband ac/dc-coupled triggered oscilloscope, a dependable DMM with diode test: a dc HV probe with meter, and a 60Hz transformer giving 0 to 130Vac output with isolation between input and output. These two functions might be in two components, but the penalty is more clipping of the waveform tips than usual. Minimize this clipping (and some problems with certain start-up circuits) by using larger-than-necessary transformers of higher wattage ratings.

Accurate voltage, resistance and current readings can be made by the DMM almost anywhere in the horizontal system. The scope can view waveforms from the horizontal oscillator to the horizontal-output transistor's collector during troubleshooting. And a high-voltage probe is required to find out whether the dc high voltage is low, correct or high. If necessary, all three instruments can be connected to different points in an intermittent chassis. After the intermittent has occurred, the results from one or two of the readouts should show the approximate location of the problem. For example with low voltage, they can be connected with the DMM to the horizontal-oscillator B+, the scope to the output-transistor base and the probe to the CRT. Then the readings are watched and analyzed as the line voltage is increased slowly from 30Vac to 80 or 90Vac, which should permit some operation when the circuit is not defective, while protecting the output transistor and other sensitive components if the circuit still has defects. Remember, a shorted flyback or other serious load on the horizontal-output transistor usually destroys the transistor instantly. Practice and refine your technique for using the variable ac-voltage transformer to allow testing at lower voltages.

Other measurements

Unsolder the wire at the horizontal-output transistor's emitter and connect a dc-current meter between the wire and the emitter pin. The current reading should prove whether or not the horizontal circuits are overloaded. Abnormally high current could indicate insufficient base drive or a heavy load on the collector of the



This is a typical waveform obtained at the horizontal-output transistor's base. Waveforms taken from other models will be slightly different.

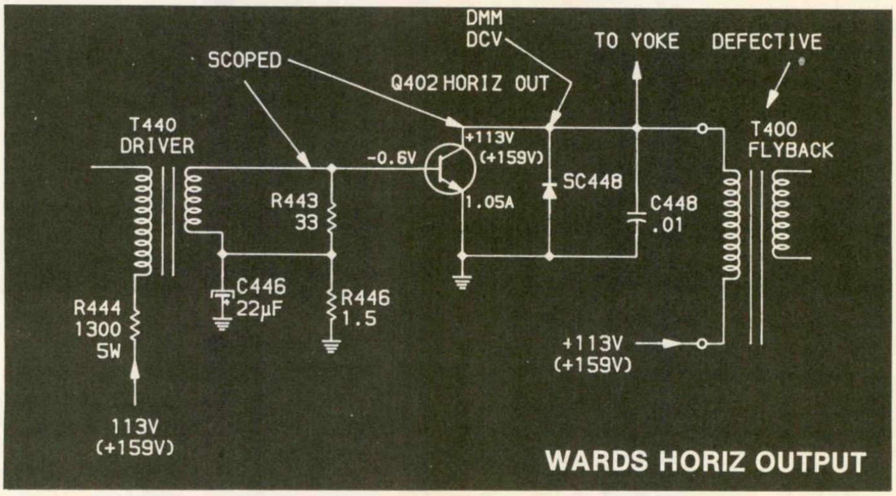


Figure 2. A high collector voltage (+159V vs. +113V) in a Wards GGY-16210C (Photofact 1961-3) usually indicates an open Q402 output transistor or lack of drive signal to the base.

output transistor.

In older color receivers, the output transistor emitter current measured between 350mA and 600mA. These televisions had little load on the flyback except the high voltage. Present-day receivers require from 500mA to 1.5A of output-transistor emitter current, and the flybacks must supply additional power for several *scan rectification* low-voltage sources. In the RCA CTC120 chassis for example, there are nine different voltage sources, and the output transistor's emitter current is about 1.2A.

Practical troubleshooting

Horizontal-sweep systems with the horizontal-oscillator and driver stages powered from the low-voltage dc-power supply (instead of a supply produced by rectification of a flyback signal) are easier to troubleshoot for problems involving overloads of the horizontal-output transistor. The horizontal-output transistor can be removed and the oscillator and driver operated first at 120Vac line voltage, while the scope and DMM check those two stages for correct operation. (Figure 1.) If they are not operating correctly, the defects in them must be corrected before the output transistor is reinstalled and full power applied. If the two stages are operating correctly, the problems apparently involve the horizontal-output stage, which then must be tested at a low line voltage to prevent ruining the output transistor or other components.

After a leaky or shorted horizontal-output transistor has been replaced, connect the current meter in series with the output transistor's emitter, and connect the HV probe to the HV connector on the picture tube (and to CRT ground, of course). The scope and DMM will be used for many different measurements, so they cannot be connected permanently. Finally, obtain ac power from the isolation/variable-voltage ac transformer. Begin with the DMM testing dc voltage at the output-transistor collector; adjust the scope for an expected waveform at the output-transistor's base.

Starting near zero, slowly increase the receiver ac power until about +60V is measured by the DMM at the output transistor's collector. Check the emitter current meter. If the current reading is more or less than half the rated current, stop and make an evaluation. Much less current might indicate a lack of proper base waveform or an open in the flyback. Much higher current than the half mark is the danger area. Perhaps the output transistor has leakage at the operating voltage. The flyback might have shorted turns or leakage to ground. Or the yoke or one of the scan-rectification power supplies (powered from the flyback) could have an excessive load. These possibilities should be investigated now at low-ac voltage before full line voltage is restored.

Scope the output transistor's base-drive waveform. A photograph shows the correct waveform of a similar receiver when operated with full line voltage. Of course, the amplitude will be lower and the waveshape will be less complex when the chassis is operated with a lower voltage during testing. Loss of base signal, an unrecognizable waveform or a very weak amplitude indicate problems in the horizontal-driver or oscillator stages. They must be tested separately (with output transistor removed and full line voltage) using DMM and scope.

While continuing to use the same line voltage that gave +60V at the horizontal-output transistor, scope the collector waveform. If the waveform has ringing or insufficient amplitude (with or without a large pulse about midway between the correct ones), it is likely that the flyback, or one of its loads, has become defective and added a virtual ac short to the flyback. Erratic pulses might be caused by arcing of the internal high-voltage diodes inside the flyback. If the output collector waveform is normal (for the reduced test voltage) but the current is excessive, one by one remove the wires supporting scan-rectification dc voltage supplies and other sweep-powered circuits.

Checking the yoke–To determine if the yoke is shorted and thus loading down the horizontal circuits, remove the red wire from the yoke terminal. A large reduction of dc emitter current indicates the yoke has shorted turns: Replace the yoke.

Remember that each of many models (the Gold Star not included) has a yoke plug with a jumper wire between two pins. When the yoke plug is removed, the absent jumper wire removes the B+ from the sweep circuits to prevent their operating without the yoke loads. That is not a hazard at the low voltages used for these specific tests. Therefore, if disconnecting the yoke had little effect on the output's dc emitter current, suspect overloads from the flyback secondary winding circuits. First, check each rectifier, using the voltage-drop diode test of the digital-multimeter. In the event some tests are inconclusive, unsolder the anode of each diode, and if the correct emitter current is restored without any noise pulses in the collector's waveform, you have located the general source of the overload. Then troubleshoot the rectifier circuits for any defective diode, filter capacitor, bypass capacitor, resistor or zener diode that might cause high leakage and load-down the flyback.

HV shutdown–To determine when a chassis is shutdown from excessive high voltage, use the variable ac-voltage transformer again. Slowly increase the receiver's ac input voltage and notice the relationship between the rising ac and the increasing low voltage and the HV. When the ac voltage is only 80Vac, but the low voltage is excessive, the LV regulator probably is at fault. Check Q801, D806, R804 and other components around Q802 and Q801 (see Photofact 1993-1).

Monitor the high voltage and notice the lowest ac input voltage that activates the shutdown. If the low-voltage regulation is operating correctly, but the shutdown is activated before the line voltage is raised to 120Vac, the cause could be excessive high voltage or a defect in the safety shutdown circuit. One fast way to test is to start at perhaps 80Vac and measure the high voltage as the ac input is increased slowly. If the two voltages rise in step, and at 100Vac the HV is 10% to 15% below the normal value, then shutdown occurs when the ac reaches 100Vac, the problem definitely is in the safety shutdown circuit. On the other hand, if the two voltages are not in step, but at about 100Vac the high voltage has already reached the normal value, followed by an increase to above normal before shutdown occurs at perhaps 110Vac, the source of the problem is excessive high voltage. As stated

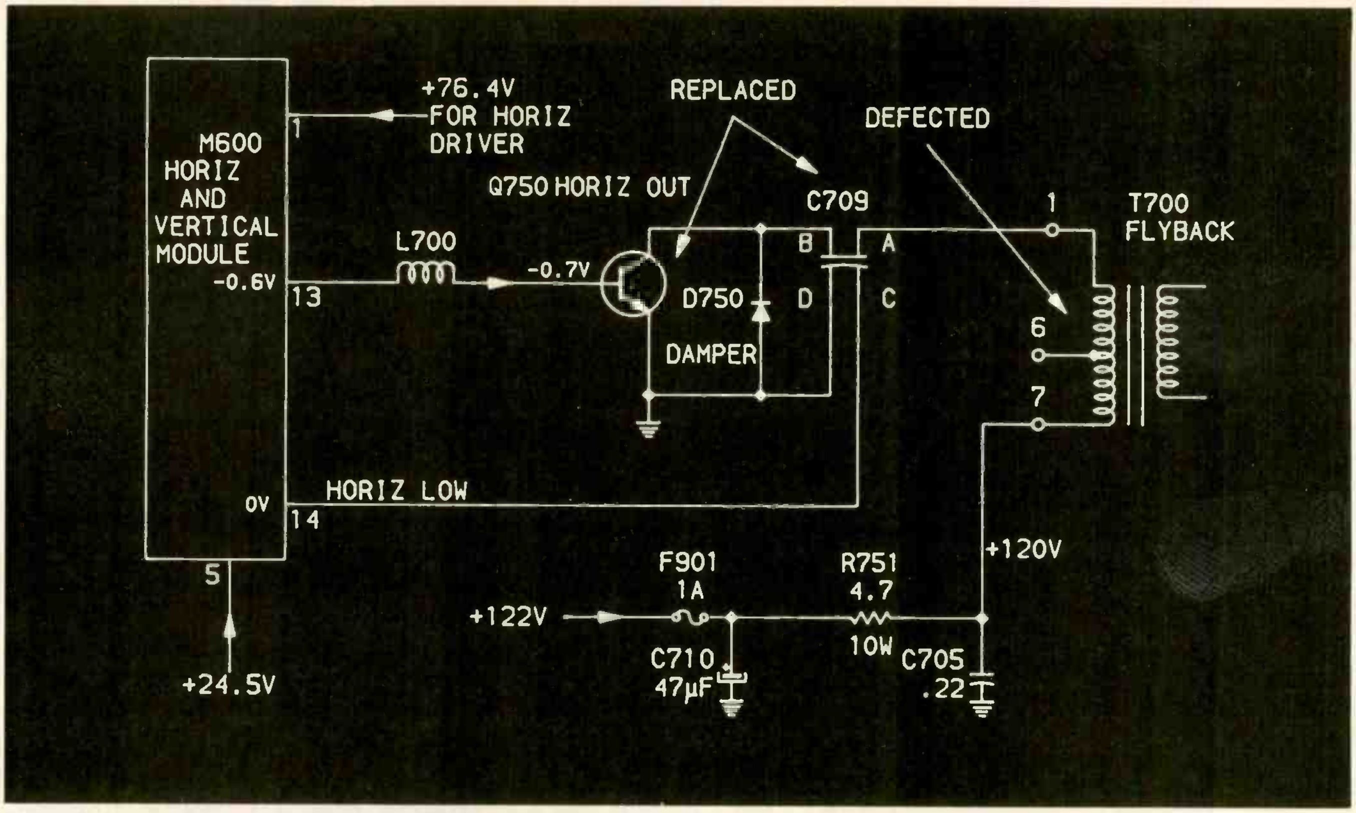
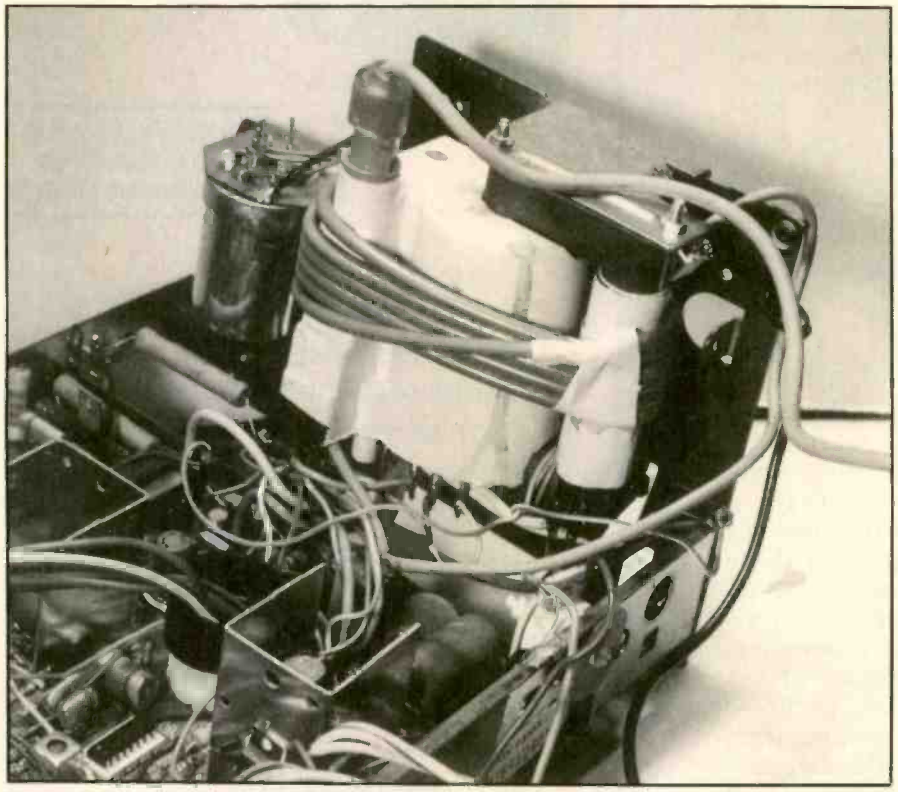


Figure 3. Instantaneous blowing of the F901 1A fuse was the only symptom of the 9M50 Admiral (1667-1). At lower line voltages, the fuse would blow when the horizontal-output transistor's collector dc voltage reached +75V. After many tests from the horizontal oscillator to C709, nothing could be found defective, although Q750 and C709 were replaced on speculation. Therefore, T700 was replaced and normal operation was obtained.



Replacing the defective T400 flyback in Wards GGY-16210C portable restored the high voltage and picture (Photofact 1961-3).

before, retrace-tuning capacitor C516 is the first suspect (Figure 1).

Remember that the amount of B+ voltage applied to the horizontal-output transistor's collector directly affects the amount of high voltage. Always test the B+ supply and adjust its voltage, if necessary. If a method is provided, also test the shutdown operation after making repairs in the horizontal system.

Wards without picture or sound

In a Wards GGY-16210C portable television (Photofact 1838-1), the Q402 horizontal-output transistor's collector dc voltage was high at +159V (normal +113V), indicating an open transistor or greatly insufficient drive signal at the base (Figure 2). Previously, Q402 and damper diode SC448 had been replaced. I scoped the Q402 base pin, finding very little signal.

A normal waveform was scoped at the base of horizontal drive Q400. Next, Q400 was tested in-circuit by using the junction voltage-drop measurement in my DMM. The forward-junction voltage and reverse leakage were satisfactory.

Q402 was removed and tested by the voltage-drop and leakage methods. While Q402 was out of its socket, I checked the base waveform with power *on*. Although the waveform did not have the usual appearance, it was much higher in amplitude. Reasoning that Q402 might be breaking down under load or having some other defect that I couldn't test, I replaced it with an ECG165 universal. The results were unchanged.

Perhaps a defective flyback or yoke was loading the horizontal-output circuit. But if so, why didn't the CB500 circuit breaker trip open? The yoke's red lead was disconnected, but the results were the same.

Finally, the flyback was replaced *and the problems were solved;* the output transistor's collector voltage reduced to normal and the base drive was good. I drew a sketch of the flyback wiring connections, not only to help us wire this flyback correctly, but it was left with the schematic for possible use with future repairs.

Admiral blows fuses

F901, the 1A fuse for the Q750 horizontal-output transistor in Figure 3, would blow as soon as it was replaced in the Admiral 9M50 TV chassis (Photfact 1667-1). When the line voltage was raised from zero by the autoformer, the fuse would blow when the Q750 horizontal-output collector's dc voltage reached +75V. Q750 and retrace-tuning capacitor C709 have been known to fail in the past, so they were both replaced. Unfortunately, the performance was no better.

When Q750 output was removed, the 120V supply increased to +132V when the line voltage was 120Vac. The Q750 base signal measured more than 6Vp-p. Q750 was replaced. The power line voltage was reduced to near zero and then slowly brought up to +70V at the output transistor's collector (remember the fuse blows at +75V). Next, yoke plug J751 was unplugged to eliminate any possibility of excessive loading from the yoke windings. Of course, pins 4 and 8 of the yoke socket were clipped together to supply dc voltage to the pincushion circuits. There was still no high voltage at the picture tube.

Replacement of T700 flyback with an original part number 79A195-1 *solved the fuse blowing.*

Another Admiral–The same F901 fuse would open in another Admiral 9M50 (Photofact 1667-1). T700 was suspected of causing the

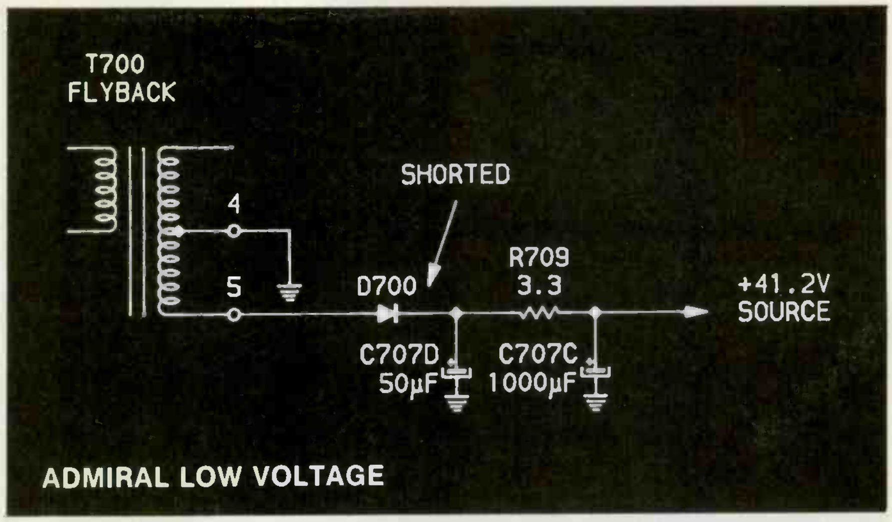


Figure 4. This Admiral 9M50 also blew the same 1A fuse when power was applied, but the defect was not the same as the previous repair. Voltage tests revealed almost zero voltage at the +41.2V source, and another test located a shorted D700. Replacement of D700 and several adjustments completed that repair.

fuse to blow because the symptoms were exactly the same: the fuse would open when the output transistor's dc voltage was increased to +85V. However, a few tests were made before T700 was replaced, because replacing a flyback is costly in time and material. Only +17V was found at the +24.5 source for the deflection module. A more important test was finding a shorted D700 (Figure 4) and the near-zero voltage at the +41.2V source. It is hard to understand why the shorted D700 in the +41.2V source (rectified horizontal sweep) could have much effect on the +24.5V source that is bridge rectified 60Hz from a winding on a voltage-regulated power transformer.

Replacement of D700 restored the horizontal-deflection/high-voltage operation and *the television operation was normal.*

Incidentally, remember that all diodes used to rectify horizontal-deflection signals or any signal of that frequency should be the fast-recovery type. Otherwise, the output voltage might be lower than it should, and the diode could operate warmer.

Shutdown in Sharp

Immediate shutdown occurred in the Sharp KMC-1984 model (Photofact 1900-2) when ac power first was applied. At first , the receiver was suspected of overload shutdown from a defect in the flyback circuit. When the ac line voltage was increased slowly, shutdown occured at 92Vac. Therefore, we reduced the ac voltage to nearly zero and increased again, but this time stopping at 87V just short of shutdown, where tests were made.

About +82V was the highest supply voltage produced by turning up the +120V adjustment (R709), but it proved the low-voltage dc circuits were operating normally. At the horizontal-output transistor's base, the waveform measured approximately 14.2Vp-p. High voltage dc at the CRT was 20.5kV (but 22.1kV or higher HV produced shutdown). This does not compare favorably with the Photofact, which lists 25.5kV to 28kV at 120Vac without shutdown.

Excessive high voltage was not activating the shutdown and the brightness was not excessive, so the overload shutdown should not be operating. Therefore, the safety shutdown circuit itself must have a defect that caused it to trip prematurely. This assumption was verified by diconnecting the cathode of zener diode ZD651. Afterward, the line voltage could be increased to the usual 120Vac without any problems. Now there could be no doubt: The shutdown circuit had a defect.

Transistors Q651 and Q652 were tested in-circuit with the voltage-drop diode test and found to be good. Next, all diodes were tested in-circuit and none were found defective. However, zener ZD651 had been checked only in the forward resistance direction. After some false trails had been followed, I checked the reverse resistance of ZD651 (which still was disconnected) and found the

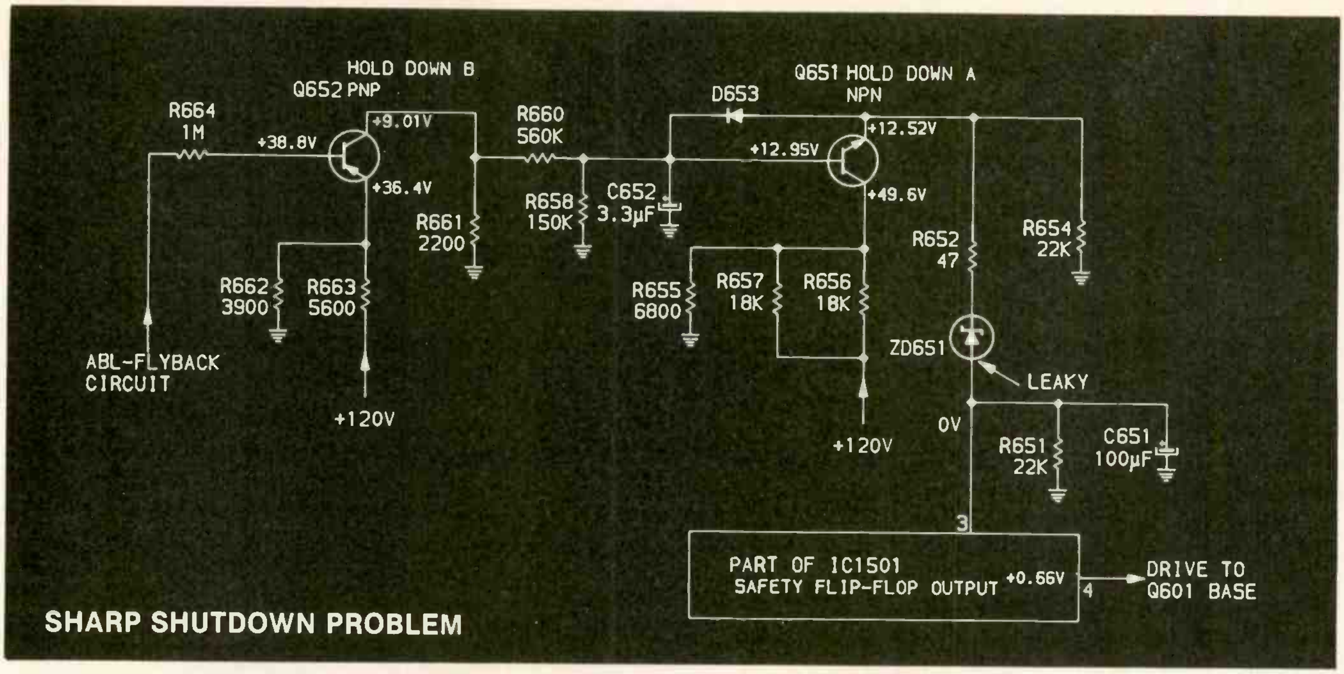
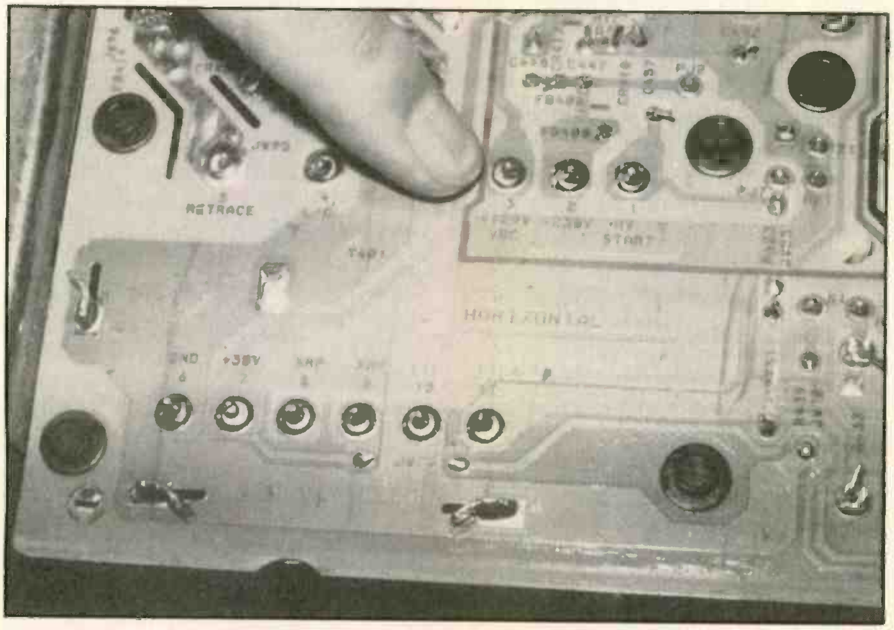


Figure 5. An overactive shutdown circuit was turning *off* the horizontal-sweep circuit in a Sharp KMC1984 (Photofact 1900-2). Using the variable low-line-voltage method, tests proved the high voltage was not excessive; therefore, the shutdown circuit must be the problem. It was. Replacement of zener diode ZD651 stopped the premature shutdown.



Pins of the RCA CTC131 flyback transformer go through eyelets in the circuit board, protruding slightly; next, they are soldered. To remove the flyback, all excess solder must be removed from each pin until all pins are free, then the flyback can be lifted from the board.

zener was very leaky, even when checked on a DMM (see Figure 5).

Installation of a new 18V ZD651 followed by several minor adjustments calmed the quick-triggering shutdown, producing excellent picture and sound from this Sharp television.

Miscellaneous suggestions

When removing a flyback, first draw a sketch of the various wires that are connected to the terminals. If the wires are color coded, write the colors on the sketch beside each wire. After you finish, go back and check the colors again; some colors are difficult to distinguish until compared carefully. If you remove more than one wire from a terminal, tie the wires together temporarily; this will help identify them when it is time to solder them to the new transformer.

You do not have to worry about correct wires with the latest RCA chassis, such as the CTC131 shown in the photograph, because each flyback pin is soldered into a rivet or eyelet. To remove the flyback transformer, remove all possible solder using solder-wick or a vacuum device. Remember, *all* terminals must be free or the flyback cannot be removed. After the new flyback is installed, check each eyelet for good soldering. And sometimes the board wiring breaks at an eyelet (on the bottom of the board). Where possible, double check the continuity using the lowest multimeter resistance range from each eyelet to a component connected (according to the schematic) to the same transformer terminal. All soldered joints should have critical visual inspections on both sides of the board.

Remember, with remote-controlled models, to bypass the *on-off* relay or supply 120Vac direct to the low-voltage power supply in those receivers that will be undergoing the variable-ac-input tests. If screen- and focus-control components are supplied with a flyback kit, be sure to use them. Dress down the picture-tube heater windings to prevent future arcing and possible CRT damage.

And speaking about arcs, do not intentionally draw a high-voltage arc, either ac before rectification or dc. Some technicians have been known to create arcs and then try to estimate the amount of high voltage from the length, intensity

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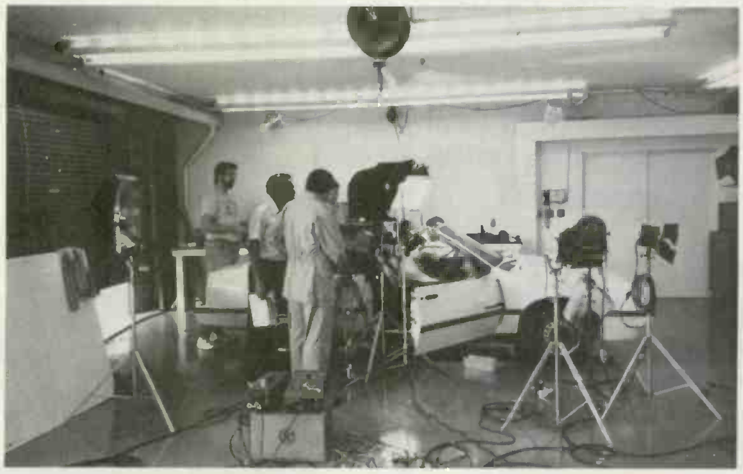

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and appearance of the arc (perhaps because they have no HV meters). This practice is strongly condemned for solid-state receivers for several important reasons. It is dangerous for the technician and difficult to do because there are no convenient points for safely forcing an arc between the HV at the picture tube and ground, for example. The manufacturers have expended much time and money to make certain arcs cannot occur. The HV wire is covered from the flyback to the CRT with no connectors in between.

However, there is another reason you should not draw arcs: Arcs can ruin solid-state components. Arcs produce steep-sided (fast-rise-time) waveforms in the HV dc voltage, and these pulses are directly applied to the HV-rectifier diodes that usually are inside the newer flybacks. Also by transformer action, these pulses (perhaps with lower amplitude and changed waveforms) are applied to the damper diode and the horizontal-output transistor's collector. These conditions are likely to cause damage, but the reason will not be apparent unless you understand that the amplitude of arcs can be increased by the fixed-tuned circuits (both intended and accidental) that are present in the flyback primary and secondaries.

One of my worries is that many technicians are not taking seriously the advice to use an isolation transformer on the TV receiver when test equipment is to be connected to it. But it is a real danger to you, the test equipment and the television. Most late-model color receivers each have a low-voltage power supply that is rectified by one or four diodes from the 120Vac line. Therefore, the chassis ground might have a voltage (measured to a good earth ground) anywhere between zero and more than 100V peak. As many of us have found, connecting the ground of a 3-prong-ac-plug oscilloscope to that so-called *cold* ground often shorts one or more bridge diodes, blows open a safety surge resistor and blows a fuse. Power of this magnitude certainly would produce a severe shock (or worse) in a technician.

Fortunately, the solution is simple: just use an isolation transformer to supply 120Vac for the receiver. Then add a variable-ac-voltage transformer (either with its own isolation transformer or in addition to it) and you will find a new ability to test safely for shorted flybacks and other massive shorts without zapping a series of replacement horizontal-output transistors. During those procedures, the receiver's ac power voltage should be reduced to whatever is needed according to the symptoms and the specific defect. Several examples have been given in this article.

Coming in...

JULY

Troubleshooting low-voltage regulator circuits—In this article by Homer Davidson, you'll find that defects in the low-voltage regulator circuitry can cause symptoms such as intermittent operation, shutdown, horizontal pulling of the picture or a flashing raster, or hum bars, that you might ordinarily assume were caused by other circuits. This article provides tips on how to determine if the problem is in the low-voltage regulator or elsewhere, and how to return the defective set to service.

NPEC Preview—The National Professional Electronics Convention and trade show for 1987 will be held in Memphis, TN, August 10 through 15. This article will provide a preview of the activities such as instructor conferences, CET exams, manufacturer/dealer meetings, seminars, golf outing and other activities.

Test equipment for personal computers—For some types of problems in personal computers, the old standby test equipment such as oscilloscope and DMM will be enough to troubleshoot the problem. In most cases, though, you can save a lot of time, effort and guesswork if you have the right piece of test gear. This article, by Conrad Persson, explores the world of digital test equipment and outlines what each kind of equipment does and how it can help in the troubleshooting effort.

Audio corner—Servo problems in compact-disc players can have you going around in circles. In this article, Kirk Vistain explains what servos do and offers tips on troubleshooting and repairing servo-related problems.

Test your electronics knowledge

By Sam Wilson, CET

1. Which of the following could be used to make a Class A amplifier?
   A.) SCR
   B.) UJT
   C.) LAD
   D.) (None of these choices is correct.)

2. When a switching transistor is used in a switching circuit, its base-collector junction is
   A.) forward biased when in the *on* condition.
   B.) reverse biased when in the *on* condition.

3. A 10,000 ohms-per-volt meter is used to measure a voltage of 3V. Its resistance is
   A.) 30,000Ω.
   B.) 3Ω.
   C.) unknown.

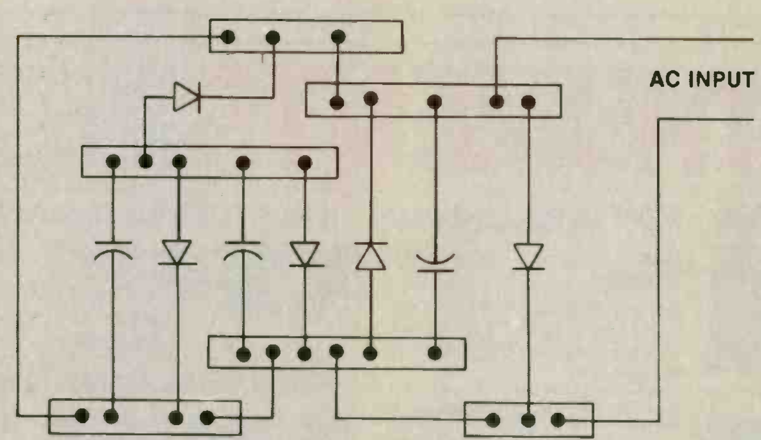


Figure 1.

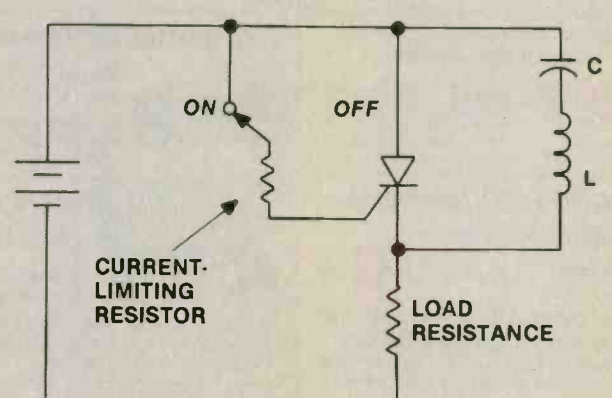


Figure 2.

4. Which of the following is used to determine if an electrolytic capacitor is OK?
   A.) BSR
   B.) VSR
   C.) ESR
   D.) VHR

5. A graph showing amplifier output for various frequencies is called a
   A.) log, log, decitrig graph.
   B.) Bode plot.
   C.) $\frac{1}{f}$ graph.
   D.) gain/slope path.

6. In a microprocessor, simple addition and subtraction is performed in the
   A.) ALU.
   B.) BFO.
   C.) accumulator.

7. The circuit in Figure 1 is
   A.) a bridge rectifier.
   B.) a voltage doubler.
   C.) a voltage tripler.
   D.) (None of these choices is correct.)

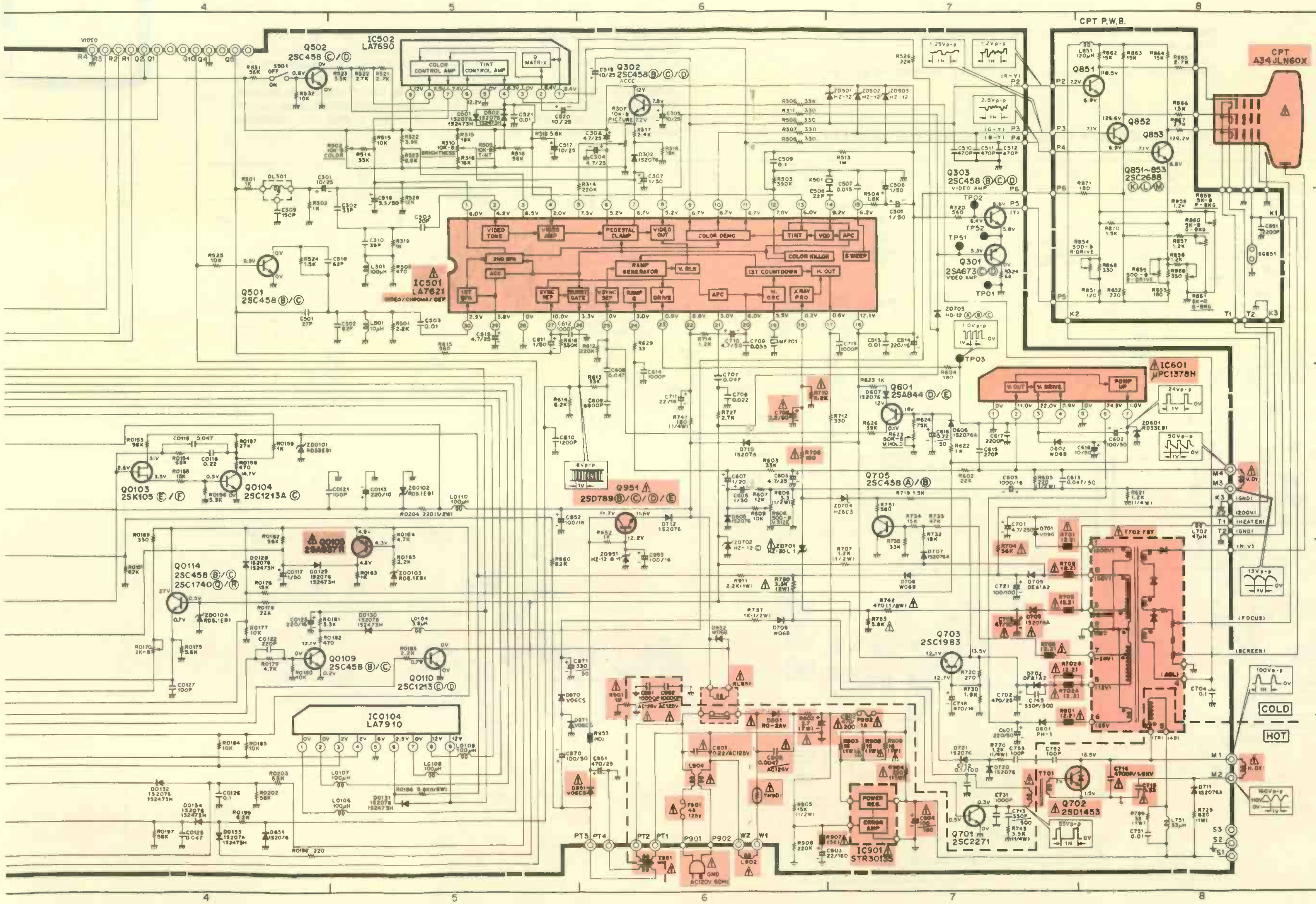
8. Is the following statement correct? When you double the capacity, the capacitive reactance is halved.
   A.) The statement is correct.
   B.) The statement is not correct.

9. For the static-switch circuit of Figure 2, L and C are used as a
   A.) snubber.
   B.) commutator.
   C.) filter.
   D.) tuner.

10. To reverse the direction of rotation of a dc shunt motor,
   A.) reverse only the field connection.
   B.) reverse the field *and* armature connection.

Answers are on page 51

BASIC CIRCUIT DIAGRAM



Product safety should be considered when component replacement is made in any area of a receiver. Components marked with a ⚠ and shaded areas of the schematic diagram designate sites where safety is of special significance. It is recommended that only exact cataloged parts be used for replacement of these components.

Use of substitute replacement parts 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 technicians only. This instrument contains no user-serviceable parts.

The other portions of this schematic may be found on other Profax pages.

- Because this is a basic circuit diagram, the value of the parts is subject to be altered for improvement.
- All dc voltage to be measured with a tester (100kΩ/V). Voltage taken on a complex color bar signal, including a standard color-bar signal.

ES&T Manufacturers' schematics **PROFAX**

JUNE 1987

3006

RCA
CTC135
chassis
Color TV

This schematic is for the use of qualified technicians only. This instrument contains no user-servicable parts.

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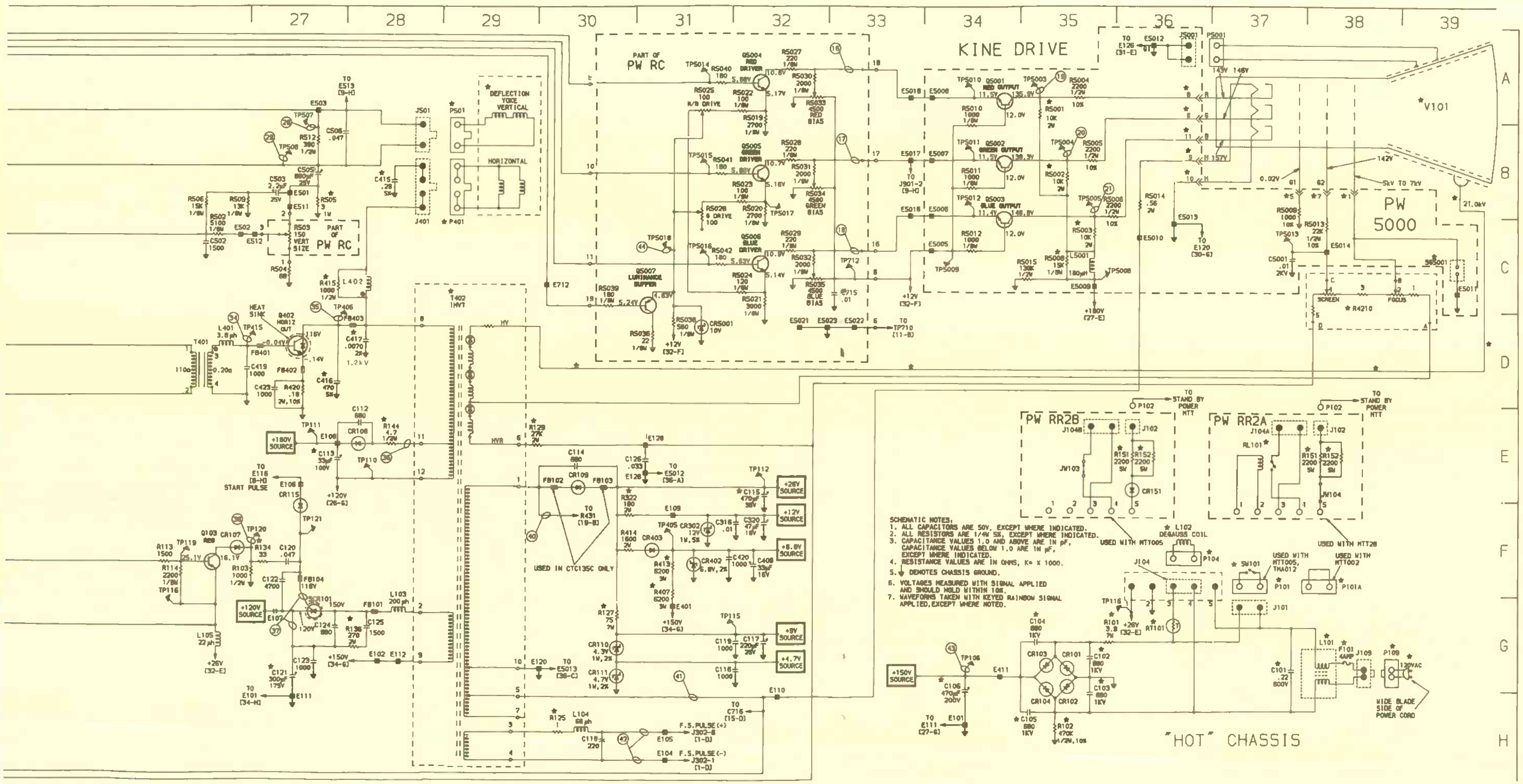
Product safety should be considered when component replacement is made in any area of a receiver. A star next a component symbol number and a star(s) on, or surrounding schematic symbols designate components that have special safety characteristics. Only the exact manufacturer's specified parts should be used as replacements. 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.

CTC135 DEFLECTION AND POWER SUPPLY SCHEMATIC



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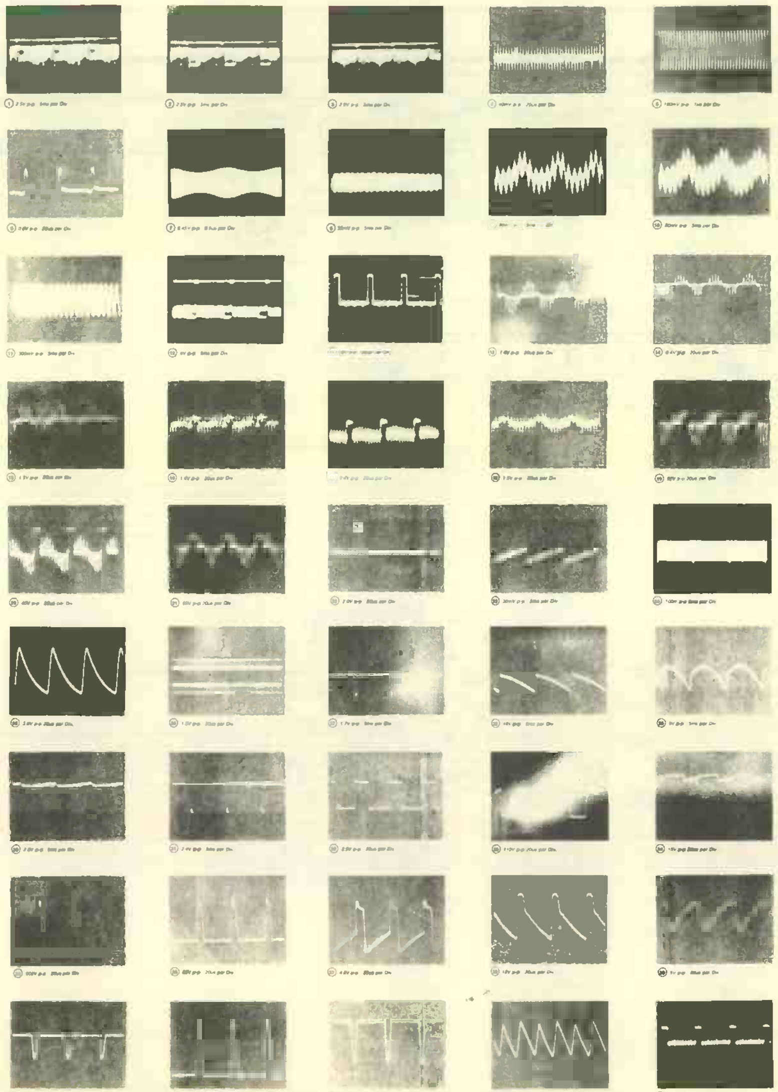
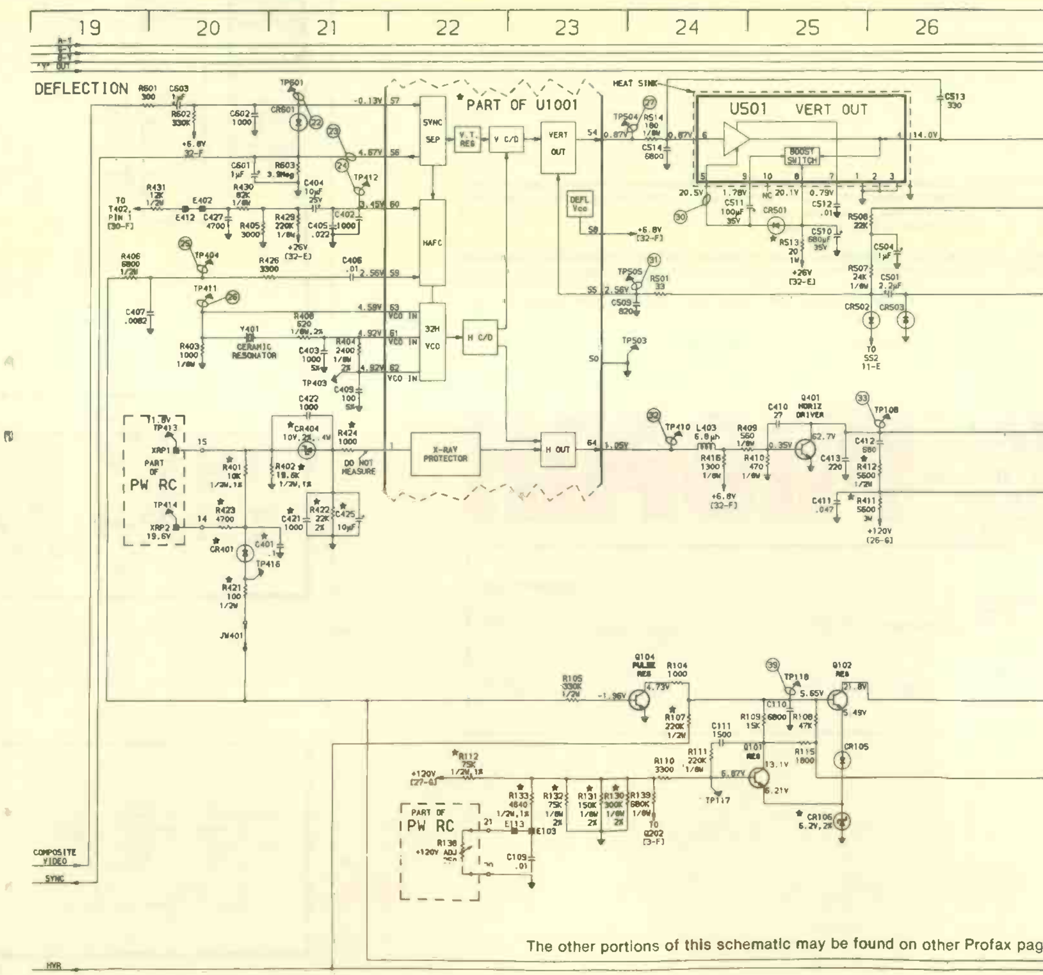
The other portions of this schematic may be found on other Profax pages.



These represent the waveforms on the oscilloscope screen when the oscilloscope's probes were connected to the test points on the signal circuit board corresponding to the numbers on the schematic.

Product safety should be considered when component replacement is made in any area of a receiver. A star next a component symbol number and a star(s) on, or surrounding schematic symbols designate components that have special safety characteristics. Only the exact manufacturer's specified parts should be used as replacements. 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.



The other portions of this schematic may be found on other Profax pages.

Product safety should be considered when component replacement is made in any area of a receiver. Components marked with a ⚠ and shaded areas of the schematic diagram designate sites where safety is of special significance. It is recommended that only exact cataloged parts be used for replacement of these components.

Use of substitute replacement parts 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 technicians only. This instrument contains no user-serviceable parts.

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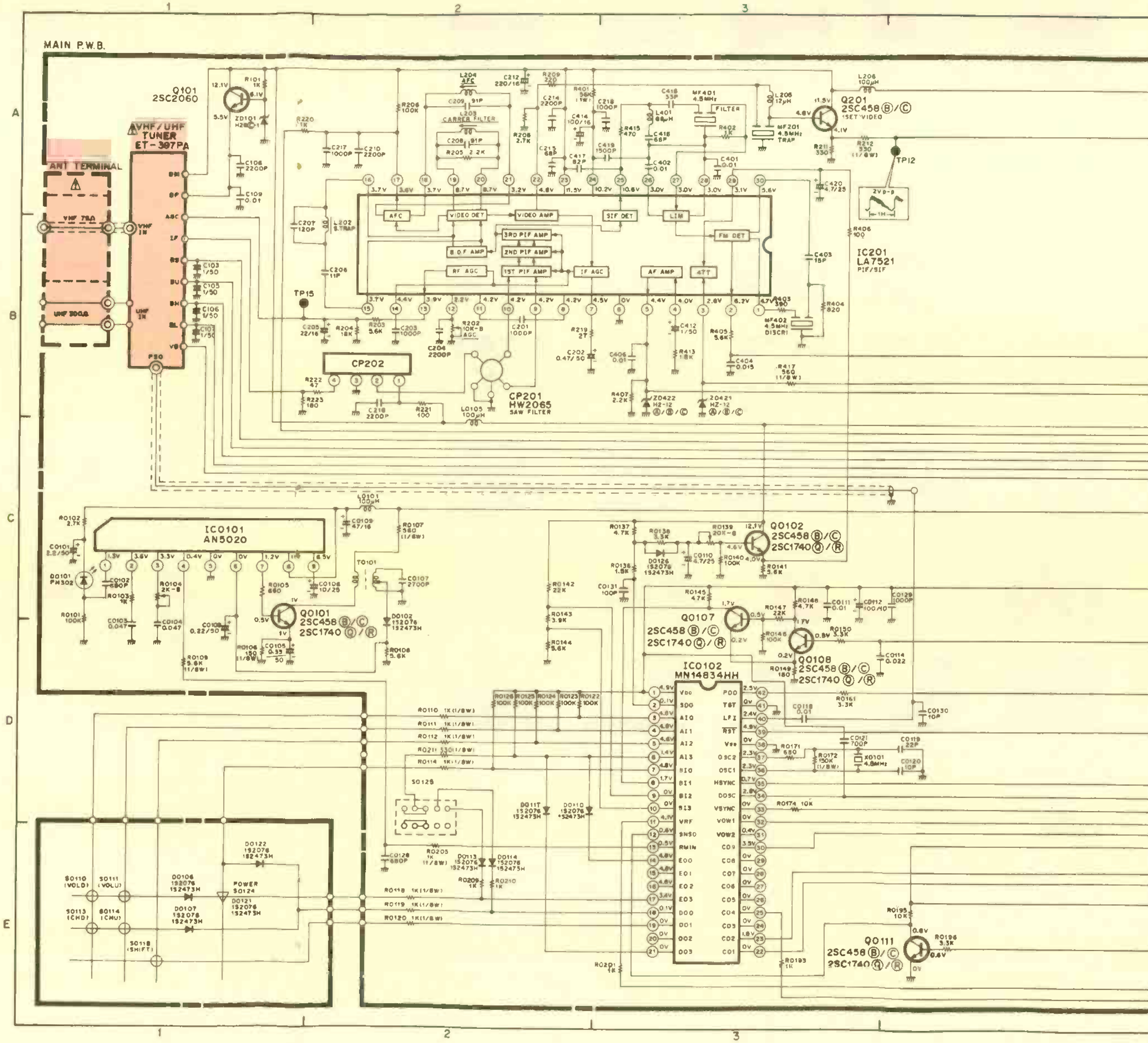
ES&T Manufacturers' schematics PROFAX

JUNE 1987



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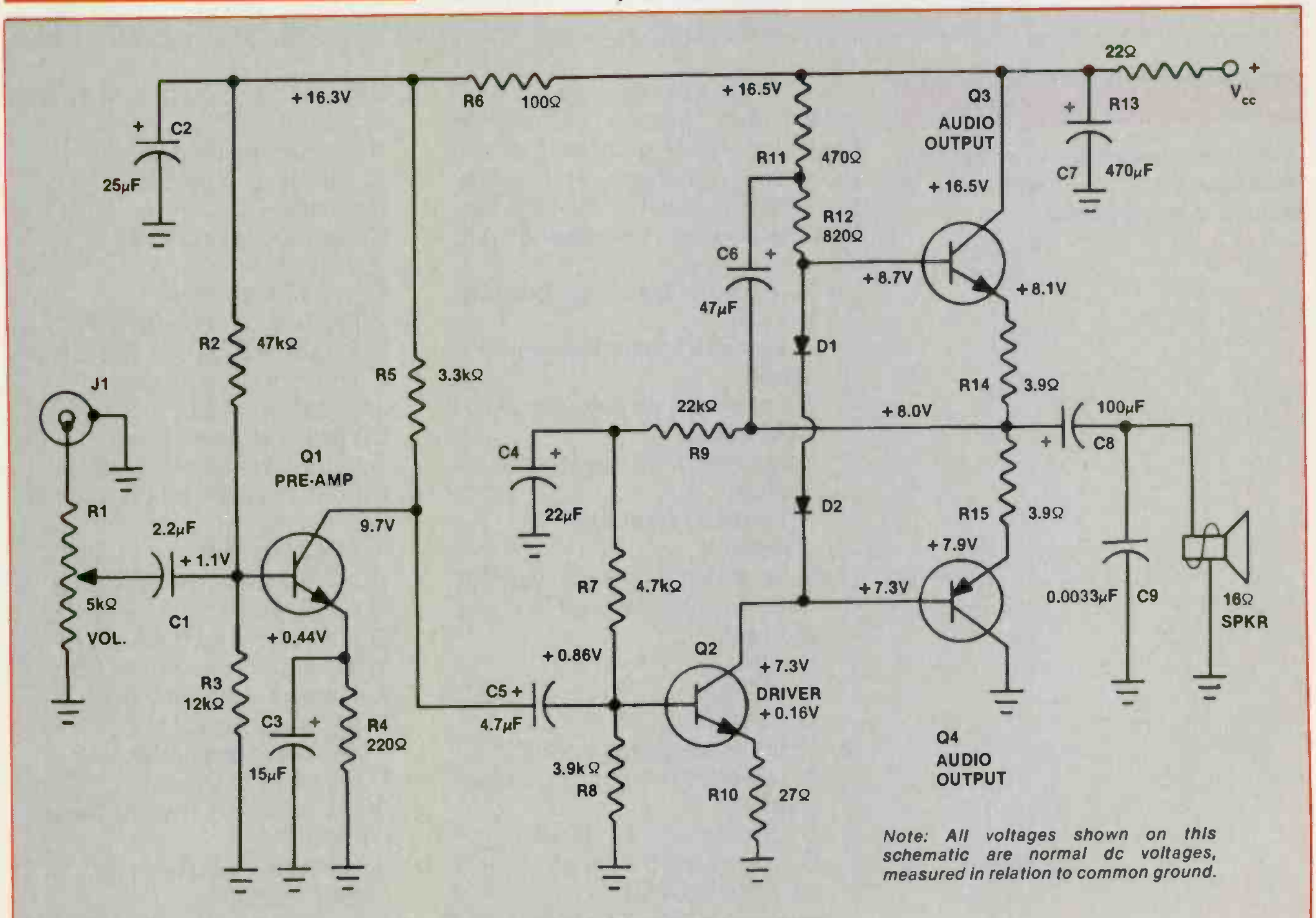
Circuit analysis and troubleshooting Quiz!

By Bert Huneault, CET

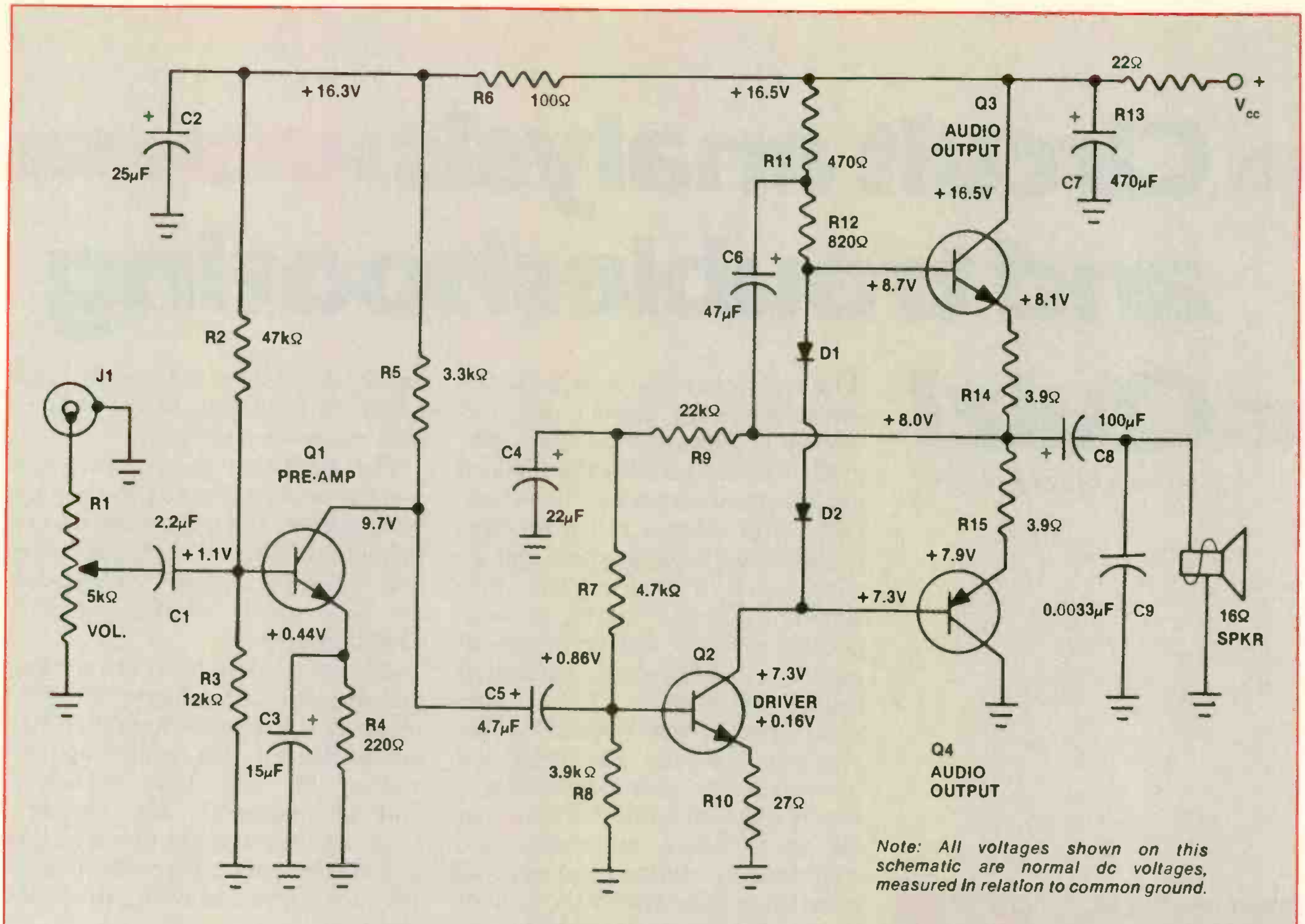
The technician who is called to the scene whenever there is an electronics problem brings skills generally associated with the medical profession and criminal investigation. With sleeves rolled up, this combination healing artist and investigative expert delves into something "sick," taking its temperature with a test probe, treating it and, ultimately, making it (radio, television, VCR...) well again. Before the "patient" is discharged, however, the technician has used other, more sophisticated test equipment to find clues, relying upon theory, experience and continuously updated professional knowledge to interpret those clues that lead to open resistors, leaky capacitors, defective transistors or whatever is preying on the vulnerable electronics device.

This multiple choice quiz gives you the opportunity to pull up your own sleeves, put your basic knowledge to the test by analyzing a circuit, interpret a bunch of clues and see how many culprits you can identify correctly.

All questions refer to the accompanying schematic diagram: a simple, solid-state audio amplifier circuit of the type commonly found in radios, TV sets, tape recorders and phonographs. The answers *with explanations* are given at the end of the quiz. Score five points for each correct answer. No cheating now!



AUDIO AMPLIFIER CIRCUIT



AUDIO AMPLIFIER CIRCUIT

For your convenience in answering these questions, this schematic is printed a second time.

Circuit analysis

This first section tests your knowledge of circuit operation and component functions, in preparation for the troubleshooting section that begins with question 11.

1. What is the function of capacitor C3?
   A.) provides tone compensation
   B.) prevents ac negative feedback
   C.) prevents dc negative feedback
   D.) reduces amplitude distortion
2. How much collector current flows in transistor Q1?
   A.) 1mA
   B.) 2mA
   C.) 4.7mA
   D.) 9.7mA
3. What is the purpose of C2?
   A.) eliminates power supply ripple
   B.) provides treble boost
   C.) increases the input impedance of Q1
   D.) decouples Q1 circuitry from the Vcc supply
4. What is the function of resistor R10?
   A.) stabilizes the Q2 bias
   B.) produces negative feedback
   C.) reduces amplitude distortion
   D.) all of the above
5. What is the function of R3?
   A.) stabilizes the Q1 base bias
   B.) increases the input impedance of Q1
   C.) provides bass boost
   D.) increases the beta of Q1
6. Output transistors Q3 and Q4 are hooked up in a:
   A.) OCL circuit.
   B.) OTL circuit.
   C.) push-pull circuit.
   D.) both (B) and (C).
7. What is the function of C9?
   A.) impedance matching
   B.) coupling capacitor
   C.) tone compensation
   D.) none of the above
8. What is the function of diodes D1 and D2?
   A.) bias stabilization for the output transistors
   B.) audio signal rectification
   C.) voltage doubler circuit

D.) none of the above

9. What is the function of the R7-R9 resistor network connected between the Q2 base and the emitter circuit of the output transistors?
   A.) provides ac negative feedback to improve fidelity
   B.) increases power gain
   C.) protects the output transistors from thermal runaway
   D.) all of the above
10. What is the function of C6?
   A.) decoupling capacitor
   B.) bootstrap coupling capacitor
   C.) tone compensation
   D.) provides ac negative feedback

Troubleshooting

In all the following questions, assume that a suitable audio source, such as a record player, is plugged into input jack J1, and the volume control is turned up.

11. What symptom will most likely result from an open R2?
   A.) no sound output
   B.) sound weaker than normal
   C.) distorted sound
   D.) squeals and whistles (oscillation)
12. Which of the following defects is most likely to damage the output transistors?
   A.) an open C6
   B.) a shorted C7
   C.) an open speaker voice coil
   D.) a shorted C9
13. Decoupling capacitor C2 becomes shorted. The resulting symptom is most likely:
   A.) distorted sound.
   B.) no sound output.
   C.) squeals and whistles (oscillation).
   D.) hum in the sound.
14. C8 opens. There will be:
   A.) no sound.
   B.) distorted sound.
   C.) hum in the sound.
   D.) loss of treble; bass okay.
15. R12 opens. The most likely symptom is:
   A.) slightly distorted sound.
   B.) reduced volume.
   C.) no sound.
   D.) smoke emerging from the equipment.
16. No sound comes out of the speaker. A signal tracer reveals that audio is present at the base of Q1 but not at its collector. Q1's collector voltage is +16.4V and its emitter voltage is 0V. The most likely defect is:
   A.) C3 shorted.
   B.) C3 open.
   C.) R3 open.
   D.) R2 open.
17. No sound comes out of the speaker. All dc voltages are normal in the audio output circuit. An oscilloscope shows no signals at the collectors of Q3 and Q4, but normal signals at the Q3 and Q4 bases.
   A.) C8 is open.
   B.) Transistors Q3 and Q4 are defective.
   C.) R14 and R15 are open.
   D.) Diodes D1 and D2 are open.
18. The sound is distorted, and the midpoint dc voltage at the R14-R15 junction is only 5V, although Q1's collector voltage remains about normal. This indicates that:
   A.) Q4 is turned *off*, for some reason.
   B.) Q4 is conducting too heavily, for some reason.
   C.) the Vcc power supply voltage is below normal.
   D.) Q3 is conducting too heavily, for some reason.
19. There is no sound out of the speaker. Signal tracing reveals a normal signal at Q1's collector, but no signal at Q2s collector. Dc voltages are normal. The most likely culprit is:
   A.) a defective Q2.
   B.) an open R10.
   C.) an open C5.
   D.) an open R7.
20. The sound suffers noticeable amplitude distortion.
   A.) C7 is shorted.
   B.) C3 is open.
   C.) C5 is leaky.
   D.) Transistor Q3 is open.

Answers

1. B. With a value of 15μF, electrolytic capacitor C3 is large enough to bypass emitter resistor R4 effectively at virtually all audio frequencies, thus preventing R4 from producing ac negative feedback (degeneration). Of course, R4 does produce *dc* negative feedback, for bias stabilization (with or without C3).

2. B. Collector current can be determined two different ways, thanks to Ohm's law (I = V/R) and the dc voltages shown on the schematic. One way is to take the potential difference across collector load resistor R5 (16.3 – 9.7 = 6.6V) and divide it by the resistance of R5 (3.3k); this yields a current of 2mA. The second method is based on the fact that collector current is equal to emitter current, for all practical purposes; applying Ohm's law to the emitter circuit (0.44V across 220Ω) also gives a current of 2mA.

3. D. C2 provides an ac ground for the dc supply feeding the collector and base circuits of Q1. Thus, together with R6, C2 forms a decoupling filter that prevents unwanted mutual coupling between stages via the common impedance of the power supply.

4. D. R10 is an emitter bias resistor that produces dc negative feedback, thus stabilizing the base-emitter bias of Q2. Because it is not bypassed by a capacitor, R10 also introduces ac negative feedback (degeneration), which reduces amplitude distortion.

5. A. Together with R2, R3 forms a base bias voltage divider network that determines the operating point (bias) of Q1. This is superior to simple fixed bias (which would feature R2 only) because the voltage divider stabilizes the base bias against the effects of temperature changes within Q1; and against the effects of different transistor parameters, should Q1 ever be replaced.

6. D. The audio output stage is a single ended, push-pull circuit featuring complementary transistors, and hooked up in an *output transformerless* (OTL) totem pole arrangement. Note that the presence of coupling capacitor C8 prevents the circuit from being called *output capacitorless* (OCL), but the absence of a push-pull input trans-

former qualifies the circuit as *input transformerless* (ITL) in addition to being OTL.

7. C. Connected across the speaker, C9 provides frequency selective bypassing, and thus tone compensation. At treble frequencies, the reactance of C9 becomes low enough partially to bypass the speaker, thus reducing the amplitude of the higher frequency signals. This is often done, especially when a small-size loudspeaker is featured. Small speakers are generally more efficient at treble than bass frequencies and therefore tend to produce a tinny sound. Tone compensation prevents treble sounds from being too loud, thus restoring a more natural balance between bass and treble.

8. A. Diodes D1 and D2 provide temperature compensation and therefore bias stabilization for output transistors Q3 and Q4. The voltage drop across each of these silicon diodes is *one junction voltage*–about 0.7V at room temperature. Therefore the potential difference between the two transistor bases is 1.4V. This gives each output transistor a base-emitter bias voltage of 0.6V, resulting in class AB operation.

When the output transistors heat up, they tend to conduct more. But diodes D1 and D2 heat up also, because they are in close proximity to Q3 and Q4. As a result, their junction voltage decreases, effectively reducing the output transistor base-emitter bias, thus offsetting the initial temperature-related rise in collector current. These temperature-compensating diodes are commonly found in totem pole power-output circuits.

Note that the two diodes also *couple* the audio signal from the collector of driver transistor Q2 to the base of output transistor Q3. The diodes *do not rectify* the signal because they are permanently forward biased, being part of the R10-Q2-D2-D1-R12-R11 voltage divider network connected between the positive dc bus and ground. Thus, the signal from the driver simply passes right through the low resistance of the diodes, on the way to the Q3 base, and suffers only a slight attenuation in the process.

9. C. The driver stage is *dc coupled* to the power output circuitry. In such circuits, transistors are prone to chain reactions wherein temperature changes in one transistor can affect the operating point (bias) of another transistor, possibly resulting in thermal runaway. R9 and R7 form a dc feedback loop between output emitters and driver base, and it is this self-biasing arrangement that protects the output transistors against thermal runaway.

Note that the Q2 base bias doesn't come directly from the Vcc supply; instead, it is taken from the junction of the R14-R15 emitter resistors and applied through R9-R7 to the Q2 base.

Suppose that Q4 heats up, reducing its internal resistance and conducting more heavily. This causes the midpoint voltage at the R14-R15 junction to drop below 8V. This reduced dc voltage is coupled through R9-R7 to Q2, causing the driver's base voltage to drop below its normal 0.86V. With less forward bias, Q2 conducts less and its collector voltage rises above 7.3V. Because of dc coupling, the base voltage of Q4 likewise becomes more positive, reducing the base-emitter bias of PNP transistor Q4. The resulting decrease in collector current compensates for the initial rise in Q4 conduction due to heat.

A similar analysis can be applied to the operation of the Q3 transistor. Incidentally, capacitor C4 puts the R7-R9 junction at ac ground potential, thus preventing ac feedback.

10. B. Because the audio signal from the collector of the driver must pass through diodes D2 and D1 on the way to the base of Q3, it suffers a certain amount of attenuation due to the resistance of the diodes, as previously explained in the answer to question 8. This results in a somewhat unbalanced push-pull operation. Capacitor C6 takes care of correcting the situa-

tion by coupling the emitter follower's in-phase output signal from the R14-R15 junction back into the base of Q3, via resistor R12. R12 reduces this positive feedback signal down to just the right amplitude. In effect, then, this boost circuit causes Q3's signal to *lift itself up by its own bootstraps*, offsetting the attenuation caused by the diodes.

11. A. There is no sound at the amplifier's output because the preamp stage is inoperative. With the essential base bias resistor (R2) open, Q1's base voltage drops to zero and the transistor turns *off*, preventing the weak phono input signal from passing through to the driver and output stages.

12. D. Push-pull output transistors connected in the totem pole configuration are likely to overheat when the load is *shorted*. With the volume control turned up, the output transistors produce a large signal at the circuit midpoint (R14-R15 junction). If the speaker terminals are accidentally shorted, or if C9 shorts, this large signal voltage tries to supply (through C8) the excessively large ac current demanded by the 0Ω load impedance. This is most likely to zap the output transistors in short order.

The moral of the story is this: When working with OTL circuits, never short the speaker terminals, and never drastically reduce the output load impedance by connecting additional speakers in parallel with the original one; you're courting trouble if you do.

If you selected answer (C) – an open speaker – you're probably an old timer. Earlier audio amplifier circuits often featured a balanced push-pull circuit with an output transformer. In those circuits, it's an *open* speaker that spells trouble because the open load reflects a very high impedance back into the primary of the output transformer. With the volume turned up, the large swings in signal current through the primary winding result in excessive back-emf, easily exceeding the transistors' breakdown voltage ratings. The writer remembers arcing and even *fires* actually caused by this type of fault in vacuum tube amplifiers. So, if you're an old timer, welcome to the club.

13. B. There's no sound because a shorted C2 kills the 16.3V dc source supplying Q1. Note that excessive current through the shorted C2 is likely to cause R6 to overheat and burn out. Always look for discolored, swollen or cracked decoupling resistors, when decoupling capacitors short.

14. A. No audio signal reaches the speaker because C8 is the *coupling* capacitor. That was easy, wasn't it? A technician's life is not filled with tough dogs only; easy ones come along once in a while!

15. C. The amplifier is dead because with R12 open, no dc voltage is available for the collector of Q2 and the output transistor bases.

16. D. An open R2 causes Q1 to turn *off*, as mentioned in the answer to question 11. With no collector current flowing through R5, the load resistor doesn't drop any voltage, allowing Q1's collector voltage to rise to the full supply voltage. Also, emitter current stops flowing and the voltage across R4 drops to zero.

17. A. With C8 open, no output signal can reach the speaker, as mentioned earlier. If you thought that both output transistors are defective because no signals are present at their collectors, you fell into a trap. Q3 and Q4 are *emitter followers*; therefore signals are *not supposed* to appear at their collectors. Also, if Q3 and Q4 were defective, dc voltages would not remain normal in the output circuit.

18. B. With R14 and R15, the internal resistances of Q3 and Q4 form a series voltage divider across the dc power supply. The circuit's midpoint (R14-R15 junction) is a good test point to monitor when troubleshooting these OTL power amplifiers. Its dc voltage should normally be equal to approximately half the power supply voltage. With the problem at hand, the midpoint voltage measures well below 8V, indicating that the voltage divider is unbalanced, the lower half of the circuit having much less resistance than the upper half. This implies that either Q4 is conducting more heavily than normal or that Q3 is conducting less than it should. Therefore (B) is the only correct answer. The culprit is probably a leaky Q4.

19. C. This is another easy one. An open C5 is the only one of the four answers that explains the absence of signal at Q2's collector while all dc voltages remain normal. Of course, a scope check at the base of Q2 would reveal no signal there either.

20. C. The dc voltage from the pre-amp's collector leaks through C5 and shifts the operating point (base bias) of Q2 towards saturation, causing clipping of signal peaks, hence distorted sound.

If you chose answer (D), you apparently overlooked an important point: Although a dead transistor can indeed produce distorted sound in some push-pull amplifiers, in this OTL circuit an open Q3 would cut off the dc supply to Q4 (resulting in no sound at all), because Q3 and Q4 are stacked in series, totem pole fashion.

The moment of reckoning

This quiz was designed to test your knowledge of circuit operation and your understanding of troubleshooting techniques. It also gave you an opportunity to pit your wits against a number of defective circuits. How did you make out? Were most of the culprits identified correctly and most of the patients made well again? At five points per correct answer, tally up your score. Your report card is shown below.

Hoping that you managed to pick up one or two useful tidbits, here's wishing you Happy and Successful Troubleshooting! ES&T

POINTS	GRADE	VERDICT
90-100	A	Congratulations, Dr. Kildare!
75-85	B	You're a promising technician
60-70	C	You need to hone your skills a bit
Under 60	F	A Mike Hammer you are not!

Photofact

These Photofact folders for TV receivers have been released by Howard W. Sams since ES&T's last report.

CAPEHART
1990AR0 (CH.M9C2-8K1) 2500-1

EMERSON
ECT1300, ECT1300A 2489-1
EC193D, EC194C 2493-1
EC10R, EC11W, EC12P 2494-1
ECR137/A/B/C 2501-1

GENERAL ELECTRIC
Chassis 25PM-C 2488-1
Chassis 25PC-J 2489-2
Chassis 19PC-J 2494-2

HITACHI
CT1965, CT19D5 2501-2

JC Penney
685-2512-00 (855-0543) 2493-2
685-2169-00 (855-4214) 2495-1

JVC
C1926, C1936 2491-1

MAGNAVOX
Chassis 19C701 thru 19C711 2497-1

PANASONIC
CTG-2067R 2490-1
CTH-2063R (CH.ADP125/NMX-GYA) 2496-1

QUASAR
Chassis ALLPDC110, AMLPDC110, LPDC110 2491-2

SEARS
564.48011650/651 2488-2
564.42002650 2490-2
564.48770650, 564.48870650 2492-2
564.40370550 2499-3

SHARP
25KC165, 25KT65 2492-1
19KP65 2495-2
19KP15B 2496-2
19LP16 2497-2
13KM05, 13KM15 2498-1
19LP56 2499-1
20KV555 2500-2

SYLVANIA
RNF600WC01/WC02 (CH. 26C501) 2495-3

ZENITH
B2712G/G2/16P, SB2713G/13G2/15N/15N2/17P/17P2 2498-2

PRODUCTION CHANGE BULLETIN

JC PENNEY
685-2093A (685-2093A-21) 2500-3

SEARS
564.41400451 2501-3

Literature

TI filter catalog, textbook

Catalog MTV/87 from *Microwave Filter* teaches TI symptoms and helps select filters to cure terrestrial interference (TI) in more than 500 different receivers.

The catalog features diagrams for standard and block downconversion receivers, showing where interference can affect the system and the choice of filters to solve the problem.

A brief history of TI sources, symptoms and information is provided on filter types such as baseband, IF notch, IF bandpass, 4GHz microwave notch, block interference and 4GHz microwave bandpass filters.

Additionally, descriptions of equipment for TVRO installations such as the Sky Doc Kit, preinstallation, TI survey kit and TVRO dish edge absorbers among other accessories are presented.

Circle (125) on Reply Card

Spring/Summer 1987 catalog

Sencore Electronics' latest catalog includes instruments for testing video, audio, components analyzers and cable systems, plus waveform analyzers, IEEE instruments and the complete line of Sencore's instrument accessories.

Complete specifications and application information are given for all products.

Circle (126) on Reply Card

Technical supplies

The new spring summer catalog from *Contact East* contains thousands of products for use in installing, testing and repairing all types of electronic and electrical equipment. Featured are tool kits, test instruments (DMMs, oscilloscopes, counters, power line monitors, disk drive testers...), hand tools (screwdrivers, pliers wrenches, crimpers...), soldering supplies, and static-control products. All are described in detail with specifications, full-color photos, prices, and are 100% guaranteed.

Circle (127) on Reply Card

Standbys, conditioners, suppressors

Power protection devices are detailed in the Power Protection Products catalog from *Perma Power Electronics.* Standby power supplies, power conditioners, computer power control centers, surge suppressors and telephone-line surge suppressors are included. Operating features and performance specs are given for each.

The catalog also explains operating characteristics of the model SPS-500 Standby Power System, which can transfer to and from battery in less than 1ms.

Circle (128) on Reply Card

Books

*Editor's note: Periodically **Electronic Servicing & Technology** features books dealing with subjects of interest to our readers. Please direct inquiries and orders to the publisher at the address given, rather than to us.*

Troubleshooting and Repairing Solid-State TVs, by Homer L. Davidson; Tab Books, 448 pages, $17.60, paperback; $24.95, hardbound.

By using case studies as examples, this book covers every circuit found in color and B&W solid-state units. The author, whose articles appear regularly in ***ES&T***, draws from the practical experience gained during more than 38 years in the radio and TV repair business. Theory is minimal, and the straightforward explanations are enhanced by 506 illustrations that include more than 100 photographs of solid-state circuits. Many of the photographs show faulty components, making them more readily identifiable when readers encounter malfunctioning devices later in their own work. Represented is the most recent solid-state TV circuitry used by the major manufacturers of all brands and models of televisions.

Published by Tab Books, Inc., P.O. Box 40, Blue Ridge Summit, PA 17214; 717-794-2191.

Operational Amplifiers and Linear Integrated Circuits, by Robert F. Coughlin and Frederick F. Driscoll; Prentice-Hall, 446 pages, $40.33, hardbound.

Operational amplifiers, generally referred to as op-amps, are widely used in electronics' linear applications. They are popular because they are low in cost, easy to use and very forgiving of wiring errors. With op-amps, useful circuits may be built without the "builder's" necessarily knowing about the device's complex internal circuitry – the very circuitry that is self-protective when those wiring errors *do* occur.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632; 800-223-2336.

Digital audiotape is on the way

By Conrad Persson

The hot word in audio lately has been "digital," just as it has been the hot word in almost everything having to do with electronics for the past decade. We now have compact digital audio discs and digital tuning. Poised for a splash into the U.S. market is digital audiotape (DAT).

DAT promises considerable advantages over conventional audiotape. The most important of these advantages is sound quality. As with the digital audio disc, digital audiotape will provide greatly improved sound quality while eliminating noise sources such as, in the case of tabs, tape hiss.

The technical information on which this article was based was derived from a Sony technical paper entitled Digital Audio Tape (DAT).

Other significant advantages of the new DAT format are long recording times on a tape cassette, compact size and the ability to search for the start of each recorded track.

Two formats

Digital audio on tape can be achieved in one of two methods. One of these uses a fixed head as in current audiotape recorders and is called stationary DAT or S-DAT. The other format uses a rotary head, in a manner similar to the method employed in VHS videocassette recorders. This approach is called rotary DAT, or R-DAT. At the moment, because of a number of advantages, R-DAT is favored. At the present time, S-DAT is regarded as a possible future technical innovation.

R-DAT technology

The signal recorded on a tape in the R-DAT system is recorded using a technology called pulse code modulation (PCM), the same method that is used in recording digital audio compact discs. This technology allows high quality recordings (similar to that of a master tape) or a tape cassette that's about half the size of analog compact cassettes, but will play for two to three hours. The long recording time and small size are possible because the R-DAT

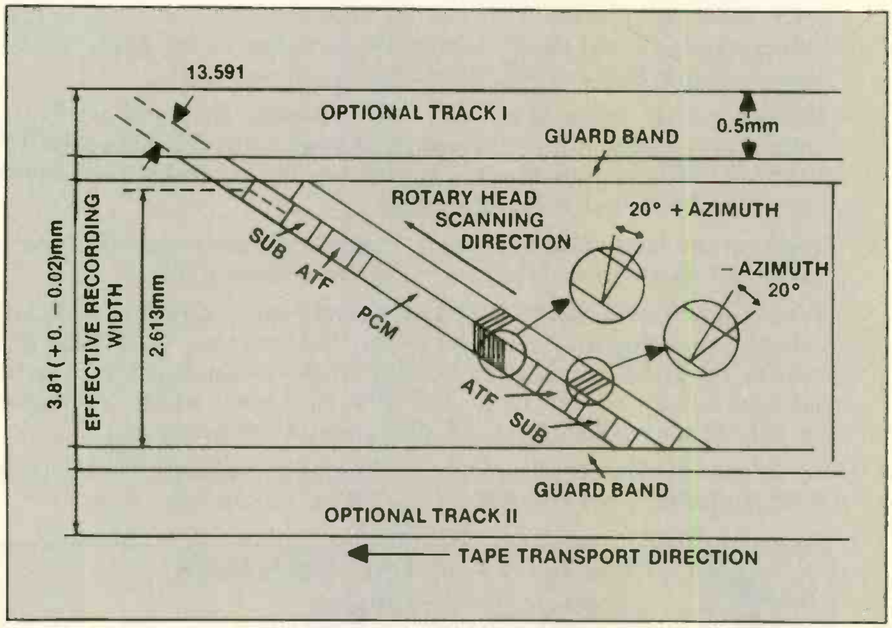


Figure 1. The audio signal on an R-DAT is recorded in a series of diagonal strips, in a manner similar to the recording process with videotape. Because the track width is narrow (13.591μm) recording speed is ¼ IPS, and it is possible to record two to three hours on a cassette that's half the size of analog compact cassettes.

system records and plays back at a tape speed of $1/4$ IPS, compared to the tape speed of a conventional cassette of $1\,7/8$ IPS.

Format

Refer to Figure 1. Notice that the audio track is recorded on the tape in a series of diagonal strips, similar to the way the video signal is recorded on a VCR tape. The width of the track is 13.591μm; about one-tenth the thickness of a human hair. The length of the track is 23.501μm. Each bit of data within the track is 0.67μm in length. The recording density for an R-DAT tape is thus 114Mbits per square inch, the highest tape recording density ever achieved.

The signals being digitized for recording on the tape include the entire audio range of 20Hz to 20kHz. According to information theory, when using a sampling process, in order to accurately reproduce a range of frequencies, the signals must be sampled at a rate of at least twice the highest frequency that will be encountered. That would mean that a sampling frequency of at least 40,000 samples per second would be necessary. The R-DAT format uses 48kHz. Because each sample consists of 16 digital bits of information, and in a stereo system there are two channels, the system must process 1.5Mbits per second.

In order to compensate for errors in the signal, extra information must be added. This increases the signal data rate to about 2.45 Mbits/s. The addition of sub codes to enable various functions to be controlled pushes the data rate to 2.77Mbits/s.

Heads make contact only part of the time

DAT is a digital process and uses a buffer to store some of the signal information between the time it is read off of the tape by the play head and the time it is processed into analog music and fed to the amplifier. Because of this, it is possible to have the play heads in contact with the tape only part of the time. Specifically, (see Figure 2) the R-DAT head drum is 30mm

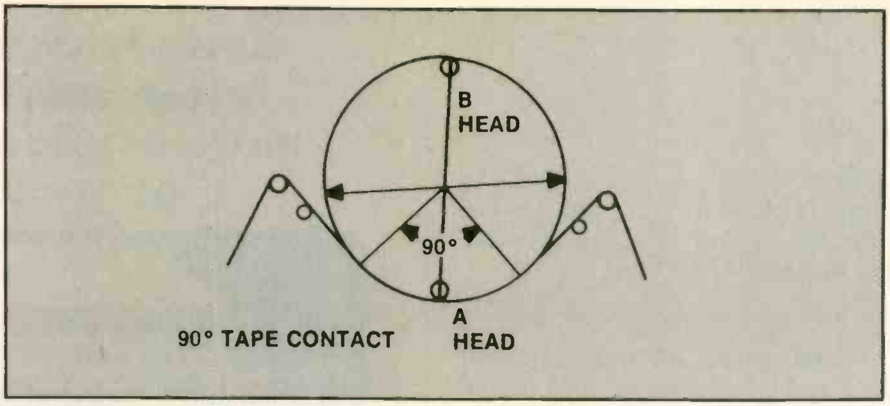


Figure 2. Digital signal processing makes it possible to use 90° tape contact, improving head and tape life, yet allowing high-speed tape transport and high-speed search while the tape is in contact with the drum.

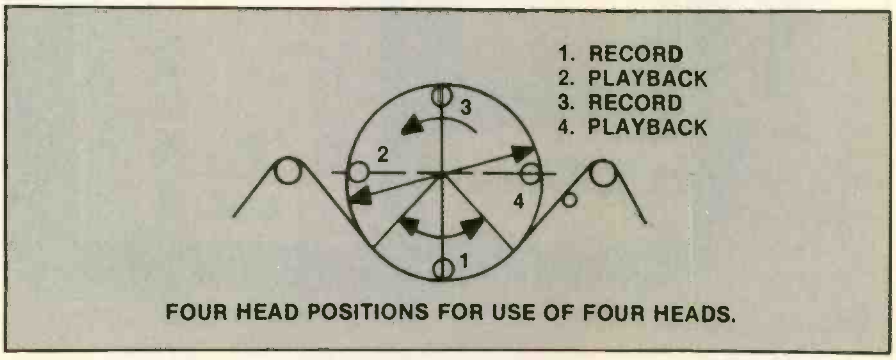


Figure 3. Use of four heads instead of only two will allow simultaneous tape recording and playback, providing a record-monitoring function.

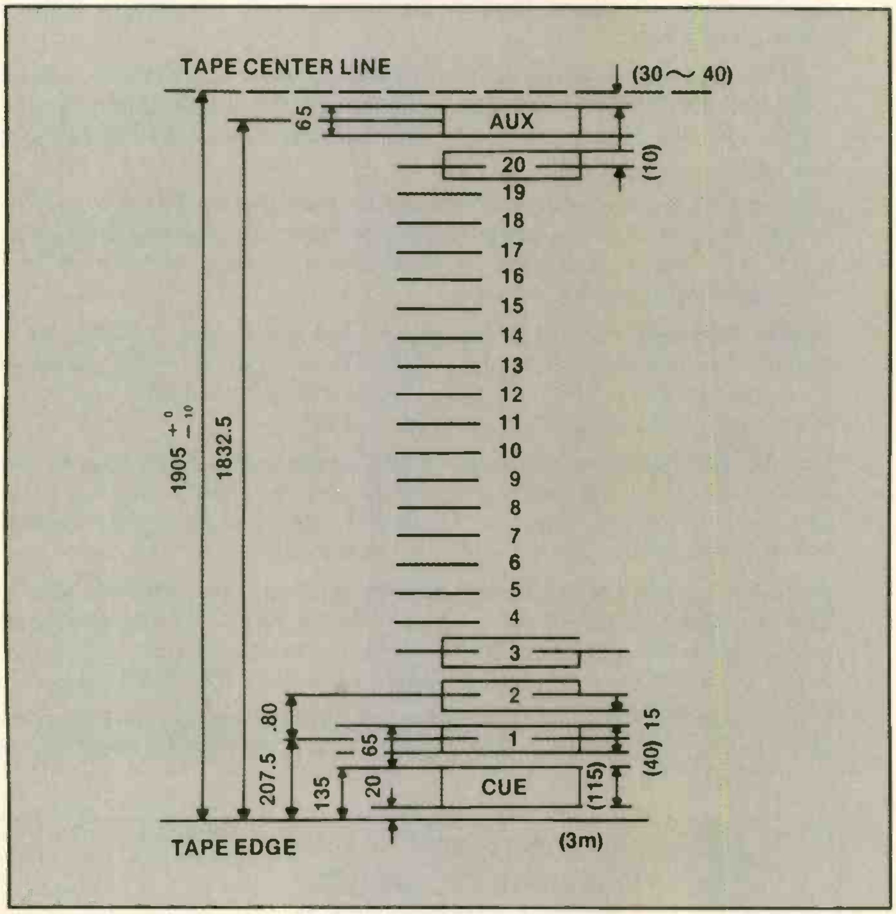


Figure 4. Currently envisioned S-DAT format distributes recorded data across the width of the tape. Current technological limitations relegate S-DAT to possible future development.

in diameter and is in contact with the head drum only through an angle of 90° or one-quarter of the drum's circumference. Because the heads are on diametrically opposite sides of the drum, 180° apart, the signal is recorded or played back only 50% of the time. During the other 50% of the time, the signal is interrupted because the heads are not in contact with the tape.

This discontinuous approach to recording and playing back the signal confers certain advantages.

Three advantages accrue because the tape wraps only 90° around the head drum:

1. Only a short length of tape is in contact with the drum. This reduces damage to the tape, and allows the system to operate at high-speed for transport and search while the tape is in contact with the drum.

2. Tape tension is low, which contributes to long head life.

3. If four heads are used instead of two (Figure 3), the heads can be separated by 90° so that you will be able to play back at the same time as you're recording, thus providing a record monitor function.

Two more advantages accrue because the record/playback signal can be converted to a high range signal of 7.5Mbits/s. This enables the system to overcome any inadequacy in low-range characteristics.

1. The small head drum size and small size of the rotary transformer is a direct consequence.

2. The signal-to-noise ratio is improved.

Stationary DAT

The helical recording method of recording many narrow diagonal strips with a rapidly rotating head on a slowly moving tape allows recording and playback of higher frequencies in videotape and R-DAT. That approach is obviously not possible with S-DAT.

This limitation is overcome with S-DAT by distributing data across the width of the tape (see Figure 4). That's the theory. In the real world there are limits imposed by tape noise, dropouts, compatibility, the fact that heads must be mass produced and the complexity of the circuits. With current technology, the tape speed is in the same range as that of an analog compact cassette, and the tape needed for S-DAT is expensive. Right now, S-DAT is being looked at as a future technology.

Legislative problems

Unfortunately, at the present time DAT seems to be the victim of its own success. Because the quality of sound on this system is so good, and because a recorded tape can be dubbed onto a blank tape with absolutely no loss of fidelity, the recording artists, record companies and anyone else who has a vested interest in recorded music have expressed concern that there will be wholesale illegal copying of tape recordings, thus siphoning off funds that should be going to pay for legitimately produced tapes.

Legislation is pending that might require anti-recording chips in all DAT recorders shipped into the United States. Hearings concerning this sales restriction were begun in May before appropriate House and Senate subcommittees. Previously, this product-specific amendment was part of the giant Omnibus trade bill (H.R.3), but was deleted to make the DAT issue a freestanding bill. Testimony opposing the bill will be presented by representatives of the National Association of Retail Dealers in America (NARDA).

NARDA's position is that such legislation would deprive consumers of the opportunity to enjoy the latest state-of-the-art technology, and it would deprive retailers of the opportunity to sell the product. ES&T

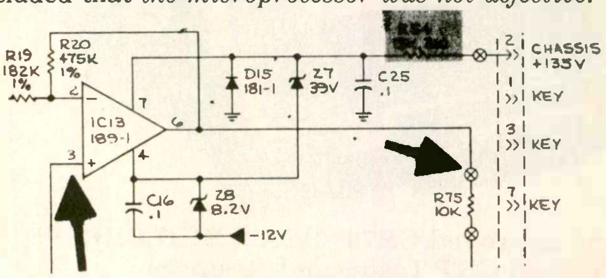
Troubleshooting Tips

VHF channels will not tune
Magnavox T809

(Photofact 2026-1)

Channels of this Magnavox T809 receiver would not tune up or down the VHF band. Although the mixer B+, RF-oscillator B+ and band-switching voltages were all normal at the tuner, the *tuning* voltage remained a steady +39V when attempts were made to tune the channels of the VHF low and high bands.

As I looked over the tuner-control schematic, I decided to begin by checking the binary logic outputs at port 1 of the microprocessor. This is where the tuning-voltage decision originates, so I thought it would be a logical place to begin the tests. After all, these circuits are very complex and seldom are checked completely during repairs. As I punched in different channel numbers, the port 1 outputs changed binary states. This is normal, and I concluded that *the microprocessor was not defective.*



From the microprocessor, the digital information passes through buffers and enters a digital-to-analog converter made of bilateral switches and op-amps. Rather than trying to trace through this jungle of circuitry, I merely went to the output, where the analog voltage should appear. This point was the filtered dc voltage from R10 and C22 that is connected to pin 3, the non-inverting input of IC13, the final tuning-voltage amplifier. Notice pin 2, which brings in any AFC tuning corrections. Pin 6 should have the VHF- and UHF-tuning dc voltage (notice on the full schematic the series 10kΩ resistor and the 0.47μF bypass for the tuning voltage at the UHF-tuning end). Of course, this voltage should be different for each channel.

As stated before, the pin-6 voltage remained at +39V although an attempt was made to tune in several channels. Finally, I decided IC13 was the most likely suspect. *After IC13 was replaced, all channels tuned properly.*

David Luckner
Corning, NY

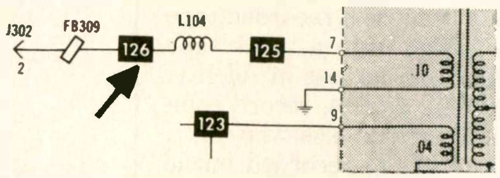
No picture, very little sound
RCA CTC120A

(Photofact 2296-2)

After I removed the back and moved the machine to a serviceable position, I verified the complaints against this CTC120A-chassis RCA television. Volume could be turned loud or soft, but the sound was just noise except for weak, noisy sound from our local Channel 2. None of the channel-selector buttons operated; LED channel-readouts did not change.

Using my digital multimeter, I checked voltages around the tuner and the tuner-control module looking for any incorrect voltages. On tuner module MSC012A at pin J1, I found the +5.1V missing. Next, I moved to the source of the +5.1V source at TP2509 (regulated by zener CR2504), but there was no voltage. The +5.1V source is produced from the +8.7V supply at TP2503, but there was no voltage there either. Diode CR2503 rectifies pulses to produce the +8.7V supply. Therefore, I checked CR2503 for shorts. When it was found to be OK, I tested the associated filter capacitor C2509, but it, too, was not defective.

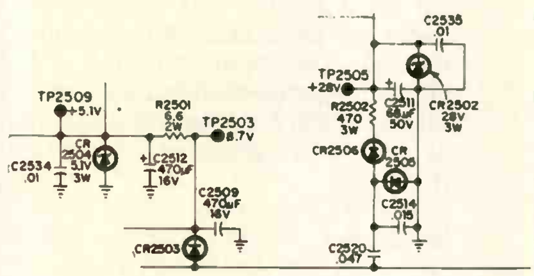
Finally, I brought out the heavy artillery, my trusty oscilloscope, and began looking for negative horizontal pulses at J2/pin 6 on module MCS012A, but they were missing. At the source, pin 7 of flyback T402, the negative pulses were normal. Something between those two points was stopping the pulses. I traced wiring back to the main chassis and J302 pin 2, but no pulses. I suspected that L104 might be open. When I checked on the CircuiTrace 125 side, the pulses were normal, but not at CircuiTrace 126. This pointed precisely to an open in L104, but as I was examining L104, I noticed a bad soldering connection on the 126 side of the coil. I cleaned off all the old solder and resoldered the lead correctly.



Pulses now were reaching the tuner-control module, allowing the +8.7V and +5.1V voltage sources to operate as intended. The tuning buttons and the channel-readout LEDs were bringing in the correct stations. The job was over except for minor adjustments and replacing the back.

Since the problem of the open coil, I have found another in the same model and heard of several in different brands and models that had the same symptoms because of a loss of pulses to the tuner-control circuit. Keep this in mind.

Many defects produce symptoms that point toward the cause, making our diagnosis easier, but that was not my good fortune with this open-coil symptom.

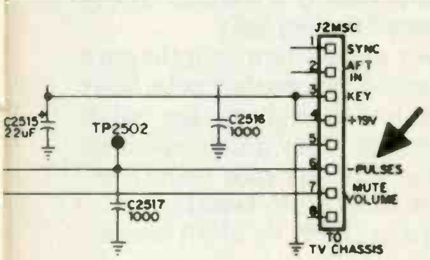


Ivan L. Wood
Batesville, AR

Answers By Sam Wilson

Questions are on page 30

1. D. SCRs and UJTs are thyristors. An LAD is a light activated diode. None of these can be used to make a Class A amplifier.
2. A. When used as an amplifier, the base-collector junction is reverse biased.
3. C. The resistance of the voltmeter cannot be obtained from the information given.
4. C. ESR stands for equivalent series resistance of a capacitor. As an electrolytic capacitor ages, its ESR value increases.
5. B. The bode plot also is used to show amplifier phase shift vs. frequency. An interesting letter to the author was printed in the December 1986 Feedback column. In this letter Ray Ketchledge discusses the origins of the bode plot.
6. A. Addition and subtraction is performed in the ALU (arithmetic logic unit). A microprocessor does not have a beat-frequency oscillator (BFO) or a discriminator.
7. D. The circuit in Figure 1 is known as a *short circuit*. Trace the closed loop around the outside of the circuit.
8. B. Although it is true that increasing the capacitance decreases the capacitive reactance, the two values are not reciprocals.
9. B. A commutator is used to shut *off* an SCR. The SCR will stop conducting when its current is equal in magnitude, but opposite in direction, to the LC-tuned circuit. Actually, the charged capacitor in the tuned circuit tries to discharge in the anode-to-cathode direction through the SCR.
10. A. You could reverse either the field connection or the armature connection to reverse the direction of rotation. However, if you reverse both, the direction of rotation will not change. ES&T



ES&T

What do you know about electronics?

Living with models

By Sam Wilson, CET

A model is a simplified way of looking at a component, circuit, or system. An example is electron flow in a circuit.

By assuming that electric current is a flow of electrons, we can analyze circuit behavior. Actually, it is just as easy to assume the current to be positive charges and go through the circuit in the opposite direction.

Regardless of which direction you go, you are using a model that simplified the job of understanding the circuit. Actually, the current probably goes both directions at the same time. But, knowing that wouldn't be much help if you are trying to figure out how a differential amplifier (or any other circuit) will work for various input signals.

There is nothing wrong with models. They're great to live with, but don't marry them. The older they get the harder they are to live with and the harder they are to get rid of.

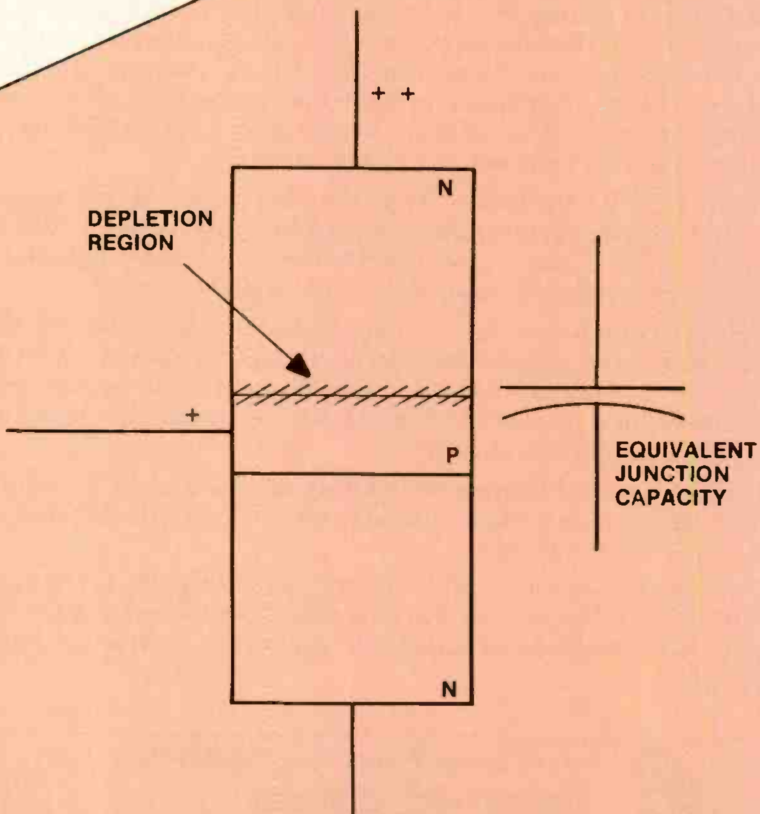


Figure 1. At a semiconductor PN junction, holes and electrons combine, forming a depletion region.

High voltage bipolar transistor circuits

As an example, consider the idea that solid-state circuits are operated with low voltages. Students today go through technical schools working with transistors, FETs and integrated circuits that work at a maximum of 24V. That protects the school from problems that can occur if a student should get zapped accidentally.

I often wonder how long they are out of school before they poke their fingers into a high-voltage solid-state circuit. They get complacent working with the nice (safe?) circuits on their proto boards.

A bipolar (NPN or PNP) transistor is *normally* operated with the base-collector junction reverse biased. An exception is in switching circuits in which the emitter-base and collector-base junctions both can be forward biased.

In this discussion, however, let's assume that the transistor is being used for a high frequency or very broad range of frequencies.

The model of Figure 1 shows that there is a depletion (insulating) region between the base and the collector. During the normal operation of the transistor in an amplifier, the reverse bias increases this depletion region.

The junction capacity that is formed by the depletion region and the P and N materials can be very troublesome at high frequencies. As shown in Figure 2, the high-frequency signal sneaks through the capacity so it appears at the output without being measured.

By greatly increasing the collector voltage, as shown in Figure 3, the depletion region is increased. That has the effect of moving the capacitor plates apart and lowering the junction capacity. The overall result is that the high frequency capability is improved... and so much for the idea that transistors are always connected into low-voltage circuits.

High-voltage MOSFETS

Depletion-type MOSFETS are usually connected into low-voltage circuits. However, enhancement MOSFETS can be another story altogether.

Consider, for example, the family of curves in Figure 4 for an RRF-430 MOSFET. This curve

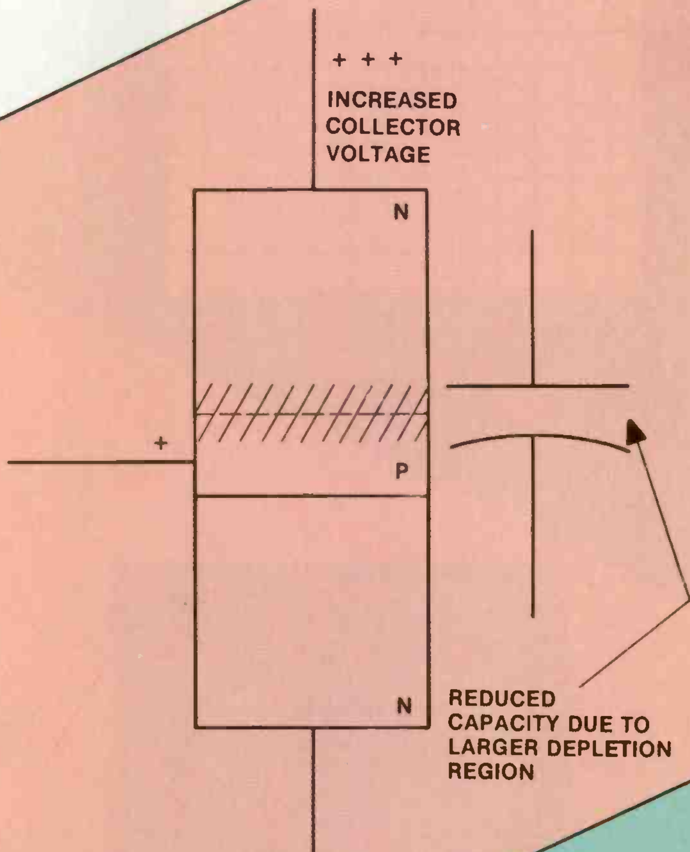


Figure 2. The PN junction has as a characteristic a certain amount of capacitance. At high frequencies, this may couple unwanted signals to the output.

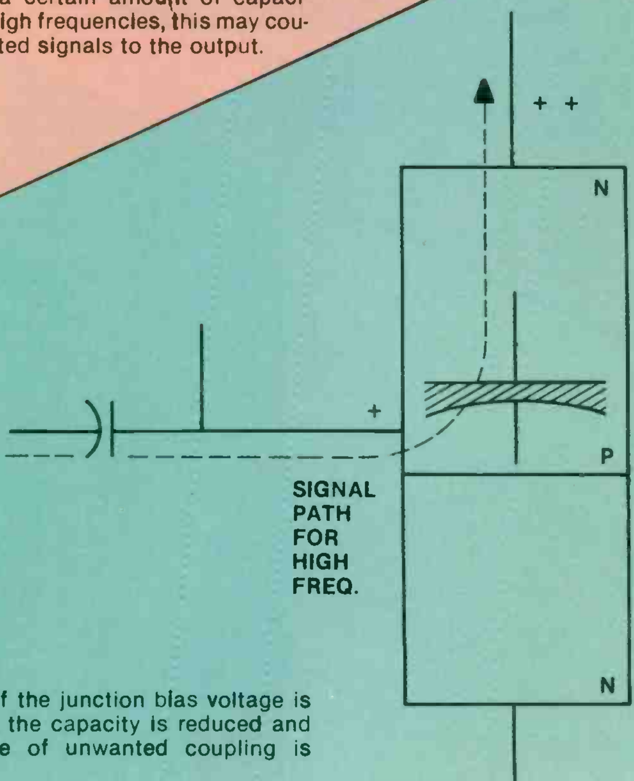


Figure 3. If the junction bias voltage is increased, the capacity is reduced and the degree of unwanted coupling is reduced.

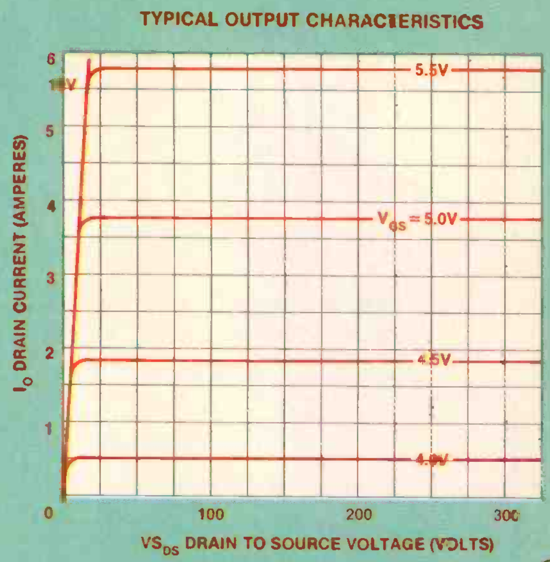


Figure 4. This family of curves for an RRF-430 MOSFET implies that the power-supply voltage in a circuit using it could easily be above 150V.

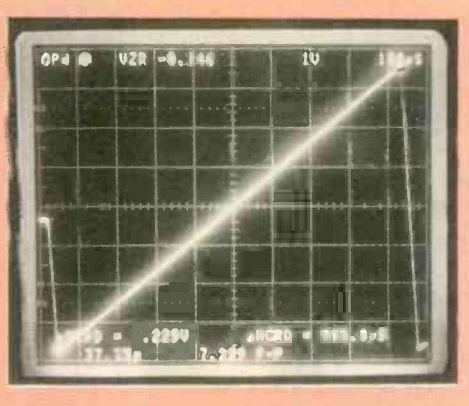


Figure 5. Here's a very linear sawtooth created in the lab.

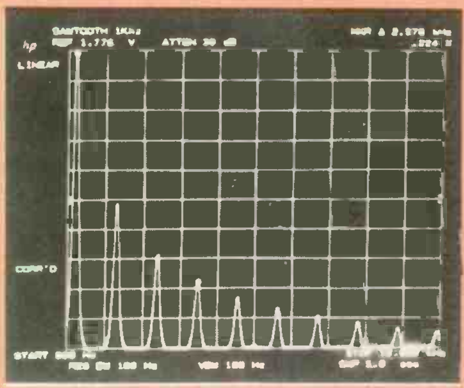


Figure 6. This photo shows the harmonic content of the sawtooth in Figure 5. The bright spot on the fourth harmonic is a delta marker.

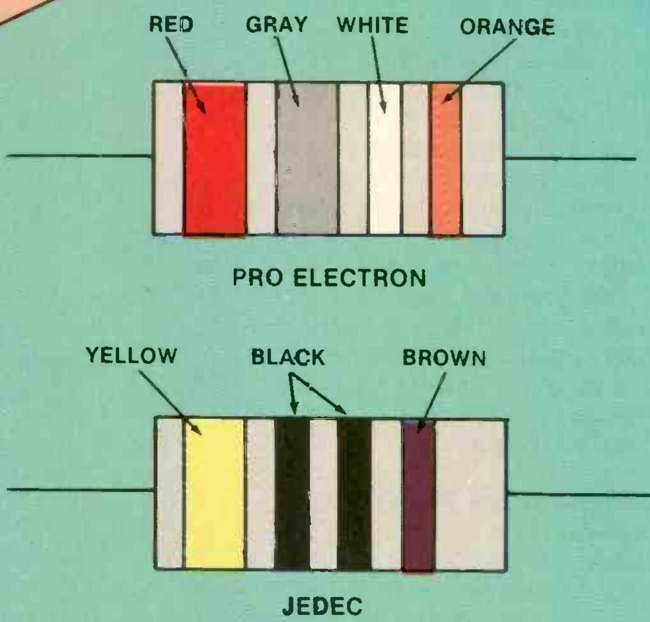


Figure 7. Two color codes are currently in use for semiconductor diodes: JEDEC and PRO ELECTRON.

was taken from an RCA catalog. Note the high voltages on the voltage axis. The power-supply voltage in a circuit using this MOSFET could easily be above 150V!

This is another example of a high-voltage, solid-state circuit.

Letter from a reader

For many years reader Ramon Valdes has been sending comments, suggestions and a few criticisms. In one of his letters he sent pictures of his laboratory. He is well equipped for experimenting.

At the present time Mr. Valdes is experimenting with the use of a sawtooth waveform (instead of a square wave) for analyzing amplifiers.

Figure 5 shows a photograph of a very linear sawtooth that he has generated in his lab; Figure 6 shows the harmonic content of the sawtooth displayed on his equipment. The bright spot on the fourth harmonic is a delta marker. Although he experimented with a sawtooth test, he doesn't consider it to be very useful. Here is a direct quote from his letter:

"Your article 'Tests for Low-Frequency Amplifiers' in the September and October 1986 issue of ***Electronic Servicing and Technology*** states the following: "Having presented the case for the sawtooth waveform test, the next question is: Why is it seldom used?' The answer is that there are automatic distortion analyzers on the market that will quantify distortion instantly and without *eyeballing*. Tektronix, Hewlett Packard, Amber, Sound Technology, Krohn-Hite and probably others make analyzers that not only have automatic nulling but also autoinput ranging. If you do warranty work, the unit you repair must meet specifications as to output voltage, distortion, bandwidth, etc. Therefore, sawtooth or square wave testing might be an excellent empirical test procedure if you have sophisticated test gear, but very impractical for routine servicing. Even the use of a function generator for judging at what frequency an amplifier is down to 70.7% is awkward because all of these distortion analyzers can be set to relative zero dB settings; all you do is vary the frequency until the meter reads –3dB."

My comment

I agree with what Mr. Valdes says about better equipment being available for quantitative tests. I have never advocated the use of the sawtooth or square wave test for that type of application.

The sawtooth or square wave should be used for a *qualitative test*. In other words, it requires a judgement and experience to be useful. You don't get a number, such as a frequency value, to tell the bandwidth. Instead, your experience must be used to evaluate the resulting display.

It is a quick test that utilizes low-cost test equipment. Think of the sawtooth and/or the square wave as a troubleshooting tool and not as a method of testing an amplifier against specifications.

Diode color codes

It is a good idea to review various color codes of components as a memory refresher. There are two diode color codes being used: JEDEC and PRO ELECTRON. Both are shown in Figure 7.

The wide band for the JEDEC code shows where to start reading (hold the diode so the wide band is on the left as shown in the illustration). A 1N is assumed to precede the code, and the bands are the identifying number. For the example shown, the diode is a type 1N4001.

Table 1 shows the code for the PRO ELECTRON type. The example shown is a BA Y 93.

TABLE 1

Broad bands First band	Second band	Small bands Serial number
AA – brown	Z – white	0 – black
BA – red	Y – grey	1 – brown
	X – black	2 – red
	W – blue	3 – orange
	V – green	4 – yellow
	T – yellow	5 – green
	S – orange	6 – blue
		7 – violet
		8 – grey
		9 – white

Products

VCR precision alignment kit

A VCR precision alignment kit from *Jensen Tools* contains a selection of tools manufactured to extremely fine tolerances and designed for critical adjustments of VHS and Beta videocassette recorders.

The kit includes a base plate reference jig and a height gauge, plus an 8-piece driver/wrench set with precisely configured bits.

Circle (75) on Reply Card

Frequency counter

The *Philips* PM6669 frequency counter breaks through the traditional price/stability barrier for instruments of this kind with its MTCXO (mathematically temperature-compensated crystal oscillator). Up to now, high-stability counters have used costly oven-stabilized oscillators. The stability of lower-cost instruments has been limited by the use of standard crystal oscillators or TCXOs (temperature-controled crystal oscillators).

In the MTCXO principle, the time base crystal oscillator is individually calibrated by factory measurement of its temperature-dependent frequency curve, which is then permanently stored in a non-volatile memory.

Circle (76) on Reply Card

Data communications service kit

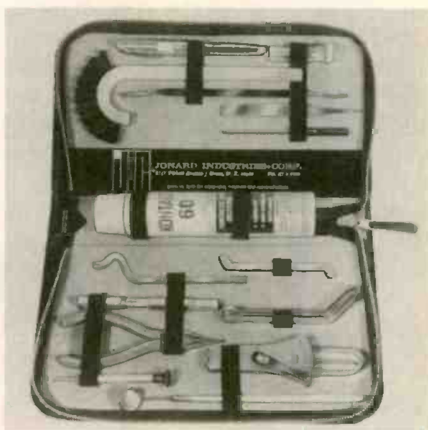
Designed for the installation and repair of computers, terminals and printers, this kit from *Contact East* includes all the tools necessary to accomplish both routine and more difficult service tasks.

All cases come with combination locks and two removable pallets. A full complement of accessories is offered for your specific data communications service needs.

Circle (77) on Reply Card

Relay servicing tool kit

This 15-piece kit contains precision tools necessary for adjusting, servicing and calibrating all types of relays. All tools are made of carbon steel, with heavy chrome plating. Dielectric tools permit adjusting and repair on *live* equipment without stopping operation.



From *Jonard Industries*.

Circle (78) on Reply Card

Flex-shaft attachment adds finger-tip control

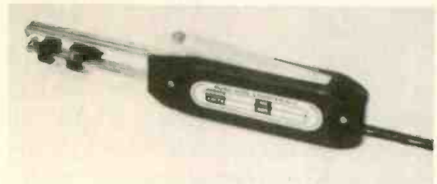
The model 225 Flex-Shaft attachment has been introduced for use with *Dremel's* new Moto-Tool line. The 36-inch cable and pencil-thin handpiece attaches to the Moto-Tool to provide lightweight, finger-tip control.

The cable attaches to Moto-Tool models 395, 285 and 275. The handpiece uses a collet to hold the variety of Moto-Tool cutting, carving and engraving bits. When using the flex-shaft, the Moto-Tool can be hung in a stationary upright position, reducing the operating weight of the Moto-Tool for intricate applications.

Circle (79) on Reply Card

Thermal stripper

Rush Wire Strippers announces model THS-20, a hand-held thermal stripper for use in stripping insulation from solid and stranded wires of sizes between 12 AWG and 43 AWG. The model THS-20 strips most thermoplastic insula-



tions, including Teflon, Kapton, nylon, plastics and PTFE to military and aerospace standards. It is self-contained, operating from a 115V, 60Hz electrical supply.

Circle (80) on Reply Card

Two new tools

GC Electronics introduces the insulated terminal crimper/stripper/cutter (GC12-465) and the GC cable tie installation tool (GC12-470). The crimper/stripper/cutter comes complete with color-coded crimping slots to simplify spotting correct crimping areas. The 8-inch tool also contains a 10-22 AWG wire stripper; a wire cutter is positioned at the tip.

The cable tie installation tool tightens and cuts cable ties flush in one operation, and is adjustable to lightweight or heavyweight settings.

Circle (81) on Reply Card ES&T

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Audio Corner

By Kirk Vistain

Hi-Fi interference

We've all heard the joke about a person with so many fillings that he heard voices in his head whenever he passed within five miles of a transmitter. I won't vouch for its veracity, but there is little doubt that radio-frequency interference (RFI) is becoming ever more prevalent as spectrum crowding increases. In this installment of *Audio Corner* we'll talk about RFI that affects audio equipment. I'll also refer to it as *HFI*, short for hi-fi interference. The source of HFI is not only radio transmissions, but also the myriad noises spraying out of microprocessor-equipped appliances. As you know, the prevalence of square waves in computer circuitry yields a rich harvest of harmonics, many of which can interfere with TV and audio products.

How HFI works

Audio Rectification

You might be wondering how a radio frequency signal of several megaherz is able to affect an audio circuit, given the great difference in frequency. Well, of course, the problem stems from something we're all familiar with, diode rectification. Every transistor and IC has diode junctions. Given RF of sufficient amplitude, they will rectify the signal, stripping off the carrier, leaving only the modulation, which is generally in the audio passband. This occurs with FM as well as AM transmissions, thanks to a phenomenon called *slope detection*. Actually, there are many other potential detectors besides semiconductors inside any piece of electronic gear.

Wherever two dissimilar metals join together, a diode junction is possible. This is not nearly as much of a problem when one of the contacts is gold. Thus you notice that high end audio gear often uses gold plated phono jacks. Another potential trouble spot occurs between the circuit board land and chassis on equipment that eschews wired grounds in favor of compression connections. The manufacturer is hoping that the board will be screwed down tight enough to make proper contact. This is an excellent way to ensure that the unit will have strange ground-failure related problems after several years of moderate use.

Other Effects

Some audio circuitry is sufficiently linear at a given radio frequency that rectification does not occur. The offending signal may pass right through several stages of amplification and on to the output amplifiers, which attempt to reproduce the inaudible RF at the cost of audio distortion. This is a tricky one to locate, but a scope should do it. Another possibility is that dc from detected FM interference may unbias a stage, causing troubles ranging from distortion to repetitive failure of a semiconductor. Fortunately, this sort of trouble is uncommon.

Entrance Points

Interference can enter a system along one of three paths. First, it simply can penetrate the cabinet. Secondly, it can use the power line. Finally, interconnecting cables offer another entry point. When trying to eliminate HFI, we first must discover which path it uses, then apply appropriate reduction techniques.

During diagnosis, we need to ask some questions.

Does the interference occur on all programs, or just one particular one, such as phono?

Does the unit have to be turned *on* to have a problem? (Don't laugh. I've worked on televisions that only picked up CB interference when they were powered down.)

Is the interference from a commercial radio or TV station, or is it from one of the personal communications bands? Is it even modulated with intelligence, or just some stray garbage from a microprocessor clock, aquarium heater, or the like?

If you suspect the noise enters from the power line, try disconnecting the ac cord while monitoring the output. If the noise immediately disappears, you've found the entrance way. If it dies off slowly as the filter capacitors discharge, it's coming in another way. On amps and receivers that have a speaker protection relay, you may need to jump the contacts out of circuit to make this test. You might also get a big pop out of the speakers if the plus and minus supplies discharge at different rates.

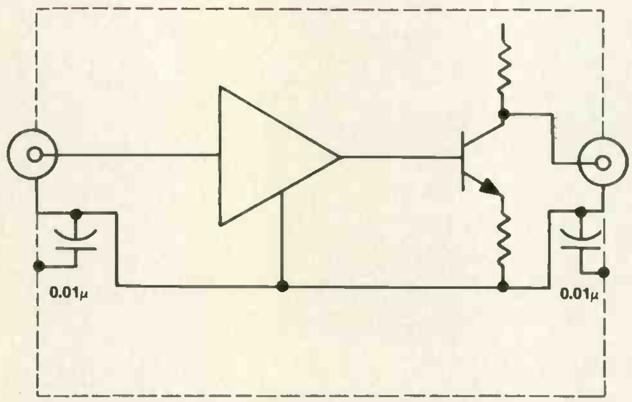

Figure 1. Capacitors bypass shield to chassis, keeping RFI out of amplifier ground.

HFI is insidious. The mere fact that input cables are properly shielded and grounded does not preclude the possibility that they will act as antennas at some frequency. For example, see Figure 1, which shows a hypothetical amplifier stage. Even though the shield is *grounded*, it still can couple noise into the cabinet from outside. This happens because an audio ground is not necessarily an RF ground. The wire connecting the input jack shield to circuit ground may be a dead short at 20kHz, but an inductor at RF. In that instance, noise will be coupled into the ground system of the amp.

Countermeasures

There are many ways of reducing HFI. The best is to keep it out of the system altogether. Second, and more realistic, is to design the circuitry to be as immune as possible In practice, we must use a 2-pronged attack, reducing both infiltration and susceptibility to a minimum.

Going back to our previous example, entry via interconnect cables, let's trap out the noise at the input jack. One way is to connect a capacitor between the input jack ground and chassis ground. A 0.01mF ceramic usually works. Keep the capacitor leads as short as possible and solder them in place. Now we've provided a low impedance path to the chassis for any RF that might show up on the shield.

Noise entering via the power line can be reduced by adding a couple of chokes and capacitors. See Figure 2. You can't assume that just because a piece of equipment is expensive, and was manufactured by a major electronics company, it has proper line filtering. As a matter of fact, it probably doesn't. Quite often, the power transformer offers the only protection from RFI. Noise filters that plug in on the receptacle end are not always effective, especially if the ac cord itself is acting like an antenna. One thing you can try that does not require internal modifications is to wrap several turns of the line cord around a ferrite core such as is found in most AM radios. A piece of tape serves to secure it in place. This works most effectively in the AM (MW) frequency band.

Internal noise, generated by clocks, oscillators and digital switching circuits, should be eliminated during the design phase by proper attention to bypassing logic ICs and providing separate ground returns for audio and digital signals. If you have trouble with a unit, it may be necessary to add 0.1mF bypass capacitors between Vcc and ground at as many logic ICs as is practical. You might also experiment with grounding, but this is often difficult, especially when the manufacturer has not done his homework.

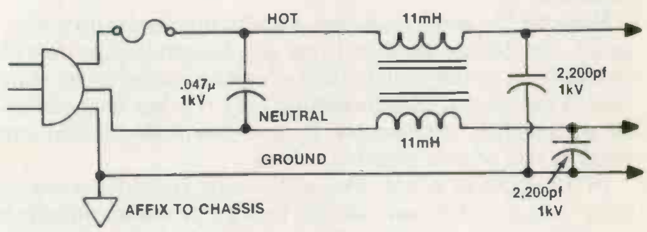

Figure 2. RFI line filter, good for 1~100MHz

A column of this length can no more than touch briefly on the subject of RFI. For your further study, I'd recommend *The Radio Amateur's Handbook*, published by the American Radio Relay League, Newtington, CT 06111; and *Consumer Electronics Systems Technician Interference Handbook–Audio Rectification*, published by the Consumer Electronics Group of the EIA, 2001 Eye St. NW, Washington, DC, 20006. ES&T

Computer Corner

By Conrad Persson

Do it with numbers

It really isn't necessary to understand computer numbering systems in order to be able to operate or repair a computer, but it's one of those veils of mystery that enshrouds computers and which disappear once you penetrate it.

Because the semiconductor circuits that make up a computer are 2-state devices (they can be conducting or not conducting, or they can exhibit a high or low voltage), computers can deal with information only if it has been encoded so that it is represented by a series of digits that can assume one of two possible values.

In the physical world, we can simulate this with a row of light bulbs. Let's say you're trying to communicate a number to someone with the row of light bulbs shown in Figure 1. To convey the number 1 is simple: just light up the rightmost bulb.

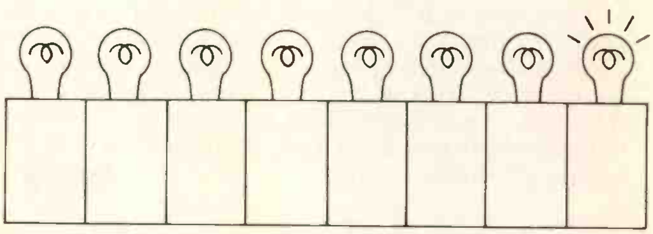

Figure 1. Two-state devices such as those used in computers can be simulated in the physical world by using light bulbs (they can be *on* or *off*). The number 1 can be represented by lighting the rightmost lamp.

If you wanted to convey the number 2, you could simply light up the rightmost two bulbs, Figure 2. With a scheme such as this, you could represent a number up to 8 with your eight light bulbs. Not a very economical scheme if you'd like to represent numbers that run up into the thousands.

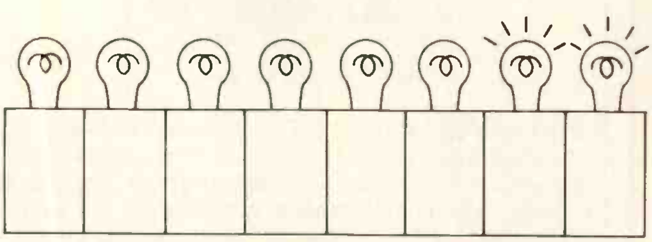

Figure 2. One way of representing the number 2 is to light two lamps. Using a scheme such as this, you could be able to represent up to the number 8 using eight lights.

Postional notation

Instead of using a number of light bulbs to represent a number that you wish to convey, you could do the job more economically by letting the position of a lamp represent a number. For example, if you and the person with whom you wish to communicate agree, you could simply light the second lamp from the right to represent the number 2 (See Figure 3).

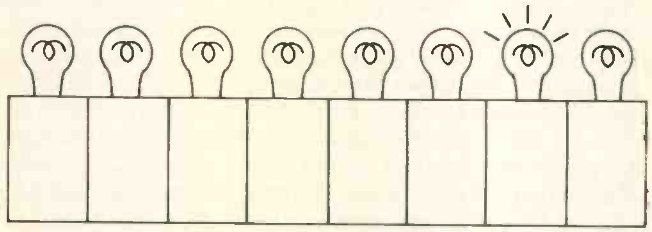

Figure 3. Another way to represent the number 2 is to use the position of the lamp to convey its value. In this case, when the lamp that is second from the right is lit, it represents the number two.

So far, so good. Now what do you do if you want to represent the number 3? Well, you have a bulb in the rightmost position that represents the number 1. You have a bulb in the next position that represents the number 2. If you light them both, you have a signal that represents 2+1, or the number 3.

Because you can represent numbers up to 3 using the rightmost two lights, it would make sense to use the third bulb from the right by itself to represent the number 4. Now look. If you light up the 4 bulb and the 1 bulb you have number 5. If you light the 4 bulb and the 2 bulb you have the number 6. If you light all three bulbs, you have 4, plus 2, plus 1. That's 7. So, using only three bulbs, each of which can be turned *on* (1) or *off* (0), you can represent the numbers 0 through 7.

You can represent larger numbers by lighting farther to the left. Because the first three bulbs can represent numbers up to 7, the fourth bulb from the right will, when lit alone, represent the number 8. Using the same scheme discussed above, but with the fourth digit, we can represent the numbers from 0 to 15.

You've just discovered the binary system

Extending this same logic a little further (see Figure 4), the fifth bulb will represent 16. The sixth, 32. The seventh, 64. The eighth lamp position will represent the number 128. So, using just eight bulbs, we can represent the numbers from zero to (128+64+32+16+8+4+2+1) or 255. In fact, this is exactly how the binary numbering system works.

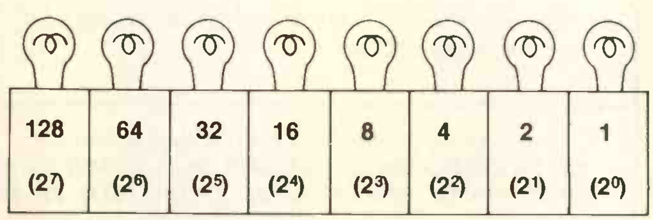

Figure 4. By using the position of the light bulbs to represent certain values, it is possible to represent the numbers 0 to 255 using eight 2-state devices.

Converting from binary to decimal and vice versa

To convert from binary to decimal is a piece of cake: we've already done it. Take another look at Figure 4. The "weight" of each position is shown below that position. So, for example, the binary number 101101 is equivalent to (starting from the right), $(1\times1)+(0\times2)+(1\times4)+(1\times8)+(0\times16)+(1\times32)=45$.

2)1 r 0 — MOST SIGNIFICANT DIGIT

2)2 r 1

2)5 r 1

2)11 r 0

2)22 r 1 — LEAST SIGNIFICANT DIGIT

2)45

Figure 5. In the successive division method of converting from decimal to binary, the remainder after each division becomes the binary digit for its respective position in the binary number. The quotient of the last division becomes the most significant digit.

You can convert from decimal to binary in at least two ways. One way is to divide successively by two. It works fine, but doesn't really show well what's going on. The other way is to start by finding the largest multiple of two by itself in the number, in this case 45. Start like this: $(((2\times2=4)\times2=8)\times2=16)\times2=32$. That's the highest multiple of 2 in 45, because if you multiplied by 2 again, you'd get 64, which is larger than the number (45) we want to convert.

Going back to the idea of positional notation, that means that the binary number that represents 45 will have as its most significant digit, a 1 in the sixth position from the right.

Now subtract 32 from 45. That leaves 45-32=13. Because 13 is smaller than 16, the 16's digit in the binary representation of the number 45 will be zero. So far the binary representation for 45 is 10xxxx.

The highest multiple of 2 by itself in 13 is $2\times2\times2$, or 8, so there will be a 1 in the 8's position. Because we now have 32 and an 8 (a total of 40) in the binary representation of 45, there's only 5 more to complete the number. There's a 4 in there, and then that leaves only a 1, and no 2's digit. So the conversion back to binary gives the number 101101, and lo and behold, that's the number we started with.

Another time we'll talk about hexadecimal. ES&T

Some *more* terms and what they mean

This concludes the glossary begun in the May issue of ***ES&T*** of terms imposed by the introduction of VCRs, describing VCR components and their operation. This glossary is reprinted courtesy of the General Electric Company.

Glossary

Frame
One complete TV picture. See "Field."

Gate
A circuit that will deliver an output only when a specific combination of its inputs are present. For use in analog or digital applications.

Guard Band
This is the space between video tracks on the videotape in the SP mode. Guard bands contain no information.

Hall Effect IC
An external magnetic field causes current to flow in this type of device.

HD
Horizontal drive signal.

Head Cylinder
A cylindrical piece of metal that houses the video heads. The tips of the heads protrude slightly from the surface of the cylinder so that they may scan the tape as the cylinder spins.

Head Switching
The action of turning *off* during playback, the video head that is not in contact with the videotape. A particular video head will be turned *off* 30 times per second. This is done so that the head that is not scanning the tape, and therefore not delivering a good signal, cannot contribute any noise to the playback signal.

Head Switching Pulse
The signal that is applied to the head amplifier to perform head switching. This is a square wave at 30Hz, with a 50-50 duty cycle.

Helical
A word used to describe a general type of VTR in which the tape wraps around the video head cylinder in the shape of a 3-dimensional spiral, or *helix*. The video tracks are recorded as a series of slanted lines.

Interchangeability
A term used to describe how well a particular VTR will play back a tape recorded on another VTR of the same type. Good interchangeability indicates good playback.

Interlacing
The property of the scan lines of two TV fields to lie in between each other. See "Field."

Interleaving
A term used to indicate that the harmonics of the chrominance signal lie in between the harmonics of the luminance portion of the video signal as it is viewed on a spectrum analyzer. This means color information of a video signal does not interfere with, although broadcast at the same time as, the luminance information. Also, signals that have this interleaving property are not readily seen on a TV screen because of their virtual cancellation characteristics.

Interleaving signals (fi) must have the following frequency relationship:

$$fi = \left(\frac{2n+1}{2}\right) \times fH \quad (n=0, 1, 2, 3, 4....)$$

$$fH = 15{,}734\text{Hz (H sync frequency)}$$

Jitter
The name of the effect on the playback picture if a VTR has too much wow and flutter. The picture appears to have a rapid shaking movement.

Luminance
This is the portion of video signal that contains the sync and B&W information.

MMV
Monostable multivibrator. Usually an IC device that gives a logic high or low output with a variable duration upon receipt of an input pulse or transition.

Non-Linear Emphasis
This is similar to regular emphasis with the difference that small-level, high-frequency portions of the signal are given more of a boost than higher level high-frequency portions.

NTSC
The National Television Systems Committee. These four letters identify the United States color television standard.

PG
Pulse generator used in the servo circuits.

Q
A term used to describe the graphic response of a filter or tuned amplifier.

Review
To scan the playback picture at a faster than normal speed in the Reverse direction.

Rotary Chroma
The name of the process used in VHS to change the phase of the chrominance signal at a rate of 15,734 (same as H sync frequency) times per second.

Rotary Transformer
A device used to magnetically couple RF signals to and from the spinning video heads, thus eliminating the need for brushes.

Sample and Hold
A process used in comparator circuits by which the value of a particular signal is measured at a specific moment in time, then this value is stored for later use.

Search
To scan the playback picture at a faster than normal speed in either the forward or reverse direction.

Servo
Short for Servo mechanism. This is an electromechanical device whose mechanical operation (for instance, motor speed) constantly is being measured and regulated so that it closely matches or follows an external reference.

Skew
Another way of saying Tension Error. Skew is actually the change of size or shape of the video tracks on the

e of recording to the time of playback. s a result of poor tension regulation by ambient conditions that affect the tape.

The 3.58MHz continuous wave signal used r information.

till.

or

w."

se Stability

A term describing how closely the playback video signal from a VTR matches an external reference video signal, in regard to sync timing rather than picture content.

Tracking

This is the action of the spinning video heads during playback when they accurately track across the video RF information laid down during recording. Good tracking indicates that the heads are positioning themselves correctly, and are picking up a strong RF signal. Poor tracking indicates that the heads are off track, and picking up low level RF signal or noise.

VCO

Voltage controlled oscillator: an oscillator whose frequency of oscillation is governed by an external voltage.

Video Head

This is the electromagnet used to develop magnetic flux that will put RF information on the tape. In VHS, two video heads are mounted in a rotating cylinder around which the video tape is wrapped. As the cylinder spins, each video head is allowed to alternately scan the tape.

Video Track

The name of the RF information laid down during recording, as a particular video head scans across the tape.

VHS

Video home system.

VTR

Video tape recorder.

VV

Video-to-video, or the actual playback picture produced from a tape during playback.

VXO

Voltage controlled crystal oscillator, similar to VCO except that a quartz crystal is used as a reference which can be varied.

White Clip

After emphasis, the positive-going spikes (overshoot) of the video signal may be too large for safe FM modulation. A white clip circuit is used to cut off these spikes at an adjustable level.

XTAL

Abbreviation for crystal.

Y Signal

The B&W portion of a video signal containing B&W information and sync. ES&T

Readers' Exchange

Wanted:

Bell and Howell Schools (DeVry Institute) Oscilloscope Assembly manual 9560-3, Part II, for 5-inch triggered-sweep oscilloscope. Will pay for photocopies, or will copy and return. Or, would appreciate anyone telling me how to obtain a copy. *Miguel R. Lamoglia, Magna Tech Electronic, 630 Ninth Avenue, New York, NY 10036.*

Regulator board for Magnavox color television, model 704208-1. Also horizontal osc. board for model 703881-3. *Hornick Radio & TV, 4366 Eastport Drive, Bridgeport, MI 48722; 517-777-2494.*

RCA senior volt-ohmist, model WV-98C or similar; meter for Hickok No. 225. State condition and price. *Portage TV, 414 Cleveland Road, Ravenna, OH 44266; 216-297-1491.*

Training video tapes: will trade for the TV and VCR service training tapes that I have. Send list to *CW Electronics, 11728 IL Route 72W, Forreston, IL 61030; 815-938-2564.*

Sams Photofacts sets Nos. 1 through 150; any pre-1950 TV service manuals or literature; any pre-1950 televisions, state condition, make/model, price, etc. *Don Hauff, 9988 107th Ave. North, Maple Grove, MN 55369.*

Information leading to the identification and/or purchase of best B&W set made. Living-room size, any age, prefer older. *H. Paprocki, 240 Rosedale, Rochester, NY 14620.*

Sams Photofacts after No. 1500; Sams CB, MHF and TR books, please send list and price wanted. *Nancy Hauver, 34 Burlington Ave., Rochester, NY 14619.*

Operating instructions and schematic for Hickok model 660 white dot-bar, color-display generator. *Mr.Fixit, 1136 N. 45th St. Milwaukee, WI 53208; 414-344-7143.*

Replacement idler wheels for Akai VT-100 video recorder, junk unit OK; schematics for Akai VC-115 B&W camera and for Ricoh RIFAX-3300H facsimile machine. *Jeff Parker, Hi-Tech Electronics, 7901 Twin Oaks Court, Raleigh, NC 27615.*

Telequipment scope, model D52 or S52. Telequipment is a subsidiary of Tektronix. *J.G. Shoemaker, Color TV Sales & Service, 600 First St., Leechburg, PA 15656.*

Service manual/schematic for Teledyne Packard Bell 19-inch color television, Telemagic 100, chassis CBS2. Will pay for original or copies. *John Phipps, 1412 Navaho Trail, St. Charles, MO 63303.*

Leader 524L, 35MHz to 40MHz with calibration delay. Will pay top dollar for good equipment. *Miller TV, P.O. Box 364, Portales, NM 88130; 505-356-4207.*

Vacuum tube No. 1HTF10 for Beckman pH meter, model 72. *D.E. Weisshaar, Augustana College, Chemistry Department, Sioux Falls, SD 57197.*

B&K 1077 analyst or tuner subber. *Frank Lurry, 4924 69th St., San Diego, CA 92115; 619-462-7445.*

Schematics for Vectrex arcade system, model HP3000, built by GCE. *Robert W. Freeman, 14010 Glenview Place, Huntsville, AL 35803.*

Transformer from Panasonic 8-track player-recorder, model RS-806US. Made by ISO, No. QLP-0614S. Also desire schematic for same. *David W. Finley, 7 Foley Beach Road, Hingham, MA 02043.*

Sencore SG165, late model, in excellent condition, with manual and leads. *Multi-Tek Electronics, P.O. Box 25, 1430 W. Congress St. Allentown, PA 18105.*

NRI course for television and VCRs, lessons only, without the kits. *Marcel Lotwin J., Laboratorio de Muntenimiento, Apartado Postal 11-456, Mexico 11 DF 06100, Mexico.*

Apple III machines, with or without monitors and IDS Graphics printers. Reward offered for leads to successful purchase of *quantity* of above. *Murray C. Johnson, Box 272, Oxbow, Saskatchewan, Canada SOC 2BO.*

Any Tekfax Nos. 100 through 115. Will trade for any ite
under "For Sale." *Robert P. Morrison, 1640 Mill Oak
Beach, VA 23464; 804-467-8605, after 6 p.m.*

Commodore 64, working or not. *Dan's TV, 316 East E St., Hu
67501.*

Schematic or service manual for Record-A-Call model 80A tel
answering machine. *R.N. McEntire, 323 Tram Road, Columbia, SC 2*

I collect old computer equipment and parts. Tell me what you have, at wha
price. Also need service information on Fonovox type 05778W radio. Will buy or copy. *Tom Radigan, 264 Addison Road, Riverside, IL 60546.*

Supreme test equipment, models 85C, 89, 189, 333, 385, 530, 535. Thordarson fly 196 or equivalent; early Hallicrafters television with round picture tube and metal cabinet. Early radio and TV advertising, promotional items, neon signs, lighted clocks, etc. *Doug Heimstead, 1349 Hillcrest Drive, Fridley, MN 55432.*

Sams CB service manuals, Nos. 148 to 154, 166, 167, 169 to 177, 179 to 207, 266, 267, 272 to 274, 281, 282, 284 to 293. *Larry Jackson, Route 2, Box 299J, Hamptonville, NC 27020; 919-468-2758.*

NRI model 315 25-inch color television, assembled or unassembled, working or non-working. *David M. Kinchlow, 1515 Walnut St., New Albany, IN 47150.*

Schematic for Simpson model-T radiotelephone. Will pay for copy. *L. Rollins, 2991 Clay, Apt. 45, Paducah, KY 42001.*

Sencore–LC75, PR57, TF46, VA48, used but in good working condition. *Louis Zeman, 10 Benchmark Drive, Boulder, CO 80303; 303-499-1500.*

For Sale:

Complete CB bench including B&K 1040, B&K 2040, B&K counter, Sams CB-1 through CB-279, $1,200; B&K 1077B TV analyst, $250; Heath sweep marker generator, $175; Sams TV Photofact folders No. 1300 through 1829, $1,060; several AR manuals. *Frank Wolff, 6 White St., Topsham, ME 04086; 207-729-0566, after 5 p.m.*

Flyback tester. *Dan's TV, 316 East E St., Hutchinson, KS 67501.*

B&K 467 CRT rejuvenator with 11 sockets, excellent condition, $200; Sencore CA-55 capacitor tester, like new, $300. Cash or money order only. Will ship UPS. *Larry Poffen, 12550 E. 132nd St. South, Broken Arrow, OK 74011; 918-455-1041, 918-455-3680.*

Sams Photofact folders, 206 varied, from Nos. 84 to 2143; 231 in a complete set from Nos. 2159 to 2389; 69 books in the AR, CB, CM, MHF, SD, TR and TSM series. $250 plus shipping for all. *Ronald Cowell, 7963 Lynbrook Court, Ferndale, WA 98248.*

Fluke 1900A multifunction counter, 80MHz, autoranging, mint condition, $120. *L. So, 1392 Rowe Road, Schenectady, NY 12309; 518-372-9063.*

Quasar service manuals, CTV Nos. 1 to 43, TV Nos. 1 to 28; RCA service manuals Nos. 1972 to 1982; variety of Quasar and RCA panels. Best offer. *L. Rollins, 2991 Clay, Apt. 45, Paducah, KY 42001.*

New and old tubes at 85% off list. Send large s.a.s.e. for list. *Mitchell Electronics, 4 Golf Ave., Maywood, NJ 07607.*

Test equipment–SG 165 AM/FM stereo analyzer, CG 169 color-bar generator, FS 134 field-strength meter, RCA WV 98C VTVM (never used); Sams Photofact folders from No. 1741 to 1810. *George Maleski, Laura Lane. Bedminster Farms, Bedminster, NJ 07921.*

Assembled Heathkit IT-2232 component tracer (built-in CRT), as new, used infrequently, $150, including shipping. Trade for B&K or Viz 7-inch analog multimeter, regulated and metered 0-40 dc power supply, etc. *Kevin Kubista, Burt's Music and Sound, 1123 Sherman Ave., Coeur d'Alene, ID 83814; 208-664-4957.*

Sony VP1200 ¾-inch U-matic videocassette player, new rubber and lube, $350; Sony SL8200 Beta VCR, excellent condition, $200; Zenith IR9000 Beta VCR, $50 as is, or will recondition for $200; Sony TC630 reel-to-reel tape deck, working, $75; Simpson white-dot generator, working $30; Yamaha CR820 stereo receiver, repairable, $30; Concord DBA-9 Dolby noise-reduction unit, working, $25. *Joe Sanfilippo, P.O. Box 347, Woodruff, WI 54568; 715-356-6004 or 715-356-7564.*

Sams Photofact folders, 291 sets from No. 41 through 331; RCA equipment-marker/adder WR-70A, sweep/generator WR-59C, video multimarker WG-295C, mixer grid matching pad WG-418A, IF test block WG-416A. Best offer plus shipping. *LeRoy Barnes, 118 W. Main St., Camden, TN 38320; 901-584-6411.*

1947 Tung-Sol tube characteristics chart; 1947 RCA receiving tube manual; 1950 RCA receiving tube manual; Knight KG-686 RF generator; Knight KG-687 sweep/marker generator; Knight KG-688 sine/square wave generator; EICO 442 curve tracer; EICO 685 transistor analyzer; RCA WG-307B bias supply; EMC 801 bridge; Heath IM-25 solid-state analog VOM. All in new condition, probes and instructions included. *D.A. Richard, 27 Dean St., Hudson, MA 01749.*

Hewlett-Packard 2401B integrating digital voltmeter, ±0.01% dc accuracy, frequency to 300kHz, $300; Diehl Mark III scanner, $250; Hewlett-Packard 202A low frequency function generator, $60; Bell & Howell (Heath) digital voltmeter, $40; Bell & Howell oscilloscope, 5MHz triggered, $85. All with manuals, shipping paid. *Fred Jones, 407 Morningbird Court, Niceville, FL 32578; 904-678-1803.*

B&K color-bar generator. *Hornick Radio & TV, 4366 Eastport Drive, Bridgeport, MI 48722; 517-777-2494.*

Hewlett-Packard scope, dual-trace, plug-in, No. MX-2930B/USM, broken switch on channel A, restorable or for parts, $20; Sams manuals-MHF 177; TSM Nos. 1 through 11, 13, 27, 30, 35, 42, 48, 49, 50, 52 through 62; AR19, 21, 23, 25, 28, 35 and 45-$2.50 each. Sams Selective Data Library, Vol. 1, covering Majestic postwar radio models through May 1948, $10. All items plus shipping. *Donald H. Nash 1444 Pulaski St., Port Charlotte, FL 33952.*

Sencore SG165 stereo analyzer, complete, new condition, $450; Sencore CR31A Super Mack picture tube tester/restorer, $450; B&K 40kV HV meter, $20; degaussing coil, $10; leakage tester, $20; touch-test probe for Sencore transistor tester, $20. *Bill, R840 Emerald Lane, Edgar, WI 54426; 715-257-7214, after 6 p.m. CST.*

Diehl Engineering Mark V diagnostic computer, new, $495, negotiable. *Duane Conger, 4321 Herrick Lane, Madison, WI; 608-238-4629.*

Sams Photofact folders, Nos. 401 through 500, 100 total at 25 cents each, plus UPS shipping. Also have both rare and current tubes at reasonable prices. *Ted Youngman, 2225 Vigo St., Lake Station, IN 46405.*

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Sams CB service manuals Nos. 1 though 147, $3 each, $175 for all. *Larry Jackson, Route 2, Box 299J, Hamptonville, NC 27020; 919-468-2758.*

EICO model 369 TV, FM sweep and post injection marker generator. Heathkit vectorscope. For sale or will exchange. *Frank Lurry, 4924 69th St., San Diego, CA 92115.*

Sams color TV "Service Made Easy," Vol. 3, $3; Sams color TV Field Service guide, Vols. 3 to 5, Sams AR24, AR46 and TSM50, $1.50 each; Zenith HF-13 Stereo service manual and Zenith SP12 Space Command Remote Control service manual, $3 for all plus postage, c.o.d. *Robert P. Morrison, 1640 Mill Oak Drive, Virginia Beach, VA 23464; 804-467-8605 after 6 p.m. EST.*

Complete audio-video service bench, including Sencore video analyzer, Sencore stereo analyzer, B&K 80MHz, quad input 8-trace scope. All equipment is near-new, perfect, with all manuals and accessories. Send s.a.s.e. or call. *C.K. Parker, 2928 Brighton, Kansas City, MO 64128; 816-924-5295.*

Radio and TV parts, text books, service manuals, 800 new, standard-brand tubes, 85% off list price. Send large s.a.s.e. for list. *Max Seligsohn, 1455 55th St., Brooklyn, NY 11219.*

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AUTOMOBILE RADIO and tape replacement parts. Delco, Chrysler, Philco-Ford, Motorola, Panasonic and many others. Large inventory. Laran Electronics, Inc., 3768 Boston Road, Bronx, NY 10469. (212) 881-9600. National (800) 223-8314, NY State (800) 446-4430. 1-85-tfn

CABLE TV CONVERTERS & EQUIPMENT. Plans and parts. Build or buy. Send S.A.S.E. C&D Electronics, P.O. Box 1402, Dept. ES&T, Hope, Arkansas 71801. 1-86-tfn

VCR REPAIR SOLUTIONS for VHS models. Over 150 symptoms and cures. The hard ones. Send $11.95 to Eagle Electronics, 52053 Locks Ln., Granger, IN 46530. 5-87-8t

SERVICE MANUALS. Large Shop has 18 yr. collection of duplicates. All original manufacturer. All new. Audio $2.00, video $5.00. Send SASE for list. Tape Recorder Clinic; 4850 E. Speedway; Tucson, Arizona 85712. 11-86-tfn

PHOTOFACTS: Individual folders #1 to #1400 $3.00. Above #1400 $5.00. Sent same day first-class postpaid. Loeb, 414 Chestnut Lane, East Meadow, NY 11554. 4-87-6t

3000 COLOR TV REPAIR TIPS, 31 Brands 116 Page Manual. Send $21.00 to A. Fernandex, Box 546110, Surfside, Florida 33154. 4-87-3t

TV TROUBLESHOOTING. Over 120 schematic ILLUSTRATED problems-solutions of difficult repairs. Also, 12 steps to easier TV repair, 25 pages $12.00. Bonus: Remarkable diagnostic tool. Determine operation of high voltage circuits every time, no mistakes. $5.00. Jones, Box 702, Niceville, Fla. 32578. 4-87-3t

2,100 PHOTOFACTS AND CABINETS $875. 1077B Analyst $225. All in excellent condition. Larry Williams, Route 1, Ridgeway, Illinois, 618-272-7449. 6-87-1t

SENCORE SG165 stereo analyzer, $495.00, 1-801-487-8742. John Graber, 1252 E. Driggs Ave., #B, Salt Lake City, UT 84106. 6-87-1t

TV TOUGH DOGS 200 symptoms and cures. Send $6.95 to DAVIS TV, 11772 Old Fashion Way, Garden Grove, CA 92640. 4-87-3t

BUSINESS OPPORTUNITIES

T.V. SALES & SERVICE. Well established business located northern Virginia. Owner retiring and will help with financing. Call 703-972-7027 after 7:00 p.m. EST. 6/85-tfn

ELECTRONIC REPAIR, inventory & equipment. 11 years at same location. Small recreational town in Idaho. Owner wishes to retire. $15,000. 208-756-2916, Box 488, Salmon, Id. 83467. 5-87-3t

BUSINESS OPPORTUNITIES

TV SALES & SERVICE—20 years in Orange County, CA. Excellent customer base and reputation. Well organized and profitable shop. For information call Bob Klein, PCM Realty, (714) 768-7261. 5-87-2t

VCR-TV-STEREO Service Business—Have 33 major companies for warranty service. Est. 27 years—Retiring. L.I. 516-475-2203. 6-87-1t

HELP WANTED

CAMERA-VIDEO Technicians needed. Top pay and benefits for well trained and experienced technicians who are expert with consumer and/or industrial cameras and VCR's. Training by manufacturers such as Sony, Hitachi, Panasonic, etc., are necessary for job experience. Come to sunny Florida and enjoy your work & leisure time. Write or call ATLANTIC ELECTRONICS INC., 1232 NE 26th St., Ft. Lauderdale, FL 33305. (305) 564-8274 10 AM to 6:30 PM. Ask for Dave or Joe. 8-85-tfn

VIDEO/AUDIO technician needed. Top pay and benefits for well trained and experienced technicians who are expert with consumer TV and audio equipment. Training by manufacturers such as: Sony, Hitachi, RCA, Panasonic, etc. are necessary for job experience. Write or call: Atlantic Electronics, Inc., 1232 NE 26th St., Ft. Lauderdale, FL 33305, 305-564-8274 (10 AM 6:30 PM). Ask for Dave or Joe. 06-86-tfn

ELECTRONIC TECHNICIANS—Part time for field service and preventative maintenance. Openings nationwide. Must have own transportation, flexible hours, and some equipment. $15.00 per hour. Send Resume to Field Service, Best Power Technology, P.O. Box 280, Necedah, WI 54646. 6-87-2t

WANTED TO BUY

WANTED TO BUY: Wen 199 Gun and 1984 tips. Wells & LaHatte, 919 Clay Street, Vicksburg, MS 39180—601-636-5806. 6-87-1t

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Servicing & Technology

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P.O. Box 12901
Overland Park, KS 66212
Phone: (913) 888-4664

NORWOOD, AUSTRALIA
Hastwell, Williamson, Rouse PTY. LTD.
P.O. Box 419
Norwood, S.A. 5067
Phone: 332-3322
Telex AA 87113

LONDON, ENGLAND
Nicholas McGeachin
Roseleigh House, New Street
Deddington, Oxford OX5 4SP
Phone: (0869) 38794
Telefax: (0869) 38040
Telex: 837469 BES G

TOKYO, JAPAN
Haruki Hirayama,
EMS, Inc.
Sagami Bldg., 4-2-21, Shinjuku,
Shinjuku-ku, Tokyo 160, Japan
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ELECTRONIC Servicing & Technology

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For issue of June 1987
Void after October 1987

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- 37☐ Electronics Equipment Or Components Manufacturer
- 38☐ Government and Military: Federal, State, Municipal
- 09 Education
  - (a)☐ College, Library, School, Including Instructors
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- 30☐ Other ____________

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- EE☐ **Company Management** Such as General Manager, Owner, Partner, President, Vice President, Director And Other Corporate Personnel
- FF☐ **Operations Management** Such as Service Manager, Operations Manager, Production Manager, Customer Service Manager, Marketing/Sales Manager, Purchasing Manager, Credit/Accounts Manager and Other Operations/Administrative Personnel
- GG☐ **Engineering/Technical & Other Personnel** Such as Engineer, Technician, Field Service Engineer, Specialist, Engineering Associate and Other Engineering And Technical Support Personnel
- KK☐ **Other** ____________

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- D☐ 26-50
- E☐ Over 50
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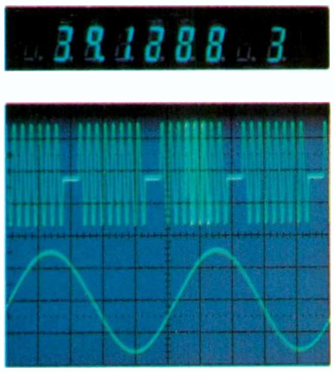
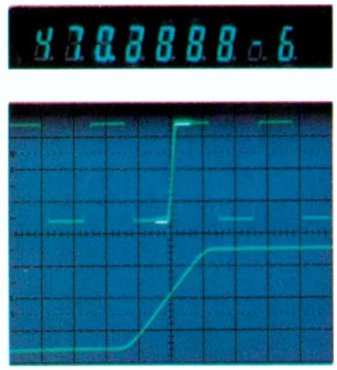
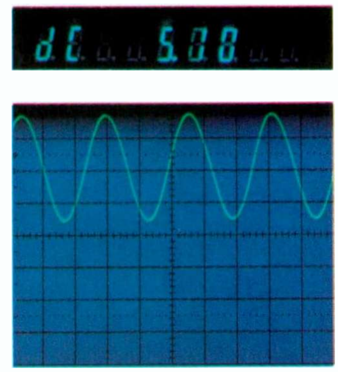
NOW GET SCOPE, COUNTER AND DMM INPUT ALL AT ONCE THROUGH ONE PROBE!



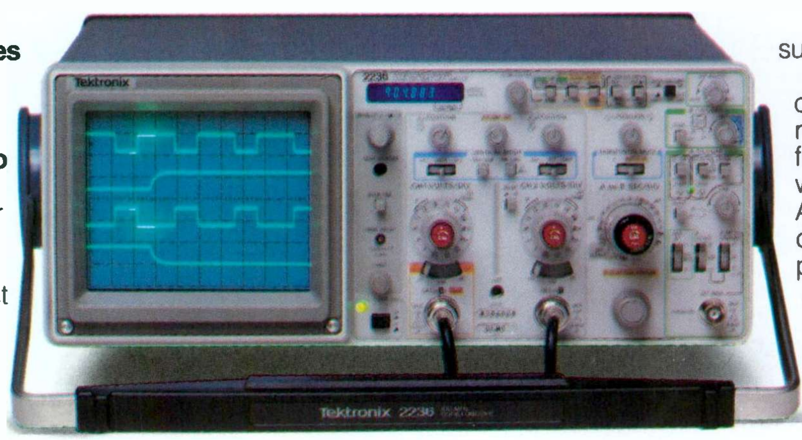
Gated frequency measurement. B sweep triggering during the intensified portion of the A sweep. Intensified portion frequency is measured with the counter/timer/DMM.



Delay time measurement. Delay time from the start of A sweep to the start of the B sweep is measured with *crystal accuracy.*



Channel 1 dc volts measurement. The average dc component of a waveform is measured directly through channel 1 with direct digital fluorescent readout.



The Tek 2236 combines 100 MHz, dual timebase scope capability with counter/timer/DMM functions integrated into its vertical, horizontal and trigger systems. For the same effort it takes to display a waveform you can obtain digital readout of frequency, period, width, totalized events, delay time and Δ-time to accuracies of 0.001%.

The same probe is used to provide input for the CRT display and the digital measurement system, resulting in easy set-up, greater measurement confidence and reduced circuit loading. Probe tip volts can also be measured through the Ch 1 input.

Precision measurements at the touch of a button. Auto-ranging frequency, period, width and gated measurements are push-button-simple. And the 2236 offers an independent floating 5000 count, auto-ranging multimeter with side inputs for DC voltage measurements to 0.1%.

A built-in, auto-ranging ohmmeter provides resistance measurements from 0.01 Ω to 2GΩ—as well as audible continuity. Automatic diode/junction detection and operator prompts serve to simplify set-up and enhance confidence in your measurements.

Bandwidth	100 MHz
No of Channels	2 + Trig. View
Max. Sweep Speed	5 ns/div
Digital Readout Features	Direct Ch 1 Voltage Meas. 0.5% DC; 2.0% AC RMS Resistance: .01Ω to 200 MegΩ Continuity/Temp: Audible/C° or F° Totalizing Counter: —1 counts to 8,000,000 Direct Freq. Meas: 100 MHz to 0.001% acc. Period, Width Meas: 10 ns with 10 ps max. resolution
Timing Meas. Accuracy	.001% (delay and Δ-time with readout)
Trigger Modes	P-P Auto, Norm, TV Field, TV Line, Single Sweep
Weight	7.3 kg (16.2 lb)
Price	$2650
Warranty	3-year including CRT (plus optional service plans to 5 years)

The 2236: scope, counter, timer, DMM plus a 3-year warranty —all for just $2,650.

Contact your nearest distributor or call Tek toll-free. Technical personnel on our direct-line will answer your questions and expedite delivery. Orders include probes, 30-day free trial and service worldwide.

Call Tek direct:

1-800-433-2323 for video tape or literature,

1-800-426-2200 for application assistance or ordering information.

In Oregon, call collect:
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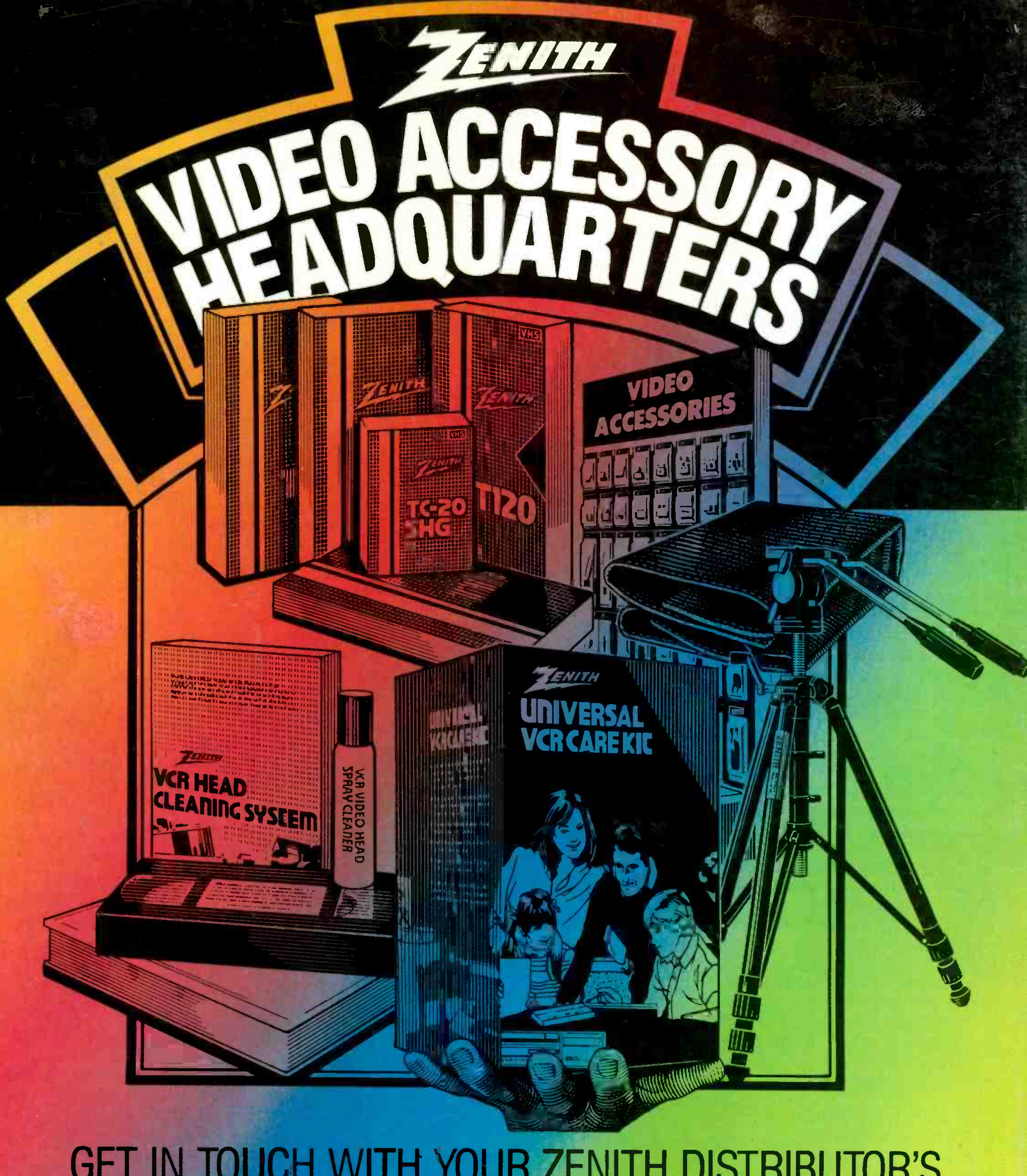

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