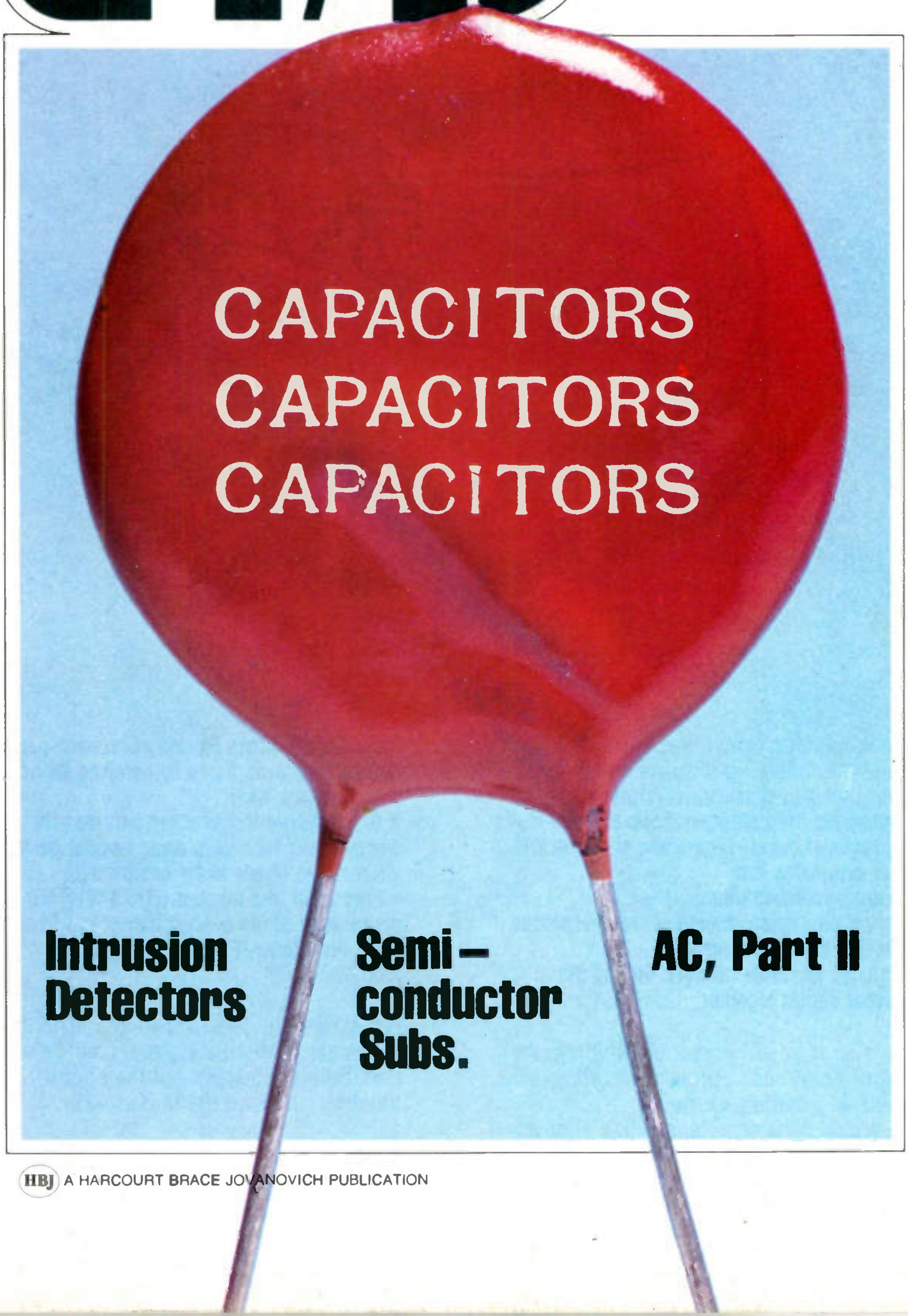
ET/D

APRIL 1981 • $1.50

ELECTRONIC TECHNICIAN/DEALER

LEADING THE CONSUMER AND INDUSTRIAL SERVICE MARKETS



Intrusion Detectors

Semi-conductor Subs.

AC, Part II

HBJ A HARCOURT BRACE JOVANOVICH PUBLICATION

INDUSTRY REPORT

Admiral Parts Distribution

All Admiral parts operations are being consolidated and will be handled by the Admiral National Parts Center. A study by Admiral and its former distributors determined that since Admiral electronics products were discontinued, parts could best be handled on a factory direct basis. Twenty-four hour, seven day, WATS lines have been installed. Normal working hours are 8:00 AM to 4:30 PM central time. After hour orders will be taken by recorder and must be by part number. The numbers are 800-477-8361; in Illinois the number is 800-322-0486. Mail orders may be sent to Admiral, National Parts/Accessories, 903 Morrissey Drive, P.O. Box 2845, Bloomington, IL, 61701.

Comsat Asks DBS Approval

Satellite TV Corporation division of Comsat was to have applied in mid-December for FCC approval of authority to begin three-channel direct to home subscription satellite broadcasting service in 1985. According to *Television Digest*, plans are to first ask for authority to set up an experimental system and then to launch as many as six satellites to serve areas roughly corresponding to time zones.

Agricultural Electronics Marketing Information Service

Tandy Corporation/Radio Shack, in a joint announcement with Professional Farmers of America, recently revealed plans for agriculture's first electronic marketing information service. Called Instant Update, the service provides farmers and agribusinessmen immediate access to the market-making events that affect commodity prices, crop yields and other data important to improving farmers' business activities.

Instant Update information will be transmitted via telephone lines to VIDEOTEX terminals specially made by Tandy Corporation/Radio Shack for the Professional Farmers of America program. The Radio Shack terminal utilizes standard telephone lines and a standard television set to receive and display the information 24 hours a day.

The Professional Farmers of America's version of the Radio Shack VIDEOTEX terminal contains 16K of memory that allows up to 32 screens of information to be stored for instant user recall and analysis. A Radio Shack spokesman said; "The Instant Update program is not a test but actually the first commercial application of this type and the largest program of its kind in the United States to date."

Radio Shack's TRS-80 Model II computer was chosen as the connecting link between the central data base and the information user. By operating in a Store/Forward mode the TRS-80 Model II links and dispenses agricultural marketing information in the central data base to the individual TRS-80 VIDEOTEX terminals at the subscriber's home or office. The TRS-80 VIDEOTEX terminal has the ability to access other data bases making it more flexible to the user.

The program was to begin March 2.

Zenith Announces 1980 Earnings

Zenith Radio Corporation announced in mid February that its earnings for 1980 were $26.4 million, $1.40 per share. Sales in 1980 totaled $1.186 billion, including the sales of the Heath Company.

GTE, North American Philips Deal Closes

The sale of GTE's consumer electronics business, Sylvania, Philco Sylvania picture tubes, etc., closed for $128 million in cash and notes according to an SEC filing by Philips. The total reorganization is expected to be slow; the first Sylvania/Philco personnel will move to Magnavox headquarters in Knoxville, Tennessee from Batavia, New York in June. Justice Department approval of the sale was, it is felt, greatly influenced by GTE's insistence that it would phase out TV production and sell facilities if the deal was not approved. According to *Television Digest* North American Philips likewise threatened to close down Magnavox if the sale was not permitted.

RCA To Develop Music Video Discs

That RCA "SelectaVision" and RCA Records will jointly develop and produce original music video discs for use on RCA's "SelectaVision" Video Disc System was announced in late February. It is expected that RCA recording artists will be featured in many forms of video music "from live performances to special studio creations."

NAB Objects To Interim DBS Authorization

The National Association of Broadcasters, in a statement issued in early December, said it would be "a rush to judgment" for the Federal Communications Commission to allow interim authorization of Direct Broadcast Satellite (DBS) service prior to development of a fully-considered United States policy. It termed such action "premature, prejudicial in the extreme to permanent policymaking and nothing short of imprudent rulemaking."

In its filing NAB said interim authorization makes no regulatory sense especially with a new-technology service which necessitates the investment of enormous private and public resources. The Association said it makes even less sense and is more damaging to authorize an interim service "which presents potential prejudice to the development of permanent DBS policy decisions." NAB noted that such operating authority would prejudice the Commission's basic question of "whether any broadcast satellite service is appropriate for the United States."

Similarly, NAB said, interim DBS operators would be favored over potential competitors for limited spectrum space availabilities by virtue of their existing channel operation. In addition, NAB said, such a step would be contrary to promised Congressional consideration of DBS and pointed out that Senator Bob Packwood (R-Ore.), incoming chairman of the Senate Commerce Committee, has said that the "implications of DBS are 'so profound' that the issue should be taken up by the Congress and not left to a regulatory agency."

NESDA Convention Plans

NESDA's 1981 annual convention will be held August 3-8 at Tarpon Springs, Florida, (near Tampa/St. Petersburg). The convention is co-sponsored by the Florida Electronics Service Association.

Registrations received before April 30 are $90 per person and $80 for each additional family member. Before June 30 the rates are $100 and $80. Thereafter the rates are $110 and $90.

Among the scheduled events are a technical school, a trade show, an instructors conference, a seminar on cable TV golf and tennis tournaments, meals and cocktail parties.

For more information write NESDA, 2708 West Berry, Ft. Worth, TX 76109.

Color TV Imports Decline

Imports of color television receivers and some other consumer electronics equipment declined in 1980 while imports of B & W television receivers and VCRS increased.

Color television receivers imported in 1980 totaled almost 1.3 million units, down 5.5 percent compared to 1974 according to the Electronics Industries Association's Marketing Services Department of the Consumer Electronic Group. Auto radio imports declined 23.4 percent, phonograph combinations were down 22.8 percent, and various types of audio tapeplayers declined a total of 12.7 percent relative to 1979.

Black and white receivers imported totaled 6,172,163 units, up 5.1 percent over 1979, while VCR imports were up 49.3 percent to 939,748 units.

U.S. *exports* of color television receivers more than doubled to 787,638 units. ET/D

ET/D

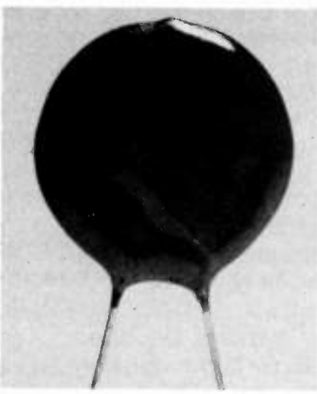
ELECTRONIC TECHNICIAN/DEALER

LEADING THE CONSUMER AND INDUSTRIAL SERVICE MARKETS

April 1981, Volume 103, No. 4

FEATURES

DEPARTMENTS



ON THE COVER: Capacitors of outwardly equivalent appearance can vary widely in characteristics. The lowly disc capacitor is available with many different temperature, frequency and voltage characteristics. For some timely information on selecting replacements see page 16.

HBJ A HARCOURT BRACE JOVANOVICH PUBLICATION ABP ABC EIA

ELECTRONIC TECHNICIAN/DEALER (ISSN 0192-7175) is published monthly by Harcourt Brace Jovanovich Publications. Corporate offices: 757 Third Avenue, New York, New York 10017. Advertising offices: 757 Third Avenue, New York, New York 10017 and 111 East Wacker Drive, Chicago, Illinois 60601. Accounting, Advertising Production and Circulation offices: 1 East First Street, Duluth, Minnesota 55802. Subscription rates: one year, $12; two years, $20; three years, $26 in the United States and Canada; all other countries: $40. Single copies: $1.50 in the United States and Canada; all other countries: $4.50. Controlled circulation postage paid at Duluth, Minnesota 55806 and additional mailing offices.

POSTMASTER: Send address changes to ELECTRONIC TECHNICIAN/DEALER, P.O. Box 6016, Duluth, Minnesota 55806.

ET/D

Walter H. Schwartz, *Editor (Duluth)*

Peter B. Credit, *Assistant Editor (Dululth)*

Tom Greney, *Group Vice President Publishing Director (Chicago)*

Don Fraser, *Graphic Design*

Missy Jersett, *Production Manager*

Debi Harmer, *Production Supervisor*

Lillie Pearson, *Circulation Supervisor*

Gene Bailey, *Reader Service*

Julie Laitin, *Promotion Director*

Dawn Anderson, *Classified Ad Mgr.*

Please submit editorial manuscripts to:
Editor ET/D, 1 East First Street, Duluth, Minn., 55802.

ADVERTISING SALES

Please send all advertising material to:
ET/D, Production Mgr.
120 West Second Street
Duluth, Minn. 55802
(218) 727-8511

East Region
Steve Del Duca
757 Third Avenue
New York, N.Y. 10017
(212) 888-4382

Midwest Region
Keith Lewis
111 East Wacker Drive
Chicago, Ill. 60601
(312) 938-2325

Southern Region
Chuck Cummings
613 N. O'Connor
Irving, TX 75061
(214) 253-8678

Western Region
Joyce Amiri
10741 Moorpark St., Suite #21
North Hollywood, CA 91602
(213) 980-7750 or (213) 760-1684

HBJ

HARCOURT BRACE JOVANOVICH PUBLICATIONS

Robert L. Edgell, *Chairman*
Richard Moeller, *President*
Lars Fladmark, *Executive Vice President*
Arland Hirman, *Treasurer*
Thomas Greney, *Group Vice President*
Ezra Pincus, *Group Vice President*
Lawrence Witchel, *Group Vice President*
Joe Bilderbach, *Vice President*
James T. Gherna, *Vice President*
George A. Glenn, *Vice President*
Harry D. Ramaley, *Vice President*

LETTERS

Perhaps one of your readers of your excellent magazine can help me. I am searching for the service/maintenance (alignment, cable stringing, etc.) manual for an ICP Model 8Tp-716 and 726 AM/FM/stereo with 8 track unit.

Thank you.

Charles T. Huth
146 Schenhardt St., Tiffin, OH 44883

Two subjects for this one letter:

1) Please consider an update of the ET/D extensive listings of where to get parts as given way back in the May & June 1977 issues. They have been an immense help in the quandry of finding parts, however, with all the changes in the industry, a new list is very necessary (hopefully would include some of the lesser known brands this time around, too).

2) Please run the following in your letters section:

WANTED: High Voltage Rectifier Socket (1AD2) for a GE model M213CWD, chassis HC. The GE part number is ET34X167 and is no longer available from General Electric.

M. B. Danish
Mike's Repair Service
P.O. Box 217
Aberdeen Proving Ground, MD 21005

CET PROGRAMS:

I am now subscribing to your magazine ET/D, which I think is the best of its kind. Your articles are of the most informative in the field of electronics and technical information.

In one of your messages to your readers you expressed an understanding about the C.E.T.–the certified electronic's technician group and its advancement. You also promised issues on information and articles on this same subject.

What has happened? Have there been some changes in the editing?

I am still looking forward to what you promised three months ago about the C.E.T. information.

A. D. Pearson
3512 Piasa Trail, Godfrey, IL 62035

Editor: Quizzes covering material you should know if you wish to pass the C.E.T. tests has been appearing in ET/D since January and hopefully will continue for some time.

Any help your readers can supply in obtaining the below listed items will be greatly appreciated.

I need schematics for the following: Sencore Model CG-10 Standard Color Generator and Heathkit Model GR-104B Black and White T.V., I will pay the cost of making a copy and postage.

I also need TEKFAX 113 and TEKFAX 111 and earlier volumes. I have been reading your fine magazine for five years.

Gary V. Pehle
27736 S. Robert Stockton Place
San Pedro, CA 90732

I need a schematic diagram for a Model 2800 Juke Box.

Does anyone know where I can get this schematic diagram?

Roy Cook
Hazel Park School District
23136 Hughes
Hazel Park, MI 48030

Would appreciate it if you could run in needed page the following:

In need of schematic on Knight Electronics Color pattern generator model KG 685.

Thanking you for same.

Ray W. Morgan
528 Arkansas St.
San Francisco, CA 94107

I would appreciate it if you would print the following need for help:

Need schematic for Realistic (Radio Shack) Model STA-75, AM/FM Stereo Receiver. Will pay for copy and postage or will copy your schematic and return.

M. L. Chapin
53811 Franklin
Utica, MI 48087

I am in desperate need of part 9AP4, 12AP4 picture tubes. Also looking for parts of complete RCA sets TRK-12, TRK-9, TRK-5, or TT-5.

Jeff Lindaro
c/o Morris TV
1 Pudanen Rd.
Danbury, CT 06810

I began subscribing to your magazine in July of 1980. I enjoy it very much. I am in need of a schematic for a Sony Model #TR-780 which I am unable to obtain locally. I see in your listing of schematics that you published it (#1780) in the March 1979 issue.

Would you please inform me as to how I can obtain that issue of the magazine or the schematic?

I will appreciate any help you can give me.

John Pannuzzo
1210 S.W. 65 Ave.
Hollywood, FL 33023

SERVICE SEMINAR

MAGNAVOX STAR SYSTEM

Test procedures for troubleshooting "countdown" problem in the Magnavox Star System. Symptom: Screen is blank and channel readout continually counts down: 99-0, 99-0, etc. This could be a bunch of different areas in the star tuning system. The first thing is not to jar the set. Very carefully take off the back. Grab your voltmeter and go to the RF unit, key voltages here will help troubleshooting. See Fig. 1.

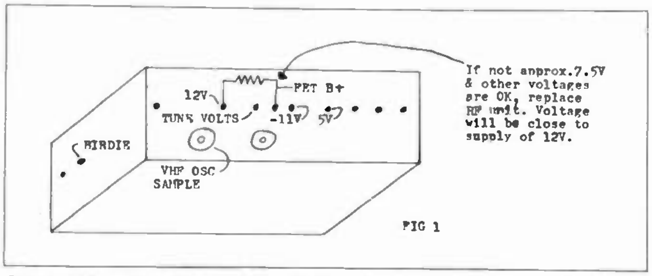


FIG 1

Start with 12 v, then -11 v & 5 v. If any of these are low, it'll countdown. If so, go to power supply module—See Fig 2.

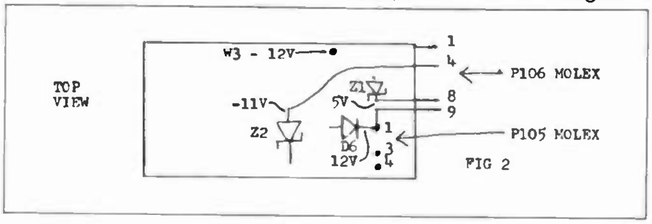


FIG 2

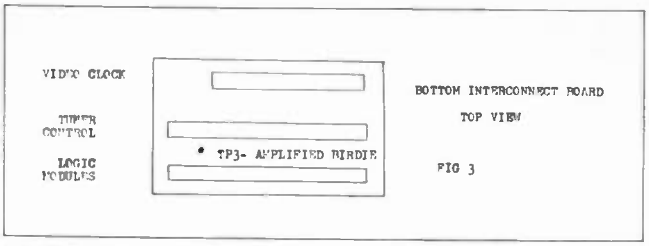


FIG 3

Whatever voltage was low, carefully go to test point shown on the board. If low there, probable bad power supply module component, zener, IC, etc. If okay on board, hang your meter back on the RF unit terminal that was low and wiggle the power supply molexs or tap with ¼ in. or whatever. If voltage comes up and set works normally, remove both molexs and clean pins on the board with Magnavox contact spray #171378-1. If the RF units voltages are good, check 36 v at Z1 (behind star power transformer on a terminal strip with a 3w glass resistor). If low or 0, zener is probably shorted. If all is okay so far, check for birdie pulses on RF unit and amplified birdie at TP3 on bottom interconnect board. See Fig. 1 & 3.

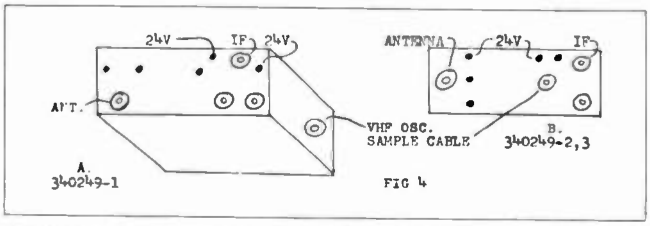
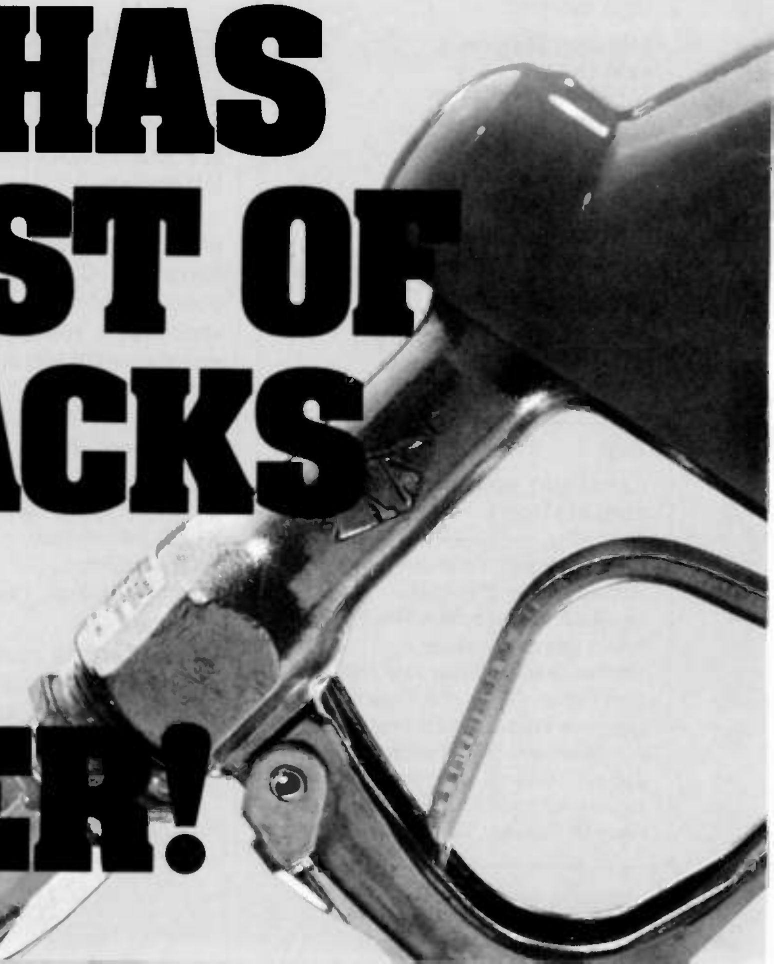


FIG 4

If birdie pulses are gone at RF unit, remove tune volts lead from VHF tuner. Use a 0-30 vdc supply through 10K resistor and while set is on and counting down, turn dc up slowly and



while channel number is going through vhf band, if any flashes of stations are seen, then RF unit is probably bad. If no stations are seen, check VHF tuner voltages as in Fig. 4A or B.

If both 24 v lines are okay during 13-2 scan on readout, then the VHF tuner is bad (local osc. isn't running), or the osc. sample cable is open or shorted. See Fig. 1 & 4. If birdie pulses are okay on RF unit but not at TP3, probably bad tuner control module. (There's a 2-stage birdie amp. on the board, birdie in on pin #22 and amplified birdie out on #21). If birdies are okay at both, then about the only thing left is the logic module (most likely the 40 pin LSI chip) I'd advise you to just replace this module, #703675-7 is the latest run that subs all lower dash #'s. This is an excellent tuning system. No fine tuning to mess with. Don't turn screwdriver adjustments anywhere without following Magnavox's instructions!! GOOD LUCK. John Russo, Santa Maria, CA.

RCA

Chassis T950, raster bounces vertically, excessive height and problem may appear intermittently. To correct: Replace R514, .82K 2 watt resistor. (Changed in value to extremely high resistance). Bob Baker, CET, Billings, MT.

Chassis CTC-31, picture blanks out on top & bottom when brightness control varied, vertical pulse on grid of video output measures 40 volts in amplitude. To correct: Replace resistor R-754, 755, 756 and/or coil L-706. William T. Wall, CET, Jacksonville, Fla.

SINGER

Chassis HE-8001, no picture—horizontal output tube goes bad each time replaced. Appears like defective HV transformer. To correct: Replace C-97 and C-24, horizontal output tube grid coupler and cathode by-pass capacitor (open). Kenneth Simmons, JR., Gravel Ridge, Ark.

SONY

All models using 2SC1127 R-G-B (video) output transistors—There are many versions of the 2SC1127 transistor in circulation, of those shown, only those similar to types C and D are suitable for R-G-B output use. Never use types similar to A or B for R-G-B output service since their VCEO is too low as indicated by the number "1" on the case. Only 2SC1127 transistors with the number "2" marked on the case in the lower right-hand corner are suitable for use as R-G-B output transistors. Sony Parts is shipping only those with the number 2 marked on the case. However, other semiconductor suppliers may be shipping rank 0 or 1 transistors which must not be used as R-G-B output transistors.

SYLVANIA

Chassis E06-2 VHF channels above 6 are weak with a beat pattern, VHF and channels 2 through 6 operate normal. To correct: Replace neutralizing capacitor C27, connect across RF amplifier transistor. Jack Green, CET, Oneanta, Alabama.

ZENITH

Chassis 19DC22, no vertical sync, video processor and horizontal sync panels test normal. To correct: Replace coupling capacitor C209. Part Number 22-3661. Located in emitter circuit of vertical oscillator transistor. Kay Glista, CET, Newington, CT. ET/D

BULLETIN BOARD

An all-inclusive catalog in one bound volume for **merchandising problem solving** is now available from *Vaco Products*. The *Merchandising Idea Book* gives ideas on how to merchandise hand tools, solderless electrical connectors and special fastening devices using *Vaco* pegboard walls. Floor and counter displays, unit displays and master displays are shown to maximize merchandising possibilities.
Circle No. 119 on Reader Inquiry Card

A 688-page Databook on **"COS/MOS Integrated Circuits,"** SSD-25OB, has been issued by *RCA Solid State Division* as another volume in its series of semiconductor databooks. The new Databook includes technical data, application notes, product classification charts, function selection charts, package information, functional diagrams, and operating and handling considerations, as well as definitive ratings and characteristics for all standard digital integrated circuits in RCA's CMOS CD4000 logic product line. The data covers the high-voltage B-Series types (20-volt absolute maximum rating), the standard A-Series types (15-volt absolute maximum rating), and special function types that include telecommunications circuits, display drivers, and interface circuits. The SSD-25OB Databook supersedes volume SSD-25OA, which was issued in August 1978, and encompasses technical data on all CD4000 circuits introduced since that date.
Circle No. 120 on Reader Inquiry Card

A free, new 104 page *Heathkit* catalog **featuring nearly 400 build-it-yourself kits** for home, hobby, and business use, has just been published by the *Heath Company*. This new edition features electronic kits in high fidelity, amateur radio, microcomputers, test equipment, automotive, and television. Among the new kits being introduced include: a new ten band equalizer, variable electronic crossover, security light control, microprocessed-based barometer and windspeed indicator, digital depth sounder, and a 225MHz frequency counter. The new catalog also contains an expanded computer section and an educational section. The computer section introduces new floppy disk systems and other hardware, plus new software. Also, the catalog highlights two new self-instruction courses in advanced electronics.
Circle No. 121 on Reader Inquiry Card

Now available from *Radio Shack* is their latest TRS-80 **computer catalog,** entitled *"Creating New Frontiers in Microcomputing."* The full-color 36-page catalog introduces the company's new Model III, color and pocket computers and VIDEOTEX system, as well as new printers, software and accessories. Detailed information is given on Radio Shack's complete line of TRS-80 products, including the original Model I and the Model II business computer. TRS-80 Computer Catalog RSC-4 is available free on request from participating Radio Shack stores, dealers and computer centers, nationwide.
Circle No. 122 on Reader Inquiry Card

The fifth edition of **Introduction to Electric Circuits** by Herbert W. Jackson has just been published by *Prentice-Hall*. Designed to be used in an introductory course or courses in electronics technology, the book contains 28 chapters

that cover the fundamental principles of ac and dc electronics with special emphasis put on circuit analysis. Featured in the fifth edition are answers to all the odd-numbered problems plus techniques on solving problems using electronic calculators. The text will prove to be useful not only to the beginning student but also to the service technician who wants to brush up on the fundamentals.
Circle No. 123 on Reader Inquiry Card

Chicago Switch has recently published a new 32 page full line catalog. This 2 color catalog includes photos, line drawings, specifications, and ordering information on Chicago Switch's entire line of **miniature and subminiature switches.** Many new items have been added to this edition which includes their Mini Mike slide switches, module series switches,, Tapit pushbutton switches, Mr. Clean I & II wave solderable slide switches, TO-5 Rotary Spasaver and pushbutton switches. Illuminated and non-illuminated rocker and paddle switches, panel indicator lights, toggle switches, Klipsocker lamp holders, and a new expanded Leaf Switch engineering design guide.
Circle No. 124 on Reader Inquiry Card

A catalog containing 96 pages of **parts and unusual items** is now available from *ETCO*. In this sixth edition ETCO offers a wide assortment of cable TV converters and accessories. Other new items include: microwave radiation detectors, wireless intercoms, wireless microphones and wireless telephones, fascinating long distance parabolic and shotgun microphones, VTR accessories, disco items, TV screen magnifiers, educational kits, hundreds of new surplus offerings, metric hardware, printed circuit materials and a large assortment of receiving and transmitting tubes—including hundreds of hard to find obsolete types.
Circle No. 125 on Reader Inquiry Card

Unex, the two-way radio people, now has available a new eight-page catalogue on its personal portable accessories. The accessories include **security products, portable headsets, and dispatch headsets.** The security products—a security kit, wireless induction earphones, transductors, and microphones—are used in both normal surveillance and maximum security operations. The Flexicom headsets, available in three models, feature a noise cancelling microphone for clearer communications. All are available in lightweight, single muff and dual muff configurations.
Circle No. 126 on Reader Inquiry Card

Micro Lamps, Inc. has recently published a 20 page catalog showing their **full line of miniature lamps** including sub-miniature lamps, BI-PIN lamps, neon lamps, telephone side base lamps, Lilliput European telephone slide lamps and many others. The new catalog is available from Micro Lamps, Inc., 1121 East Tower Road, Schaumburg, IL 60195. They can also be reached at 312-882-1787.
Circle No. 127 on Reader Inquiry Card

Waters Manufacturing Inc. **is offering a new catalog,** "Potentiometric Solutions for Sensing Servo Feedback and Process Control Applications." Catalog includes product photos, descriptions and complete specifications on wirewound and conductive plastic potentiometers. Contact Waters Manufacturing Inc., Longfellow Center, Wayland, Mass. 01778. ETD
Circle No. 128 on Reader Inquiry Card

FROM THE EDITOR'S DESK

The Federal Communications Commission has in the last couple of years proposed a number of controversial actions, the technical implications of which may not be well understood even by the FCC itself. The FCC has proposed 9kHz AM broadcast spacing, essentially eliminated the clean channel concept, proposed a number of "drop-in" TV licenses (stations with less than the formerly required geographical spacing), proposed elimination of the first class commercial radio telephone license, and, it is rumored, considering also eliminating the second class, and, required licensing of low power TV stations (allowing former repeaters to originate programming). The FCC also suggested assigning FM broadcast stations to 100 KHz spacing instead of the present 200 KHz and first approved and then in the face of protests, rescinded its approval of the Magnavox system of AM stereo. Also before the FCC is Comsat's proposal for direct broadcast satellite television and CBS' proposal for adoption of the French Telidon teletext system.

Why have most of these things been done or proposed? The reasons are basically social and political—opening broadcasting opportunities to minorities, etc. While some of these proposals have been suggested as part of a policy of deregulation there is some suspicion that that elimination of the first class radio telephone license would simply make operation of the new broadcast stations less costly.

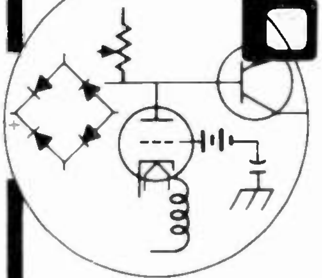
What could this mean to most of you? If the technical consequences of these are misjudged by the FCC—a political not technical body for the last few years—you may be explaining a lot to some of your customers, if, for instance, you are in one of those areas designated for a drop—in TV station. Some of your customers may have large antenna installations dedicated to receiving from a considerable distance the channel of the drop-in, (or an adjacent channel) and may not be too happy about having interference from the new station. Or if the AM broadcast band goes to 9kHz spacing many listeners will wonder why their favorite stations have moved—how many sets of car radio pushbuttons will have to be reset for people who do not understand what happened? And they will also wonder, why the interference they didn't experience before is there now. FM channel spacing of 100kHz would pose serious interference problems with millions of less than the highest quality receivers. Judging form the amount of dead air, misadjusted video tape equipment, etc., seen and heard on our local radio and television stations (one of our remote controlled stations broke in with its automatic ID every few minutes most of one afternoon a while ago), we need better technical supervision, not less as implied by the abolishment of the first class license.

Mostly I hope that the FCC will make its decisions without equiovocation. We still don't have a decision or AM stereo since the FCC first approved, about a year ago, and then in the face of some protest rescinded its approval, of the Magnavox system. What will happen when stereo sound for television and a teletext system come under consideration?

Let's hope we can understand what they are doing.

Sincerely,

ELECTRONICS BOOK CLUB



Take 4 exceptional books for $1.00

(values to $70.80)

1209 List $11.95

1236 List $14.95

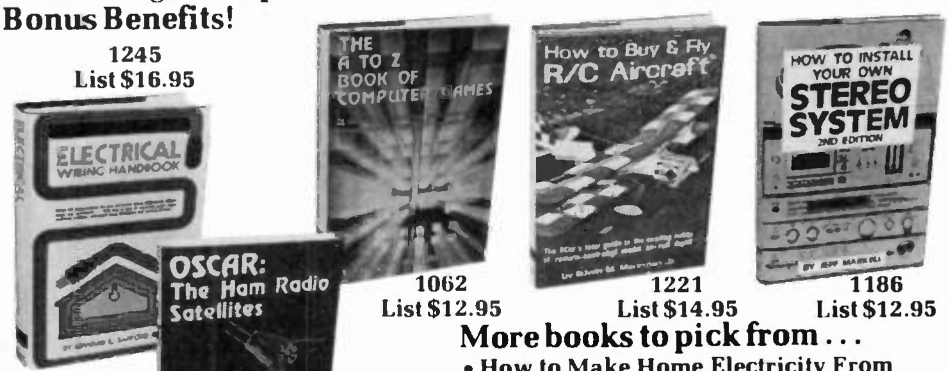
1339 List $13.95

1250 List $16.95

1225 List $15.95

Start saving now for discounts up to 75%on hundreds of interesting, info-packed volumes . . . PLUS special Members' Bonus Benefits!

1245 List $16.95



1062 List $12.95

1221 List $14.95

1186 List $12.95

1120 List $8.95

1261 List $12.95

1160 List $12.95

More books to pick from . . .

- **How to Make Home Electricity From Wind, Water and Sunshine.** List $10.95. No. 1128
- **99 Test Equipment Projects You Can Build.** List $12.95. No. 805
- **Radio Astronomy for the Amateur.** List $8.95. No. 714
- **Tower's International Op Amp Linear-IC Selector.** List $12.95. No. 1216
- **303 Dynamic Electronic Circuits.** List $9.95. No. 1060
- **The Master IC Cookbook.** List $16.95. No. 1199
- **How to Design & Build Your Own Custom TV Games.** List $14.95. No. 1101
- **Modern Digital Communications.** List $10.95. No. 955

1203 List $14.95

1066 List $19.95

1248 List $14.95

1123 List $9.95

7 very good reasons to try Electronics Book Club . . .

- **Reduced Member Prices.** Save up to 75% on books sure to increase your know-how
- **Satisfaction Guaranteed.** All books returnable within 10 days without obligation
- **Club News Bulletins.** All about current selections—mains, alternates, extras—plus bonus offers. Comes 14 times a year with dozens of up-to-the-minute titles you can pick from
- **"Automatic Order".** Do nothing and the Main selection will be shipped to you automatically! But . . . if you want an Alternate selection—or no books at all—we'll follow the instructions you give on the reply from provided with every News Bulletin
- **Continuing Benefits.** Get a Dividend Certificate with every book purchased after fulfilling Membership obligation, and qualify for discounts on many other volumes
- **Bonus Specials.** Take advantage of sales, events, and added-value promotions
- **Exceptional Quality.** All books are first-rate publisher's editions, filled with useful, up-to-the-minutes info

ELECTRONICS BOOK CLUB
Blue Ridge Summit, PA 17214

Please accept my Membership in Electronics Book Club and send the 4 volumes circled below. I understand the cost of the books selected is $1.00 (plus shipping/handling). If not satisfied, I may return the books within ten days without obligation and have my Membership cancelled. I agree to purchase 4 or more books at reduced Club prices during the next 12 months, and may resign any time thereafter.

714	805	955	1060	1062	1066	1101	1120
1123	1128	1160	1186	1199	1203	1209	1216
1221	1225	1236	1245	1248	1250	1261	1339

Name ______________________ Phone __________

Address ______________________

City ______________________

State ______________________ Zip __________

(Valid for new members only Foreign and Canada add 20%.) ETD-481

Circle No. 107 on Reader Inquiry Card

RCA STEREO VIDEO DISC PLAYER

A video disc player capable of stereo sound is planned for introduction in 12 to 18 months according to Electronic News. Quoting Jack Sauter RCA group vice-president, consumer electronics regarding a television receiver to accompany it, "Nobody has a stereo television set. We're going to build television sets that will have that capability in '82."

FLAT SCREEN TV ON GO!

Sinclair Research, Ltd. of Cambridge, England is about to contract the manufacturer of both its flat TV tube and its radio-TV combination to Timex. This receiver with a three inch screen and measuring about four inches by six inches by one inch will according to Electronics magazine be introduced at retail in late '82 for about $115.

$500 VCR

A VCR with a list price of under $500 will reportedly be offered soon by Sanyo. According to Television Digest it will be a mechanically tuned Betamax. Dealer margin is expected to be about 18 percent.

PROJECTION TV PREDICTION TO REACH $175 MILLION SALES IN '81

RCA recently predicted that its entry into projection television will push industry sales to $175 million in 1981. RCA has introduced a one-piece 50-inch screen set reportedly designed to be fifty percent brighter than current best selling systems. The new receiver, Model PFR 100R offers infrared remote control, stereo sound and audio and video inputs for VCR and disc player.

BRITISH ORGANIZE TO MARKET TELETEXT IN US

A new venture known as BVT (British Videotext and Teletext) was formed in February to market the videotext and teletext systems now operational in Britain and in the US. BVT will seek to market hardware and software for Prestel systems to telephone, cable and broadcast companies, and "Context" a broadcast teletext system, "Flair" a graphics system and "Icor" an intelligent, interactive system.

SECURITY VIEWPOINT

With the economy being what it is, many small businesses are fighting to stay in business. Making healthy profits is almost a secondary consideration. In order to ease this burden somewhat, you almost have to be a juggler. You've got to be able to spot trends, and act upon them.

If you see that the residential alarm installation portion of your business is slowing down, you can't afford to sit back and wait for it to pick up again. By the time it does, it may be to late. Had you arranged for an alternate line to be 'waiting in the wings' you could have been making money instead of losing it.

There are a number of new (in the sense of residential application) products and services on the market that could be worth your while to investigate.

One area you may want to look into is telephone access systems. They can represent healthy areas of untapped profit for the alarm dealer/ installer.

Basically, the system can be installed one of two ways. A hard wired intercom can be used or you can elect to go with a telephone controlled access system.

One such system is manufactured by Identifone, Inc. based out of N. Hollywood, California. This particular system utilizes existing telephone lines and has a private telephone line to call tenants inside the apartment.

For example, you wish to visit John Smith. His code number is listed on an entrance panel located *outside* the building. You dial his code number. A control unit (via the telephone line) retrieves the code, 'matches' it to his actual telephone number, and John Smith picks up his regular telephone to find out who is calling.

Smith is able to identify your voice (since the conversation is that of standard telephone clarity), and should he want to admit you into the building, he pushes a code on his telephone which activates the strike which is placed in the entrance door and allows you in. The entrance door automatically locks after closing.

Manufacturers of such systems say that normal installation time is usually less than a one man day.

From what I've been told, distribution for this type of system is handled mostly by security dealers (dealer networks of distribution represent *almost 90%* of controlled entry sales).

The trend for these systems seems to be growing not only in apartment complexes, but in condominiums, closed communities and private communities.

There are a number of telephone access control entry system manufacturers out there. Before getting involved in this segment of the residental security market evaluate the feasibility as it applies to your particular business.

Naturally, if you live and conduct business in a rural area, there may be less of the need than if you conduct your business in New York, Chicago, or San Francisco.

Should you determine that it would be a viable thing to pursue, make sure the manufacturer is reputable, and will offer technical support and updates on an on-going basis.

Ray Allegrezza

All about capacitors

An Update

A capacitor is a capacitor—or is it? Recent developments have produced a variety of new capacitor types and the old ones are not always what you might expect. Here's a rundown on how to solve capacitor replacement problems.

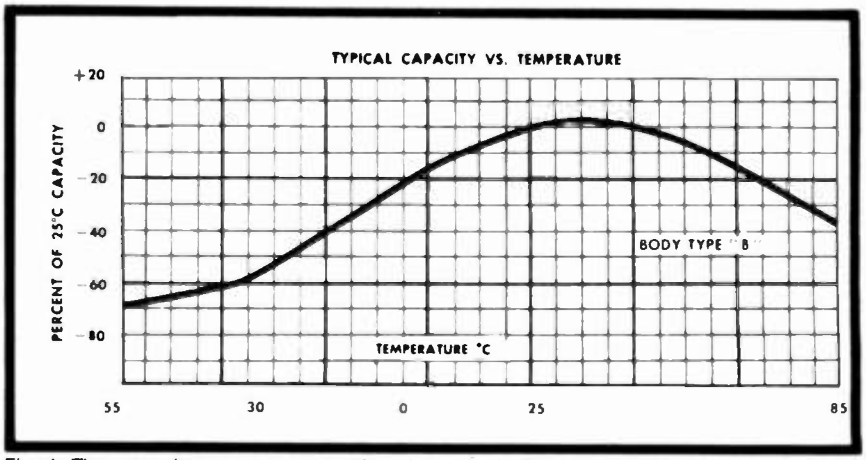


Fig. 1. The capacitance vs. temperature of a typical Z5U type ceramic capacitor intended for bypass and audio coupling use. (Courtesy Radio Materials Corporation.)

By Bernard B. Daien

Capacitors have been changing. Recently the changes have been rather revolutionary, because silver and tantalum prices have skyrocketed. Silver is used in ceramic disc capacitors, and tantalum in tantalytic capacitors. Substitutes are being used increasingly.

Ceramic capacitors now come in large sizes . . . up in microfarads. Aluminum electrolytics are being made with a wide variety of superior specifications, not only for computers, but for higher frequency use, higher ripple currents, higher temperatures, and lower leakages, but you cannot substitute one type of aluminum electrolytic for another. For example, the capacitors used in switching power supplies, or in TV flyback power supplies, have special fabrication methods.

The recent years have seen a whole new generation of plastic dielectric capacitors . . . polystyrene, polycarbonate, polypropylene. And, there is a wider assortment of dielectrics for ceramic capacitors.

Do you know that some capacitors lose 90 percent of their capacitance at higher frequencies? Do you know what the letters, "Z5U" mean, on a discap? Do you know what to do when you can't get a replacement tantalytic capacitor? What is ESL?

Like everything else in electronics, capacitors are becoming more complicated. Time was that you could stock a few basic types of capacitors . . . electrolytics, mica, paper and that was it. Now there are several types of ceramics, several types of plastics, several types of ceramics, several types of electrolytics, plus tantalums . . . and subdivisions like metallized, dual dielectric, etc. What can be substituted for what?

This article will help you update your capacitor knowledge, and facilitate capacitor substitutions. You will also learn the answers to the above questions, and many more that you may have asked.

Why So Many Kinds of Capacitors?

Different capacitors are needed for different applications, with widely different essential characteristics. Small bypass caps are needed for use with the power supply bus decoupling on digital printed circuit boards. Spikes on the power bus can cause spurious triggering of flip-flops, etc.

Tuning capacitors require good "Q." Timing capacitors require low leakage. Both require good stability with time and temperature.

Energy storage capacitors, for use with photoflash (strobe lamps), welding, etc., must be capable of many operating cycles at very high discharge currents.

Filter capacitors must be able to handle high ripple currents (which cause internal heating), in high ambient temperatures (next to power transformers), with very high reliability, since a filter short puts a power

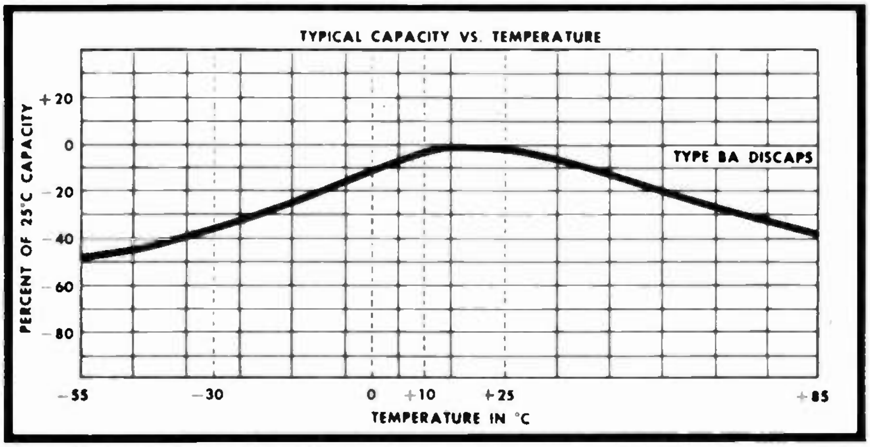


Fig. 2. The capacitance of an extended-temperature, ceramic capacitor otherwise similar to the capacitor of Fig. 1. (Courtesy RMC.)

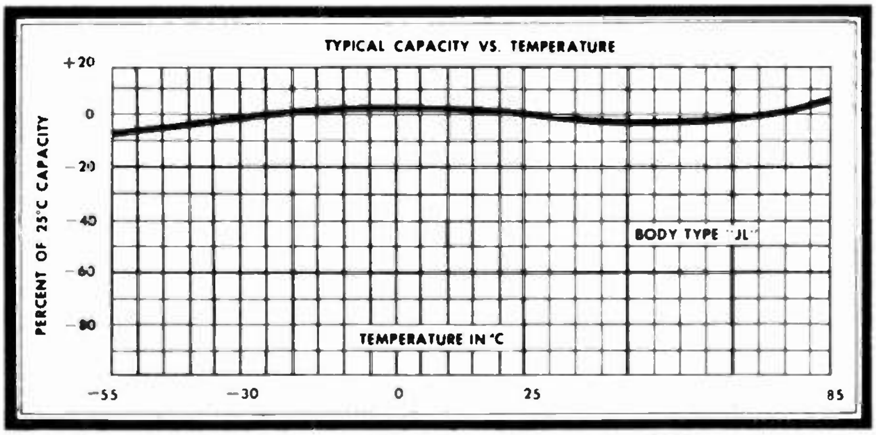


Fig. 3. The capacitance of a temperature stable ceramic capacitor, RMC type JL. (Courtesy RMC.)

supply out of business.

Radio frequency bypass capacitors must have very low "equivalent series resistance" (ESR), and very low "equivalent series inductance" (ESL) . . . otherwise they do not act as bypasses at frequencies where you expect them to have a low impedance!

And, of course, everyone wants the smallest, lightest, cheapest capacitor possible.

Putting all these factors together, it becomes obvious that no one, or two, types of capacitors can fulfill all these varied needs. If cost were unimportant, we might be able to develop some sort of "ideal capacitor" which could do most of the jobs . . . but the fact is that cost is very important to most manufacturers, so we have many capacitors, each doing just a few of the things . . . but at lower cost.

The escalating price of metals has aggravated the situation. Silver was used in silver mica, and silver ceramics (discaps) . . . tantalum was used in tantalytics, etc. Now we are using nickel in discaps, and specially processed electrolytics instead of tantalytics. If you are servicing a set with some of the original "pre-inflation" capacitors, you may have to make a substitution, because the original parts are not available. Again, cost is the root cause.

A Look at Ceramic Capacitors

Ceramic capacitors are being used more frequently now, because recent advances have made them available in larger capacities (over one microfarad). The dielectric is some form of titanate (metallic oxide) formed at very high temperature. Ceramics come in three standardized classes. Class 1 capacitors are temperature compensating, and are so marked . . . for example, "NPO" which means "Negative-Positive Zero" (negative and positive temperature coefficients are zero), or, "N750" (negative temperature coefficient of 750 parts per million, per degree centigrade). They are very predictable, but by comparison to the other classes, are quite large for their small capacitance. This is because other characteristics have been sacrificed for temperature predictability, (a linear change of capacitance with temperature). They have very good "Q" for use in tuned circuits.

Class 2 ceramics are used for general purposes. Their temperature versus capacitance characteristics shows very NON-LINEAR changes, as compared with Class 1 materials . . . These capacitors are much smaller than Class 1, for the same capacitance, because the dielectric constant is much higher, being five hundred or more. Class 2 ceramics have a lower Q than Class 1, and the capacitance drifts with time, temperature, applied voltage, and frequency! (Some of them lose most of their capacitance at very low temperature). The higher capacitance Class 2 capacitors use very high dielectric constant material to achieve the capacitance rating, the "dielectric Constant" (K), being referred to as "High K," running over 4000! The "High K" units are often made to the "Z5U" temperature curve, which is suitable only for bypass applications requiring very little temperature stability, but with lots of capacity in a small package.

Class 3 capacitors have even higher Ks, putting greater capacity into a tiny package, but they are useful only in the audio frequency range, at low voltages.

One word of caution! I found some very weird effects when using very high K materials . . . they make good transducers. Shock or vibration results in a large signal generated by the capacitor. (A form of piezoelectric effect). At any rate, I have used them as a "poor man's transducer." Wired as a vibration "mike," (high impedance), and affixed to a window, they make excellent alarm devices. If you flick one with your finger nail, in an audio circuit, be prepared to jump! Better yet, look at it with your scope . . . it really puts out a signal.

Ceramics are now made in multilayers, further increasing the capacitance . . . to a whopping one microfarad, or even more.

The Class 1 ceramics are being used to replace mica capacitors, while the higher K units are replacing tantalums. The ceramics actually work better as bypasses at frequencies of several hundred kiloHertz and higher, since they have lower ESR and ESL . . . but tantalums are more stable, and can be made in much higher values of capacitance . . . thus tantalums are still in demand for timing circuits, etc.

Some manufacturers of ceramic capacitors are now switching from silvered ceramics to a nickel coating. They claim that the product is just as good . . . but in the past it has often taken years for time dependent effects to appear . . . then, blooey! In the early days of transistors, failures occurred only after a period of time. Upon opening the device, a purple color was noted where two different metals joined . . . the phenomenon was promptly dubbed "purple plague," and it was a great mystery for a while. Eventually it was traced to the migration of metals, and the problem was solved. So . . . I am keeping my fingers crossed on the new substitutions until they have been proven in the field for a few years of actual use. However, in all fairness, they seem to be working out well so far.

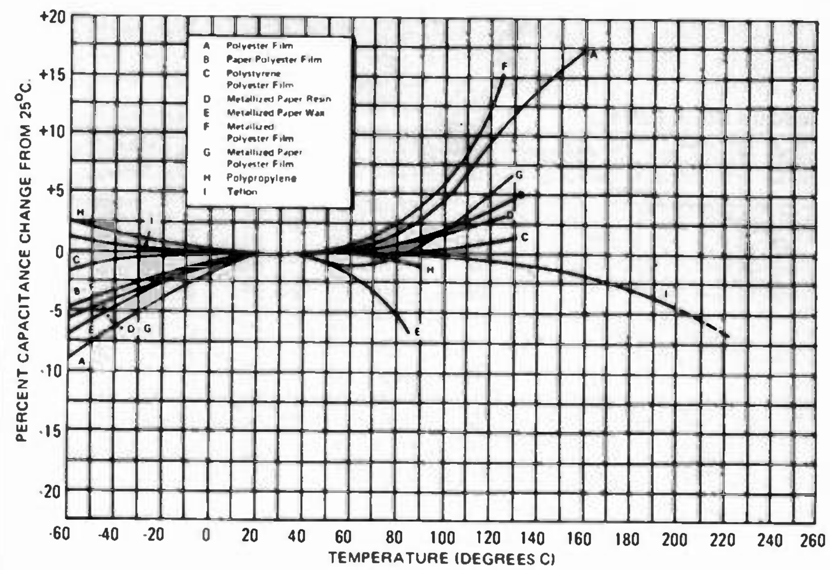


Fig. 4. Capacitance/temperature characteristics of various types of film capacitors. (Courtesy Connell Dubilier.)

And Then There Are Electrolytics

. . . and electrolytics . . . and electrolytics. You might say that the old aluminum electrolytic capacitor has a multi-personality problem. Depending upon how it is made and processed, the alumalytic can be many different things, for many different uses. In the past, the alumalytic was the first choice for really high values of capacitance, . . . the only choice for voltages up to 450 volts, . . . and the best choice for low cost . . . providing that the temperature was less than 85 degrees Centigrade, and the frequency was low . . . and providing that you could stand quite a bit of dc leakage. But that has all changed. The manufacturers are moving in to fill the shortage of low cost tantalytics. Using modern methods, and high purity aluminum, alumalytics now come in several varieties.

You have to read the manufacturers specifications to find out what each product does now. Some electrolytics are specifically tailored for use with switching type power supplies. They must have low ESL because of the high frequency ripple, be able to tolerate amperes of ripple current (the input is a square wave), and handle lots of internal heating.

Other electrolytics are processed for stability with time and temperature, and low leakage. They are intended for replacing tantalytics, and no others will do. So don't just go to your favorite distributor and ask for an "Electrolytic" anymore. Be darn sure that you understand what the use is, and buy the product rated for that use!

If the capacitor is going into an auto radio, in the north country, you had better get one rated for minus 55 degrees centigrade . . . the others lose much of their capacity before the temperature gets that low. On the other hand, if the cap is going into a hot spot, note that some makers provide units that operate up to 105 degrees C.! More . . . you will be very disagreeably surprised to find that some original equipment capacitors are very small for the capacity . . . and in a tight spot, your favorite brand might not fit at all. Some makers specialize in extra small capacitors. (Many of these electrolytics are made in foreign countries, which makes your job a little tougher!). As a matter of fact, choosing an electrolytic capacitor has become a first rate technical problem, due to the various specifications involved . . . I would suggest that you obtain the full specifications for the lines of capacitors that you stock, by writing directly to the manufacturer, and guarantee that you will be surprised by what you learn.

A word of warning about alumalytics. They have rubber or synthetic seals. The seals are affected by certain solvents, which occur in some tuner sprays, contact cleaners, etc. If the solvent gets to the seal, it will fail prematurely. The small upright type units which mount on printed circuit boards by their leads, are also affected by the use of solder flux removers. I never use anything but pure alcohol to remove flux, because many flux removers attack plastics, seals, etc.

(In an emergency, you can use some of the medical brandy which is sometimes found in service shops . . . usually in the office.)

Tantalums

Tantalytic capacitors are supposed to be a form of electrolytic capacitor . . . but they are a different breed of cat. While alumalytics are tolerant of transient overvoltages, and are self healing to a certain extent, tantalytics are not. If you go only a few volts over the rating, they fail, and fast.

On the other hand they have the ability to function at frequencies much higher than ordinary electrolytics. Tantalytics are the first choice for timing circuits, and where long term stability in a high value of capacitance is required. The leakage current is smaller than that of electrolytics . . . and best of all, the tantalytic works up to about 175 degrees C! The tantalum devices do not have to use rubber vent seals, they can be hermetically sealed, and therefore have a much longer life expectancy than alumalytics. For these reasons tantalums are used in critical applications where tough environmental conditions exist, or when long life is a prime factor. In such cases, you cannot substitute . . . but in run of the mill hi fi, etc., a modern alumalytic designed for replacement of tantalums will do

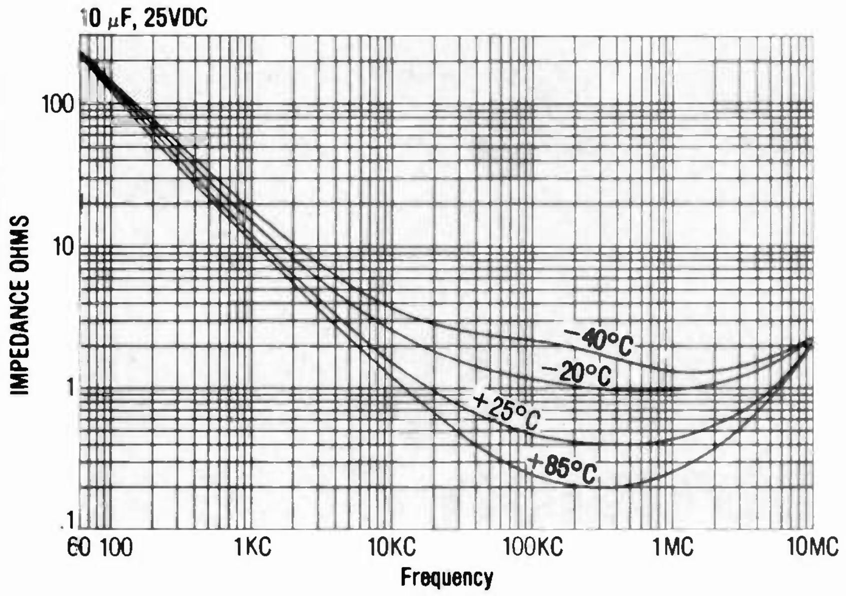


Fig. 5. Impedance/Temperature curves of a typical general purpose electrolytic (Mallory Type TT). Note the logarithmic impedance scale. (Courtesy Mallory Distributor Products Division.)

nicely. Of course if you have any doubts at all . . . put in a tantalum and charge the customer for the extra cost of purchase, pickup, etc. It's better than a recall.

Remember, don't push tantalums on voltage ratings. Allow for transients, etc. Never use a rating less than the one on the original part . . . not even by a few volts! On the same subject, tantalums cannot stand reverse voltage . . . not even a few volts! Electrolytics can take small reverse voltage transients, for a short time . . . but not tantalums. If you think you are having reverse transients, put a reverse diode across the tantalum to protect it.

If you put two tantalytics in series, reverse polarized, to make a non-polar capacitor, be sure to put a reverse diode across each one. This is good practice for electrolytics too, but in the past this has sometimes been omitted because the leakage through the electrolytic tended to provide a "sneak path" . . .

Due to the low leakage of tantalytics, you cannot rely on that anymore. (Since non-polar electrolytics and tantalytics are used in TV sets and hi fi, and are seldom on the shop parts shelf, you may want to remember this little hint.)

Dielectric Absorption

If you charge a capacitor, then short it for a few seconds, and let it stand a while, you will often find that it has "built up a charge" again. (How many times have you been zapped that way with a picture tube?) What happens is that the dielectric has a residual charge stored in it. Of course this can be a real problem in circuits which require periodic charge and discharge of the capacitor, as in timing applications. In instrumentation using the single or dual ramp system of capacitor charge as a basis, the designer depends upon the complete discharge of the capacitor as a starting point . . . i.e., the capacitor starts from zero volts. If there is appreciable dielectric absorption, there may be quite a voltage on the capacitor after it has been discharged to "zero."

Capacitors are often chosen for their low dielectric absorption characteristic, in applications where this is important. Polystyrene capacitors have low dielectric absorption, along with extremely low leakage, but must be used at lower temperatures than some of the other plastic film capacitors.

Plastics

Today we have polyester, mylar, polycarbonate, polystyrene, and polypropylene film dielectrics. The old paper dielectric has been combined with a plastic film, ("dual dielectric" capacitor, which is very reliable). The trouble with paper dielectric capacitors is that the paper is oil impregnated (oil filled capacitors), and the oil used is detrimental to human health. Eventually these capacitors leak, and cause a health hazard. To get around this, these capacitors are often put into metal sealed cans, which are rather heavy. Other than this objection, the oil filled paper capacitors are very good for high voltage use, as in transmitters . . . and they are quite stable, with very, very, long life.

The reason the film capacitors are taking over is that they have no oil, do not need cans, and thus are quite small and light. They also work at higher frequencies without heating, and thus are well suited for switching and scan rectified supplies which are so popular today.

Film capacitors have widely different characteristics, depending upon the plastic used, and the type of construction. Some can handle very large ripple currents, at fairly high frequencies. Other pack a lot of capacitance into a small volume. Due to their variety, it is impossible to catalog them here. Suffice to say that you need to recognize that all plastics are not alike, and you must be very careful in substituting plastics.

Plastic film polystyrene will soften and melt where mylar runs merrily along. But mylar has much higher dielectric absorption. I think you get the idea . . .

Now you know why some color TV manufacturers have "special" capacitors for use in horizontal deflection circuits, marked, "Use exact replacement part only!."

The real problem seems to be that capacitor manufacturers selling their products to the consumer electronics repair shops, do not include even the barest applications information. You have to request this sort of information, which is available, directly from the manufacturer. Your local distributor often doesn't even know it exists! This is classified as, "Engineering Information." Unfortunately the service technician today is often an AA, but seldom treated as such. Service shops are expected to have a very clean crystal ball, which furnishes all manner of technical information. Some of the set manufacturers have provided this sort of information but this happens all too rarely.

Thus the ball stops . . . in YOUR lap, as usual. With Yankee ingenuity, great perseverence, lots of experience, etc., the set eventually is fixed . . . the hard way. Once again, it is up to you to stay abreast of all the technical developments. Good luck! ET/D

Intrusion Detectors

The four popular types

When installing area protection devices, you have a choice of four common types of detectors each of which has advantages and disadvantages. Here are some of the factors to consider.

by George Kanelos*

Each of the four common types of space intrusion detectors, photoelectric, ultrasonic, microwave, and passive infrared has its own requirements for effective installation.

When considering the selection of equipment for an installation, first consider where space protection fits into the overall system. How many areas must be protected? Will space protection be the primary or secondary form of protection? How large is each area, and what is its shape? Where are the points of entry? What objects will obstruct the sound path? Is the environment "hard" or "soft"? What hazards exist, such as air vents, fans, blowers, hanging objects, sources of noise? Is remote control required? Individual area alarm memory or remote area annunciation?

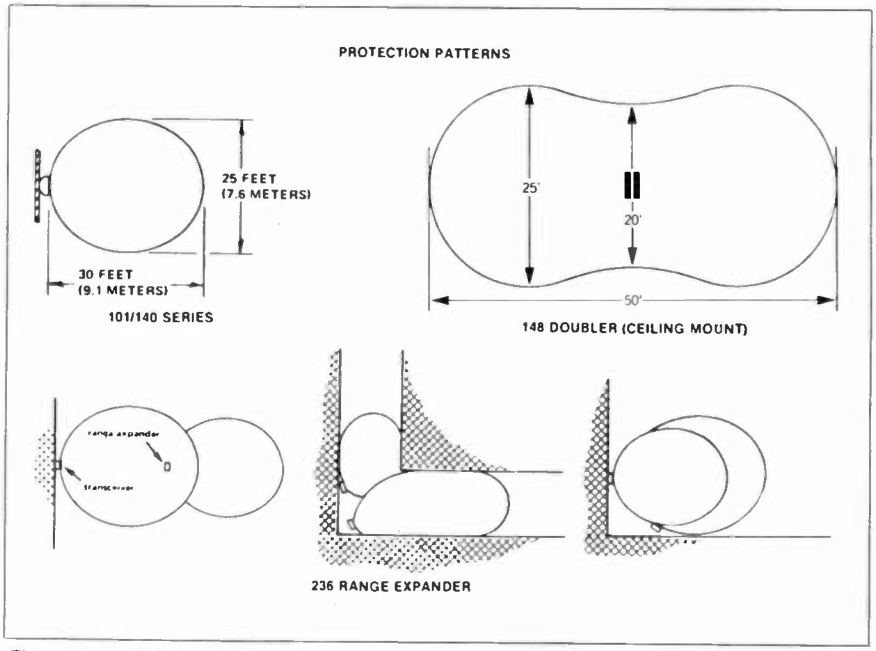


Fig. 1 Typical ultrasonic detector coverage patterns. (Courtesy ARITECH)

Photoelectric Detectors

Photoelectric intrusion detectors are among the oldest and most commonly used space protection devices. When properly installed, photoelectrics reliably provide either localized "trap" or long range area protection. They assume one of two general configurations: the conventional two piece transmitter/receiver system, consisting of separate transmitting (sending) and receiving (monitoring) units or the one piece self-contained transceiver, housing both its transmitting and receiving components in one package.

Photoelectric systems detect intrusion when an invisible beam, usually a pulse-modulated infrared signal, sent by the transmitter and monitored by the receiver is interrupted by an intruder passing between the two. A relay, located in the receiver and wired into the protective circuit of an armed burglar alarm system activates the alarm.

Photoelectrics are available for surface or recess mounting, in plastic

*of the William B. Allen Supply Co., Inc., New Orleans.

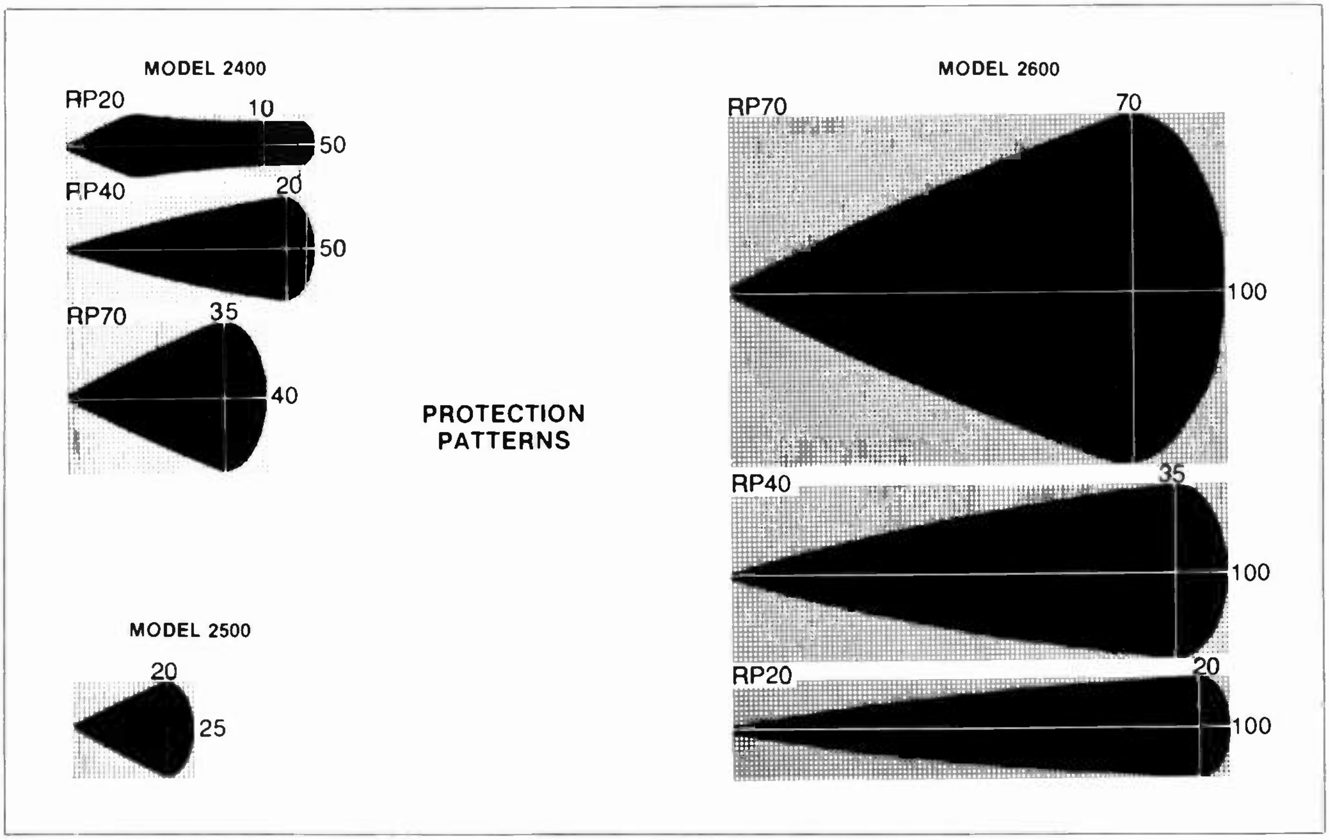


Fig. 2 Microwave intrusion detector coverage patterns. (Courtesy Solfan)

or steel enclosures and for indoor or outdoor applications. Depending on the photoelectric selected, effective range of up to 1000 feet is possible, making these units suitable for an extensive variety of applications.

Installation is relatively uncomplicated, requiring only the simple alignment of the beam passing between the transmitter and receiver or the transceiver and a reflector, after the units have been mounted in the desired locations. Inexpensive installation aids to further simplify beam alignment are readily available.

Available in some systems is a unique extension of the photoelectric's versatility which allows a protective loop to be powered by the transmitter component of the system. Wired directly to the transmitter, an open or short in this loop will cause the transmitter's light source to turn off and simultaneously activate the receiver to signal an alarm condition to the main control just as if someone had walked through the beam. The transmitter has become, in effect, a circuit receiving device allowing additional openings to be protected without additional wire runs back to the main control.

Common applications for photoelectric systems include hallways, aisles, banks of windows, stairways and heavily trafficked areas for control purposes. For indoor applications, special mirrors are available to make bends around corners and inexpensively increase coverage.

Outdoor photoelectronics, specially designed to shut down in the event of severe fog, snow or sleet and containing thermostatically controlled heaters to prevent condensation are ideally suited for short or long range (up to 500 feet) perimeter protection. A fenced area with a clear field of view between the transmitter and receiver is all that is required for reliable and relatively inexpensive protection.

Today, the photoelectric remains one of the most dependable and cost effective protective devices available to the security industry. Its versatility and long history of reliability make its consideration almost mandatory when space protection is required.

Ultrasonic Detectors

Ultrasonic waves are sound at a frequency above the normal 15,000 to 20,000 Hz limit of human hearing. They can be used to provide economical and effective indoor intrusion detection.

The phenomenon known as the "Doppler Effect" provides the operating principle of all ultrasonic detection systems. It can be explained by means of an example: A jet plane flying at a low altitude over an observer will seem, to the observer, to make a high pitched whine as it approaches and a low pitched roar after it passes. While the plane is approaching, the frequency of the sound that reaches the observer's ears is a result of the plane's actual engine sound plus the speed at which it is approaching. After the plane passes, the observer hears the lower frequency, a net result of the plane's actual engine sound minus the speed of the departing plane. This apparent change in frequency is called the "Doppler Shift."

Otherwise stated: If the source and the observer are standing still, then the frequency the observer hears is equal to that coming from the source. If either the source or the observer moves toward each other, the frequency reaching the observer increases. When they move apart, the frequency decreases.

Ultrasonic intrusion detectors utilize the Doppler Effect to perceive motion in a protected space. One or more ultrasonic sources fill the area with ultrasonic waves. These bounce off walls, ceiling, floor and other stationary objects in the area and ultimately reach one or more pick-up devices at the same frequency that was transmitted from the source. In

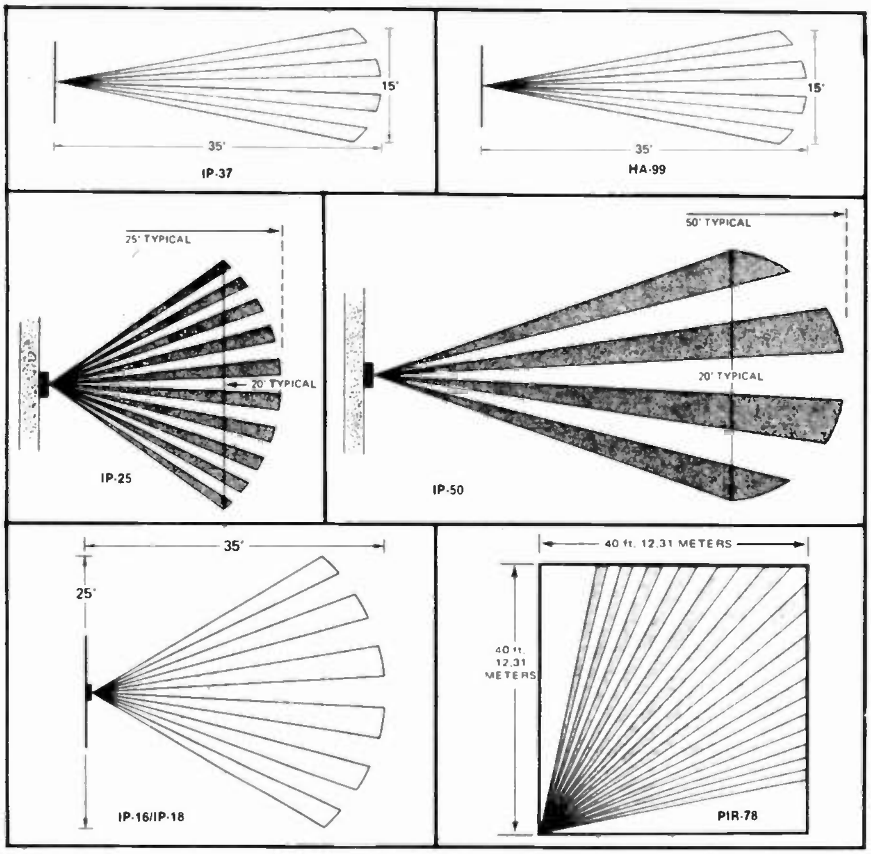


Fig. 3 Passive infrared intrusion detector patterns. (Courtesy Colorado Electro-Optics).

addition ultrasonics bouncing off a moving object (such as an intruder) will generate frequencies that are slightly higher or lower than the source's frequency. These Doppler shifted frequencies will also be picked up by the ultrasonic system's receiving transducers. The system is designed to ignore the frequency that is provided by the transmitting transducers, but will initiate an alarm signal upon receipt of "Doppler shifted" frequencies.

A transmitting transducer is a device that converts electrical energy to sound energy. A receiving transducer is a device that converts sound energy to electrical energy. Conventional speakers and microphones are examples of transducers but the transducers used for ultrasonic intrusion detection are specifically designed for this purpose. A transceiver is, of course, a single unit containing a transmitting transducer and receiving transducer.

Ultrasonic layout and performance considerations:

1) Choice of Transceivers vs. Individual Transducers: Transceivers provide excellent spot coverage where wiring convenience must be considered but where uniform coverage over a wide area is not a prime requirement. Individual transducers can provide more uniform coverage and sensitivity over an area than transceivers can provide, but generally require more wiring.

2) Coverage Pattern and Aiming of Transducers: A wide selection of transceivers and transducers with narrow, wide and omni-directional coverage patterns are available. Most can be aimed to provide additional versatility.

3) Room Acoustics: Placement and aiming of the transceivers or transducers in relation to the walls, ceiling and floor of the area influence the system's performance as do the type of surfaces (Hard, smooth reflective surfaces are best) and the presence of sound absorbing materials such as furniture, carpeting and draperies (which reduce coverage).

4) Disturbances: Air Turbulence (from drafts, space heaters, air conditioning vents, rising heat from radiators, etc.), Sources of Ultrasonic Noise (such as telephone bells, hissing steam, leaking compressed air, whistles, etc.) and Vibration (from machinery, loose fitting doors and show windows or walls that shake when the wind blows or traffic passes) all are serious sources of disturbance in improperly designed systems. A properly designed system, however, will reduce or eliminate the effect of such disturbances in a variety of ways.

5) Humidity and Temperature: Ultrasonic waves are affected by atmospheric humidity and temperature. Between the best and worst combinations of conditions, range can change over 50%. this can be taken into account during installation and adjustment of the system.

Microwave Detectors

Microwave intrusion detectors also operate on the Doppler Effect. They are available in self-contained and multihead configurations and provide a wide range of protection patterns from 25 feet to 300 feet, and function by projecting these precise, high frequency (10.525 GHz) radiation patterns into protected area. A moving intruder, interrupting a protection pattern will cause a shift in its frequency. This Doppler frequency shift is immediately sensed by the detector and electronically converted into an alarm signal.

Microwave detectors feature adjustable range controls which allow the size of the protection pattern to be varied according to the need and interchangeable antennas which permit selection of the most effective radiation pattern for a given application. They are virtually immune to false alarms caused by changes in temperature, humidity or high frequency noise created by bells, sirens, air compressors, etc. They can be successfully installed where air currents from heaters, air conditioners or breezes exist and are ideal for use in large open areas and long hallways. To insure a trouble free system, there are four precautions which should be observed before and during installation:

1) Microwave protection patterns can penetrate into undesired areas. This penetration can result in the detection of movement outside of a protected area and subsequent false alarming. The degree of unwanted penetration is determined by the material being penetrated:
To prevent unwanted penetration, the composition of wall materials bordering the protected area should be determined and microwave detectors selected with detection patterns providing minimal or no penetration.

2) Stationary metal objects reflect microwave energy aimed at them.

Although, reflection can sometimes increase protection by intensifying the coverage in a given area, reflected microwave energy should not be directed at a window through which it can penetrate or at an occupied area where movement can cause false alarming.

Material	Degree of Penetration
Glass	100%
Dry Wall	50%
Cinder Block	10%
Metal	none

3) Target size and reflectivity are critical considerations when placing microwave detectors. A target is defined as an object at which the microwave detector is aimed and which consequently reflects microwave energy. One of the most common causes of microwave false alarming is a detector aimed at a metallic or other large object which moves during the protection period. The target may even be located well outside the rated range of the detector and still create a problem. An example of this phenomenon is a 50 foot detector aimed at an overhead door located 100 feet away. If the door rattles significantly from wind or other causes, the detector may trip. This happens because a 50 foot detector is rated to sense a man taking two steps at a distance of 50 feet. Man, however, is composed predominantly of water, a moderate reflector of microwave energy and approximately equivalent in reflectivity to a six inch square piece of metal equidistant from the detector. Thus, a rattling door, because of its size and reflectivity, may be sensed at distances greater than the detector's rated range.

Again, as in the cases of penetration and reflection, observation and testing are invaluable tools in isolating and correcting problems associated with target size and reflectivity.

4) Vibration of the area in which a detector is mounted, caused by passing trains, traffic, compressors, etc., can be interpreted by the detector as the movement of a large object and result in false alarming. Vibration problems can usually be eliminated by securely mounting detectors, using vibration absorbing mounting materials when necessary and aiming detectors away from items which can be set into motion by building vibrations.

It is evident that microwave detection, like other recognized types of space protection, requires a basic conceptual understanding and careful planning. However, when properly applied and installed, microwave provides a dependable, cost effective and extremely stable level of protection. The simple precautions discussed above should not deter the use of microwave detection. Rather, as is the case with all space protection equipment, they should be carefully followed to insure a trouble free installation.

Passive Infrared Detectors

Although the use of passive infrared technology is relatively new as a detection medium, the phenomenon of infrared or "invisible light" has been understood and successfully employed in a variety of other applications for many years. Infrared, not visible to the naked eye, is transmitted in a long wave length and generated or radiated at different levels by every object, whether animate or inanimate, warm or cold, as a function of the object's temperature. Recognizing that all objects radiate infrared energy, the ability to measure small, rapid changes in the level of that energy, created by the movement of an object into a specific area, has resulted in the development of one of the most stable and reliable of all space protection devices, the passive infrared detector. The passive infrared detector, viewing a specific area, establishes a normal condition which is actually the infrared radiation level generated by all of the objects in that area. A lens or mirror system is used to focus the thermal images of the objects on the detector's sensor element. When an intruder enters the viewing pattern of the detector, his thermal image is also formed on the detector's sensor element, indicating a change in the normal condition and initiating an alarm.

Passive infrared detection offers four important advantages to the installer considering space protection:

1) Since passive infrared detection, as its name implies, does not transmit energy of any kind, interference between units in multi-detector installations is eliminated as is any potential safety hazard to humans or pets.

2) Passive infrared cannot "see" through glass or walls, and any physical barrier will stop the protection pattern. Thus, with proper installation, false alarms commonly caused by "creeping" or penetration are eliminated.

3) Because passive infrared detection uses an adjustable optical system, the protection pattern is extremely controllable, permitting small pets to enter a protected area without causing false alarms.

4) Passive infrared detectors do not "see" air and will not false alarm because of warm or cool moving air.

To help insure a trouble free installation, avoid installation of a detector facing exterior windows or where direct sunlight can strike the face of the unit. Do not install a detector where items which heat or cool rapidly such as radiators, electric motors or heating or cooling vents are in its field of view. Although gradual room temperature changes have no effect on the detector, direct sunlight striking its face or rapidly heating or cooling objects directly in its field of view may cause false alarms. The operating temperature range of passive infrared detectors is generally between 0°F to 135°F. Ideal detection situations occur where room temperature is below 85°F or above 100°F. Depending on the detector, its field of view will be divided into a minimum of four to a maximum of sixteen zones. Each zone will be viewing and monitoring a specific segment of the protected area and substantially reducing the possibility of an intruder remaining undetected.

Passive infrared, with its many advantages, range of detection patterns, mounting flexibility, installation ease and only minor limitations represents an affordable and reliable solution to many space protection problems. It can be used with confidence by even the novice installer.

To come

This has been a quick rundown on the principles and uses of the major types of intrusion detectors. ET/D hopes to have technical details of the circuitry and operation of each in the near future. ET/D

Download and Signal-to-Noise

Preamps, signal strengths and line lengths.

Given a certain signal at the antenna, you need to know what preamp you may need, if any, to function with the necessary downlead to result in an adequate signal to noise at the television receiver. Here is a useful nomogram and how to use it.

by James E. Kluge*

There are times, when calculating the design of an MATV system or even a simple residential antenna installation, that you need to know how to choose the right antenna preamp to go with a given length of downlead cable for the application. The choice is affected by several considerations, one of which is signal-to-noise degradation caused by attenuation in the downlead.

The question that frequently arises is: "With a certain preamp, given its gain and noise figure, how much downlead can I run before I start to degrade the signal-to-noise ratio?" Or, in another case, the downlead may be determined and fixed so that you need to know what preamp gain and noise figure will best preserve the signal-to-noise ratio derived from the antenna terminals.

The discussion that follows presumes that the antenna signal is marginal (perceptible snow or graininess in the picture) and that little if any degradation of the received signal can be tolerated.

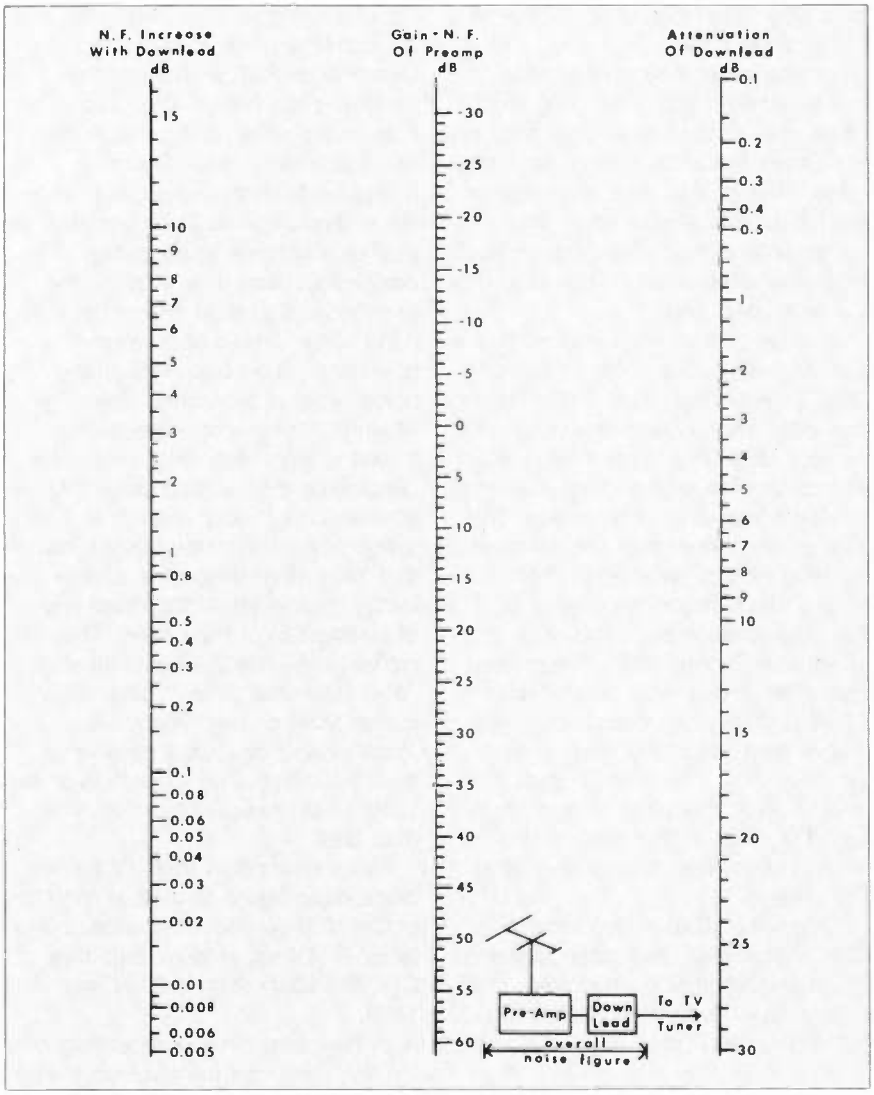


Fig. 1 A Noise Figure/Line Attenuation/Preamp gain, nomograph.

A preamp becomes necessary to preserve the antenna signal and it must have a low noise figure so as not to degrade further the marginal antenna picture quality.

For example, two basic antenna preamps for VHF and UHF differ by their gain—they are 14-dB and 24-dB gain amplifiers. Their average noise figure at VHF frequencies is 3dB and at UHF may be either 8.5dB or 2.2dB

*James Kluge is a technical editor with the Winegard Company

depending on whether you choose the standard or low-noise version. For the purpose of our discussion, let us assume that for UHF we use the low-noise preamp and to simplify our calculations we'll consider the noise figure for both the VHF and UHF preamps to be 3dB.

Assuming the signal from the antenna to be marginal with respect to noise (i.e. S/N = 30dB), any degradation caused by amplifier noise or attenuation will affect picture quality and may be noticeable. Therefore, it would be useful to know and to be aware of the noise contributing factors and their relative importance.

The nomograph in Fig. 1 offers a quick and easy way to evaluate the effects of down-lead attenuation that results in a degraded signal-to-noise ratio after the amplified signal leaves the antenna preamp.

To use the nomograph, add the noise figure (in dB) to the gain (in dB) of the preamp and locate that point on the center scale. Then, with a straight edge, pivot on this point and read on the left-hand scale the noise figure increase (in dB) and for the amount of downlead attenuation (in dB) read on the right-hand scale.

Example: an antenna preamp has a gain of 14dB and a noise figure of 3dB. Together they total 17dB; locate that point on the center scale. Lay a straight edge on this point and pivot it to intercept the left-hand scale at an arbitrarily chosen 1-dB increase. The straight edge intersects the left-hand scale at 11.1dB attenuation. This shows that a length of downlead, having approximately 11dB of attenuation, connected to the preamp output will produce an overall noise figure (preamp plus downlead) 1 dB higher than that of the preamp alone i.e. NF = 3 + 1 = 4dB. To state it another way, the signal-to-noise ratio at the end of the downlead is 1dB worse than where the signal exits at the preamp.

Different coaxial cables exhibit different rates of attenuation resulting in varying lengths. For example, 11dB is equivalent to running 230ft. of CL-2700 (RG 59/U type MATV cable with foam dielectric) at channel No. 13 or 115ft. at channel No. 70; if using CL-2800 (RG 6/U type MATV cable with foam dielectric) the above lengths increase to 350ft. and 155ft. respectively.

If you have a fixed run of downlead, and know the cable to be used, you can then go back to the nomograph and either determine the noise-figure increase, or for a given maximum increase determine the gain-plus-noise-figure total for the most economical preamplifier in this application.

Note that the noise-figure increase also represents an equal decrease in the signal-to-noise ratio as the signal passed from the preamp output to the other end of the downlead.

In a simple residential or commercial MATV system, the downlead may go directly to the TV-set tuner. TV tuners have notoriously poor noise figures that fall in the range of 6 to 8dB at VHF and 12 to 15dB at UHF. Any attentuation ahead of the tuner adds directly to the tuner noise figure. Now, the downlead has significant attenuation but the antenna preamp has gain which when the two are combined, will add up to a net gain or attentuation ahead of the tuner. If it is a net gain, then consider it as an amplifier having that net gain and a combined noise figure computed from the nomograph as in the example above. Then compute the new overall noise figure (preamp + downlead + tuner) by entering the tuner noise figure (in dB) on the right-hand scale instead of downlead attenuation. This scale is actually noise figure of a "second stage" which in the case of downlead following a preamp, the downlead is considered the "second stage". Any attenuation in the downlead, or a pad, splitter, or any inserted passive device that adds attenuation (or insertion loss) is equivalent to the noise figure of that portion of the system. Only for convenience was this scale labeled "downlead attenuation". Likewise the center scale can represent any amplifier gain or even a passive device (using the minus portion of the scale where net gain plus NF is less than 0dB).

As an example, a VHF-TV tuner has a noise figure of 10dB and 100ft. of CL-2700 downlead is connected to its input (TV-set antenna terminals). CL-2700 attenuation is 2.3dB per 100ft.

In this case, the downlead becomes the *first* portion of the combination and the tuner becomes the second. The downlead "gain" (−3.2dB) is added to its noise figure (3.2dB) to equal "0"dB. (This will hold true for any passive device or section, i.e. 0dB) Find 0dB on the center scale and 10dB on the right hand scale of the nomograph and lay a straight edge through these two points. Now read"10db" on the left hand scale and add it to the "noise figure" of the downlead to equal 13.2dB for the noise figure of the downlead *plus* the TV tuner.

Note that it was unnecessary to use the nomograph!

As mentioned previously, simply add any attenuation immediately ahead of the amplifier to the amplifier noise figure to compute the combined noise figure.

Now, let's go one step further and add a preamp ahead of the downlead and compute the overall system figure from antenna (antennas have 0-dB noise figure) through the TV set tuner. Enter preamp gain + preamp noise equals 17dB on the center scale and 13.2dB (NF of downlead + TV tuner) on the right hand scale. Read 1.6dB increase on left-hand scale. Thus, the overall system noise figure equals 3dB (preamp NF) + 1.6dB = 4.6dB. Note how adding a low-noise-figure preamp at the antenna improves the overall noise figure from 13.2dB to 4.6dB. With an 8.6dB improvement in signal-to noise, a grainy, snowy picture should readily clear up by adding a low-noise preamp.

Note also that any reduction in preamp noise figure adds directly to the signal-to-noise ratio of the picture on the screen.

It may appear at first glance that an amplifier having a high noise figure will be compensated by its low gain (because the sum of these two are entered on the center scale); or, that a high noise figure and a high gain together provides a smaller overall-noise-figure increase (which is true only because you started with a poor noise figure, high gain or both). The question is: "Can you afford to use a preamp with a poor noise figure at a point in the system where the system noise figure, to be established, depends almost entirely on the preamp noise figure?" I think you'll find the answer to be "No"!

High gain will reduce the NF increase but *never* try to compensate for a poor noise figure with higher gain.

Whether a high-gain preamp is chosen should depend on 1) how much you can reduce the NF increase versus the additional cost of more gain, and 2) whether the reduced total input capability of a high-gain amplifier will cause overload. These choices must be carefully weighed and considered. **ET/D**

AC Theory and Reactive Networks, Part II

More About AC*

Here is a continuation of last month's review of ac theory and an examination of series and parallel ac circuits

by Stan Prentiss

Pretty soon we'll be dealing with impedances as complex quantities since they have both resistive and reactive components as well as phase angles. Therefore, we'll have to know not only the magnitude of the resistive and reactive impedances but their phase angles as well. A graphic approach is very convenient.

Vectors

Equations will do the same thing as pure vector diagrams, but with fundamental series and parallel circuits, the vector graphic approach is much simpler and quicker. Actually, it would probably be easier to introduce polar and rectangular coordinates and their conversions immediately with vectors, but it may be just a little too much to grasp all at once, so we'll save this for ac circuit analysis which is coming shortly.

Vectors are useful in finding what is known as a resultant, and this means the complex sum of two or more magnitudes or forces going in different directions. For instance, take a line segment. The length of the line is the magnitude and angular position, while an arrowhead at its tip will tell direction. Let's set up a pair of lines and join them with another line. In Fig. 1, 0 to 1 could be one line segment, and 1 to 2 could be another. Then the line 0 to 2 is the resultant direction and magnitude of the initial two lines and represents the vector sum of both. Of course, both forces must be applied to the same objective and neither the 1st nor 2nd lines may have either their magnitude nor directions changed. Should such occur, then the resultant would be untrue. You may also start both forces at the origin 0 and form a parallelogram to produce the same result—and usually this is how basic vector addition is done (Fig. 2).

If you're dealing with more than two forces, then two or more parallelograms must be drawn. The illustration in Fig. 3 shows this. The forces are designated as 1, 2, 3. The resultant of forces 1 and 2 is 4. Then the parallelogram 0, 3 and 4 is formed by the dotted lines and the overall resultant of the three forces is the line 0 to 5.

This looks relatively easy—and it is—but with one considerable exception—your measuring instruments probably aren't accurate enough to provide precise results.

*from an unpublished book "Today's Electronics–Electronics for Troubleshooting," by Stan Prentiss

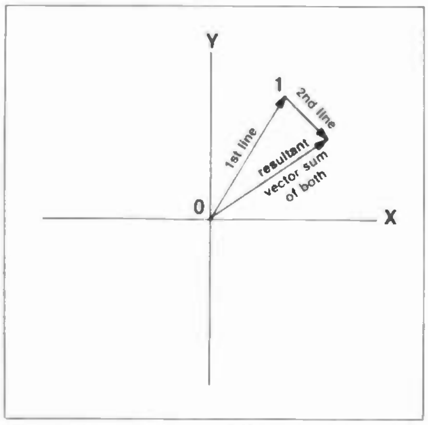


Fig. 1. An elementary diagram illustrating the addition of two vectors by simple addition.

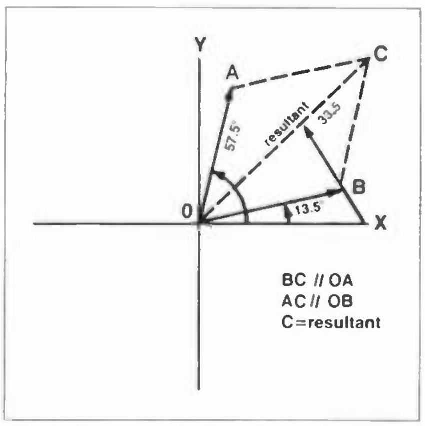


Fig. 2. A second method–by parallelogram–to find the phase angle and magnitude of simple vectors.

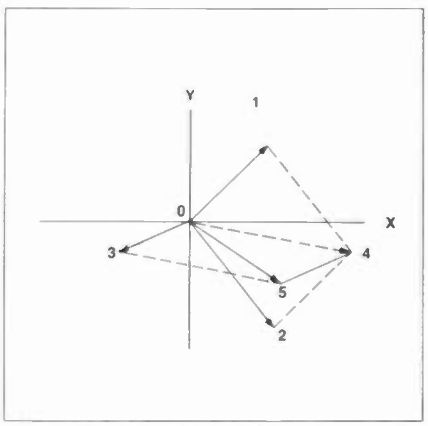


Fig. 3. Three forces acting on 0, the origin simultaneously. Use the same method twice. Double line 0 to 5 is resultant.

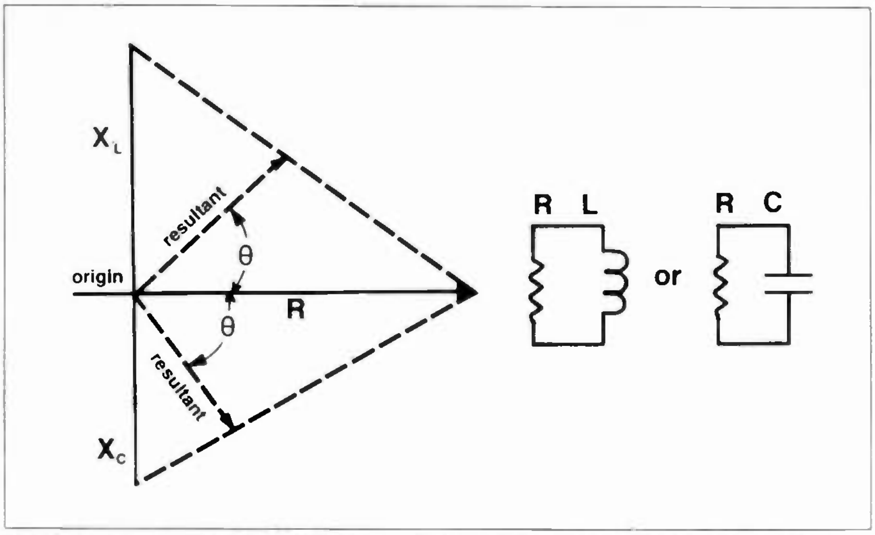


Fig. 4. A vector of the same resistance in parallel with one inductor or one capacitor.

However, vector diagrams can quickly show worthwhile approximations and are certainly useful in estimating directions forces will take as well as ultimate phase angles.

A means of determining a single resistance and reactance in parallel should also be illustrated (Fig. 4) if for nothing more than a reference and another way of finding a needed solution. This, by the way, may prove a little more accurate than the previous series methods, but is limited by a single R and X_L or X_C. For your information, let's do both the X_L and the X_C on a single diagram. Two resultants are the magnitudes of the vector parallel addition, and are at right angles to a line drawn between the 90-degree positive phase shift of the inductor and the 90-degree negative phase shift of the capacitor. Through a resistance, of course, current and voltage remain in phase. Any reactance and resistance can be done this way by simply plotting their magnitudes horizontally: draw a line between the magnitudes of each, then draw a final connection from the origin, perpendicular to the joining line. You now have the scalar resultant and its direction from the angle (theta). Now, we're ready to begin approaching the meat of the entire article, and that is reactive networks. For the novice, some of this will be relatively heavy reading, but you will now see how we can put everything together.

Reactive networks

Such networks include resistance, capacitive and inductive reactance, impedance, current, voltage, series and parallel resonance, power factor, vectors, polar and rectangular coordinates, and even phase angles. If there's anything left out, we'll discover it before we finish. The subject of transformers, by the way, may be undertaken later in a discussion of coupling and bypass circuits and transmission lines.

Now, recall Ohm's Law, where $E=IR$; then substitute the Z expression for complex impedance and make the equation read $E=IZ$. Then, when $E=IZ$, $I=E/Z = E/X_C = E/X_L$

So X_C or X_L alone can also equal Z and with this in mind, we'll begin with a basic LR circuit and discover some things about it.

A Series LR Circuit

In an inductor, recall that voltage leads current by 90 degrees, because inductors always oppose changes in current with a counter emf. So, if we were to draw a vector diagram of this condition, voltage would be at right angles to current, and current would be in phase with the series resistor. The voltage, then would be the drop across the inductance (and resistance), and the resultant and its phase angle between current and voltage in the RL circuit would look like it does in Fig. 6. The X_L reactance is perpendicular and its voltage is the IX_L drop across its impedance Z. The horizontal projection shows current in phase with resistance and, again, the current times the resistance (IR) amounts to the voltage along this portion. The total voltage in the circuit, then, is the vector addition of the IR and IX_L drops, and is the resultant, with phase angle between current and voltage represented by theta, θ. So even though X_L is a 90-degree phase shift in itself, a Z + R circuit can have an entirely different resultant and finish with a phase angle that isn't even half of what a pure inductance by itself would produce.

A Series RC Circuit

You can do the same thing with a capacitor-resistor circuit as with an inductor-resistor circuit . . . the chief difference is that the current here is *not* in phase with the resistance, and even though you can *pick out* some obvious physical features of both capacitive and inductive circuits such as the value of these components and probably the frequency that's applied, there is yet another element that must be accounted for. This is operator j, the 90-degree phase shift sign that has numerical characteristics in the four quadrants, depending on the

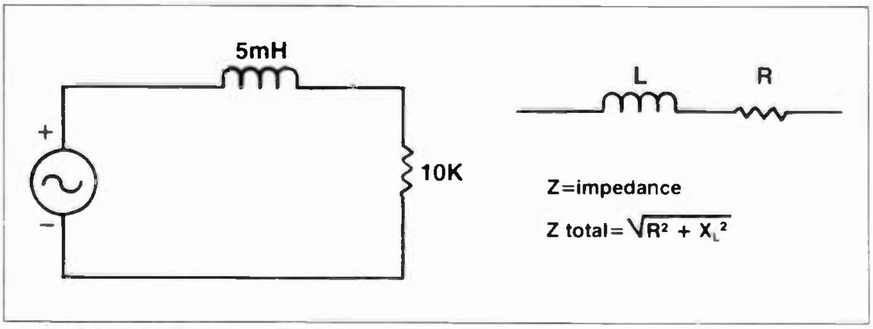


Fig. 5. A series LR circuit with ac generator.

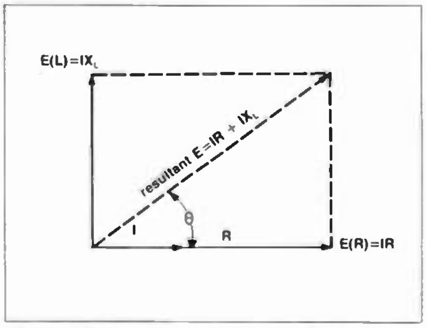


Fig. 6. Vector sum of current/voltage IR drops in the RL circuit of Fig. 5. Measured phase angle θ is 36° between current and final voltage.

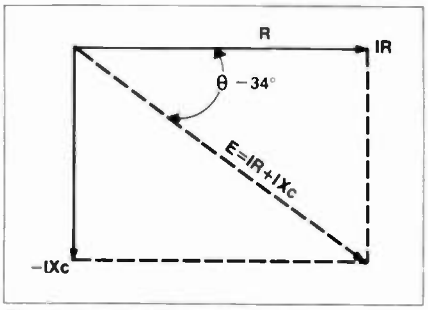


Fig. 7. A capacitive reactance and series resistance produce another rectangular solution, but the phase direction is now negative.

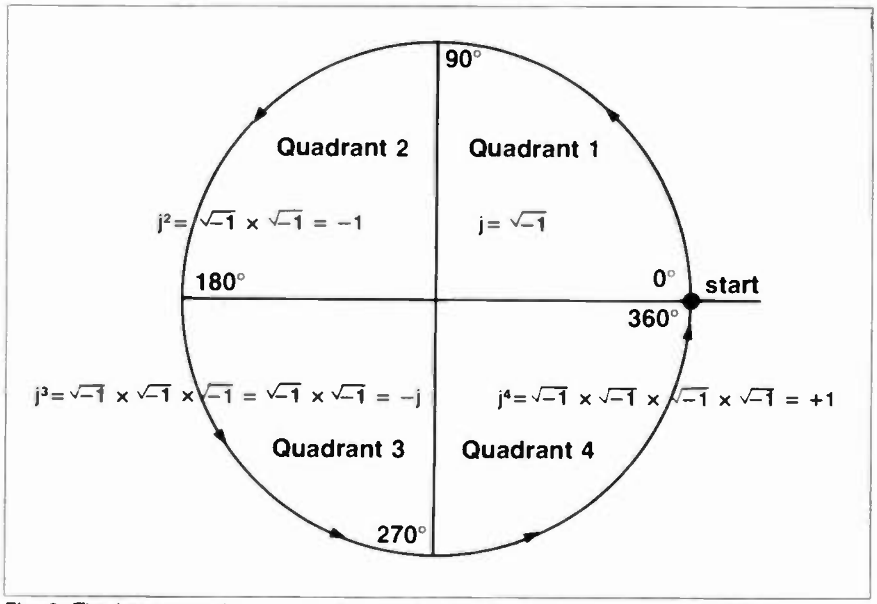


Fig. 8. The j-operator rides again. Each value of j is −1 and amounts to a 90° counterclockwise rotation.

number of times it rotates, so evident in Fig. 8. Initially, of course, $j = -1$, $j^2 = \sqrt{-1} \times \sqrt{-1}$ until, in the 4th quadrant, j^4 amounts to $+1$ . . . then the entire procedure begins again if we're speaking of a continuous cyclic wave. Unfortunately, the square roots of negative numbers have been called *imaginary* and they really aren't at all. A farad capacitor, for instance, charged to several hundred "negative" volts could do a great deal of damage if it makes the right contact. So to handle a number such as $\sqrt{-81}$, we could simply write it a $9\sqrt{-1}$, with the positive root outside; although you won't be doing this normally in electronics—at least not in this discussion. Ordinarily, j will just denote the phase shift component which is recognized as R/Z and expressed as Cosine θ.

In a circuit containing both resistance and capacitance, as an example, the voltage $E = \sqrt{E^2R + E^2C}$, and the impedance $Z = \sqrt{R^2 + X^2C}$. Therefore,

$E_z\angle{-\theta} = Er - jE_C$

and

$Z\angle{-\theta} = R - jX_C$

Also, at this point, we can find the power factor (power dissipated) in a circuit by dividing the true power by the apparent power—

pf = true power P/apparent power EI
or $pf = I^2R/I^2Z = R/Z$

or, using the phase angle between voltage and current:

$pf = EI\cos\theta$

which amounts to the apparent power multiplied by the fraction (up to 1) that derives from R/Z and becomes the cosine θ angle. The minus sign, as you saw in Fig. 7, denotes *symbolic* negative deflection of the X_C reactance. In the vectoral addition that follows, squaring the $-X_C$ quantity simply adds to the squared resistive or other reactive quantities under the square root sign. Then, to remove these positive or negative quantities from under the symbol, simply take the square root of their sum and you're dealing with a real, non-imaginary number. For instance:

$Z = R - jX_C = \sqrt{R^2 - jX_C^2}$

and, with numbers:

$Z = \sqrt{10^2 + 8^2} = \sqrt{164} = 12.81$ (slide rule accuracy)

Then, to find the cos θ phase angle of R/Z

$10/12.81 = .78$, and $\cos .78 = \angle{-38.7°}$

Had the Z been $R + jX_L$, the phase angle would have been $\angle{+38.7°}$ and the impedance would be just the same.

Now, if you also wanted to know the voltages, then the IR, IX_c drops across the resistor and capacitor would be quite easy, with the current phase angle *always* remaining the same in each calculation. Since $Z = 12.81$, and we can assign a voltage of 30V:

$I = E/Z = 2.34$ units, depending on whether Z is in ohms, K ohms, or whatever. But $Z = 12.81\angle{-38.7}$ and the angle divided into E becomes $+38.7$ for current.

So,

$IR = 2.34 \times 10 = 23.4$ units . . .

and

$IX_C = 2.34 \times 8 = 18.7$ units . . .

depending on whether I is in amps or milliamperes.

However, across a capacitor, voltage and current are 90 degrees out-of-phase. So the *voltage* phase angle across X_C equals: $IX_C\ \theta = -90° = 18.7\angle{-51.3°}$

Rectangular & Polar Coordinates

In the X_L and X_C examples of the previous paragraph (Fig. 3-2B) we have actually been dealing with *polar*

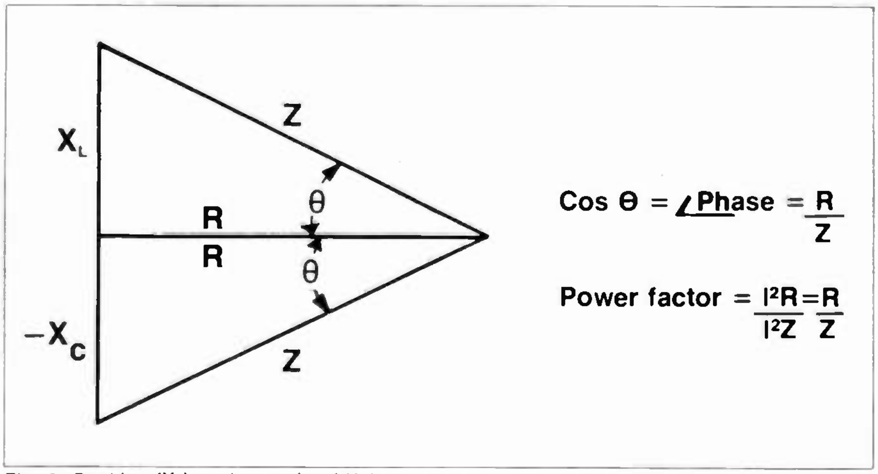


Fig. 9. Positive (X_L) and negative ($-X_C$) reactance on same diagram. Cos θ equals R/Z, the phase ∠ between voltage and current. In units between 0 and 1, R/Z is the power factor.

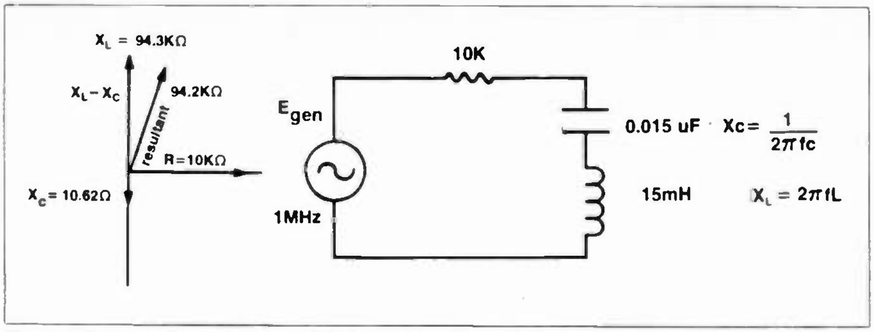


Fig. 10. Schematic and vector diagram of a series RLC circuit pumped at 1MHz. Note "large" capacitor.

coordinates–in math the X *abscissa*, vertical points of any line, and the Y, *ordinate*, of the same line. It is at this point in algebra you begin to solve simultaneous linear equations in more than one unknown. Such solutions may be attained by addition, subtraction, multiplication, and division to eliminate all but a single unknown and then solve by substitution or otherwise for the rest. Unfortunately, since the *polar coordinate* contains only the *sum* total of the resistance-impedance term, it cannot be used for addition and subtraction; only the *rectangular* coordinate can. However, the rectangular coordinate forever has the R + jX term that is very unwieldy and its long string of figures, powers, decimals, and j terms contribute to endless arithmetic errors. So what we'll do is to use the rectangular form when (and if) there are instances of addition and subtraction, but the polar form everywhere else. But we will also offer means of mathematically converting between polar and rectangular coordinates when needed, that should simplify most, if not all, problems:

Of course

$10 + j(X_L)\ 20$ in rectangular would become

$\sqrt{10^2 + 20^2} = \sqrt{500} = 22.35$ in polar and the phase angle R/Z or 10/22.5 amounts to cos 0.445 = 63.6° or $22.35\underline{/63.6^\circ}$. But if you wanted to add or subtract the polar $20\underline{/35^\circ}$ and $62\underline{/43^\circ}$ it would be necessary first to put them into rectangular form such as this:

$20\underline{/35^\circ} = 20\cos 35^\circ + j20\sin 35^\circ$
$= 20 \times .82 + j20 \times .574 = 16.4 + j11.42$

$62\underline{/43^\circ} = 62\cos 43^\circ + j62\sin 43^\circ$
$= 62 \times .732 + j62 \times .682 = 45.4 + j42.3$

Then the smaller may be either subtracted from the larger or added together, just like in arithmetic:

$$\begin{array}{rl} & 45.4 + j42.3 \\ (-) & 16.4 + j11.42 \\ \hline & 29.0 + j30.88 \end{array}$$

or

$$\begin{array}{rl} & 45.4 + j42.3 \\ (+) & 16.4 + j11.42 \\ \hline & 61.8 + j53.72 \end{array}$$

In another method, conversion of either of these rectangular forms can be slightly more direct, if you wish to use it. Here, 29 − j30.88 (the negative sign is deliberate for this example) would become:

$\tan\theta = -j30.88/29 = \arctan -1.065 = -46.6^\circ$

while $Z = 29/\cos(-)46.6 = 29/.727 = 40.5$

so 29 − j30.88 in a rectangular coordinate becomes $40.5\underline{/-46.6^\circ}$ in a polar coordinate. Note that the negative sign between the R and j terms carried over into the phase angle. If there had been a positive sign between the R and j terms, the cosine of the angle would have also been positive.

With division and multiplication, polar coordinates are used exclusively because it is only necessary to multiply or divide the magnitudes and add or subtract the phase angles.

To multiply:

$75\underline{/12^\circ} \times 20\underline{/30^\circ} = 75 \times 20\underline{/12^\circ + 30^\circ} = 1500\underline{/42}$

To divide:

$75/20\underline{/12^\circ - 30^\circ} = 3.75\underline{/-18^\circ}$

Note once more, the negative sign remains when the second angle is larger than the first in division, just as it did in the arc tan θ above. Naturally, 30° − 12° would become a +18° because the smaller was subracted from the larger.

RLC Series AC Circuits

We're now ready for somewhat more complex networks in addition to the introduction of frequency, in which actual inductive and capacitive reactances must be calculated. Selecting a frequency of 1MHz, for instance (Fig. 10), let's calculate the reactance of the three components in series, collect terms, and come up with a working resultant and phase angle:

$X_C = 1/2\pi fC = 1/6.28 \times 10^6 \times 0.015 \times 10^{-6}$

$= 1/6.28 \times 0.015 = 1/.0942 = 10.62$ ohms (almost a short circuit)

$X_L = 2\pi fL = 6.28 \times 10^6 \times 15 \times 10^{-3} = 94.3 \times 10^3$ or 94.3K ohms

So the circuit's total impedance amounts to:

$Z = 10K + j94.3K - j10.62$

Now, although the small capacitive term is actually subtracted from the

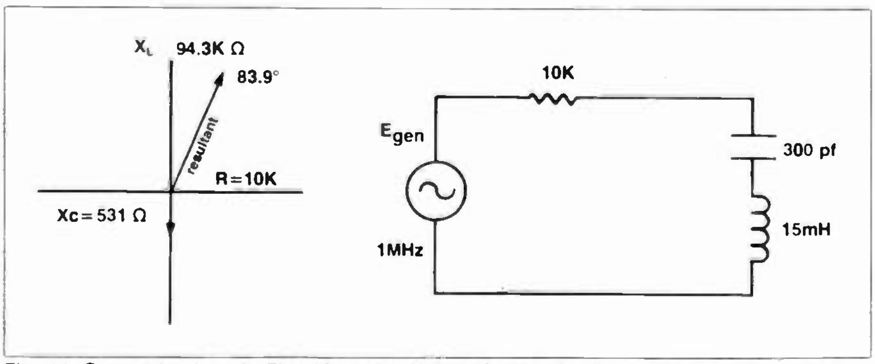


Fig. 11. Same circuit as in Fig. 10 except value of capacitor has changed. Phase angle has modified somewhat but high frequency keeps X_L reactance large.

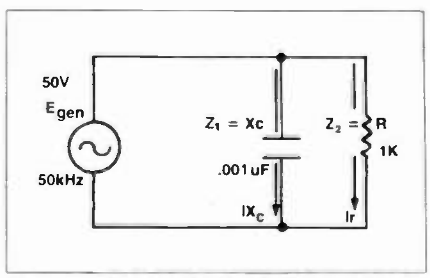


Fig. 12. An RC parallel circuit where voltage is the constant and current is variable.

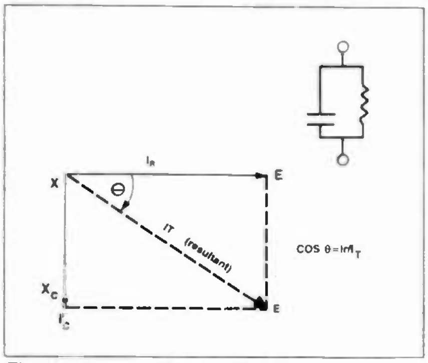


Fig. 13. Vector diagram for the parallel RC circuit. The gross resultant does not indicate a true phase angle. X_C is always shown as the $-jX_C$ position of any complex inpedance.

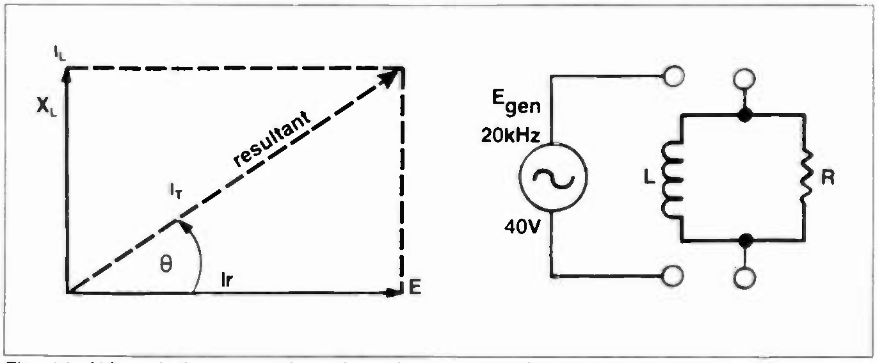


Fig. 14. Although the current lags the voltage by 90° through a pure inductor (the opposite of a capacitor), the vector is drawn "upside down" to keep the usual upward X_L perspective.

inductive term 94.3K – 10.62, the difference is negligible, so we'll make the reactive portion of the network j94.2K, just to show a small shrinkage. Consequently, the overall impedance now amounts to:

$Z = 10 \times 10^3 + j94.2 \times 10^3 = (10 + j94.2) \times 10^3$

And you can now square both terms or take the arc tan θ, whichever suits you best. For exercise, we'll do the arc tan (at slide rule accuracies, of course):

First

$Z = j94.2/10 = \text{arc tan } 9.42 = 83.95°$
$Z = R/X = R/\cos 83.95° = 10K/.106$
$= 94.5K\underline{/83.95°}$

So there wasn't much phase shift to that circuit at all because the capacitance was too large. Had the capacitance been 300pF, the phase angle might have altered somewhat and the circuit would not have been quite so predominantly inductive. Let's investigate:

$X_C = 1/2\pi fC = 1/6.28 \times 300 \times 10^{-12} \times 10^6 = 1/.1884 \times 10^{-2}$
$= 5.31 \times 10^2$, or 531 ohms

Now,

$Z = 10K + j94.3K - j531$
$Z = 10K + j93.7K$
$j93.7/10 = \text{arc tan } 9.37 = 83.9°$ so really, this value change for the capacitor doesn't help much at all. Any real change in circuit reactance will have to come from the inductor's X_L value or a reduction in frequency. The heavy reactance of X_L will continue to nullify the effects of both resistive and capacitive reactance unless its value is changed—a good point to remember when looking at strange and/or unwieldy circuits. If you wanted a series trap circuit, for instance, where at resonance the series impedance was lowest—really a resistance, you'd follow this equation:

$Fr = 1/2\pi\sqrt{LC}$ and the same equation also stands for parallel resonant circuits. In the circuit of Fig. 10, L and C would become series resonant at:

$Fr = 1/6.28\sqrt{15 \times 10^{-3} \times .015 \times 10^{-6}}$
$= 1/6.28\sqrt{2.25 \times 10^{-10}}$
$Fr = 1/6.28 \times 1.5 \times 10^{-5} = 1/9.42 \times 10^{-5} = 1.06 \times 10^4$
$Fr = 10.6$kHz

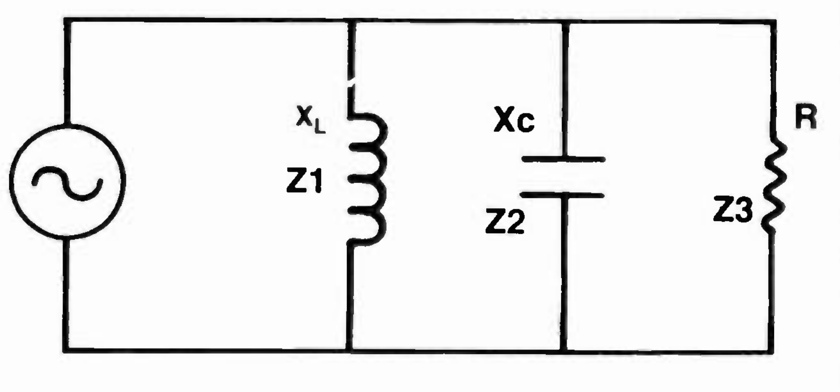
. . . a far cry from the 1MHz we started out with, but which was not intended to be resonant because, if you remember, when L and C become resonant, current and voltage are in phase—and we can't demostrate cos θ phase angles under these circumstances.

An RC Parallel Circuit

In parallel circuits, of course, voltages across components in parallel are equal, while currents are unequal, and the total current is distributed among the branch currents. To find each branch current, use Ohm's I = E/Z law, with E being the constant voltage. Since reactance varies, the currents cannot be the same, and the sum of the currents will then amount to the total circuit current.

$I = E/Z = E/R = E/X_C = E/X_L$
(Individual components)
Then, $I_T = I_1 + I_2 + I_3$ . . . etc.
Finally, the overall circuit impedance may then be derived from:
$Z + E/I_t$

Naturally, you could also add the various impedances in parallel $Z_t = 1/Z_1 + 1/Z_2 + 1/Z_3$ etc., using either/or resistors or reactances and find the total impedance. And remember, too, that in a purely capacitive circuit current leads voltage by 90 degrees. So with the voltage as a constant in parallel circuits, the variable operations are done with currents, and all vectors are illustrated with reference to the voltage vector since all voltages are equal and in phase and also in phase with voltage across whatever resistors are in the circuit. Now, the total current becomes the vector sum of the branch currents, while the current vector is drawn



$$Z_T^2 = \frac{Z_1Z_2Z_3}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}$$

Fig. 15. Total impedance in these parallel circuit is given by Z_t, while current is the vector sum of R, X_C, X_L, individual currents.

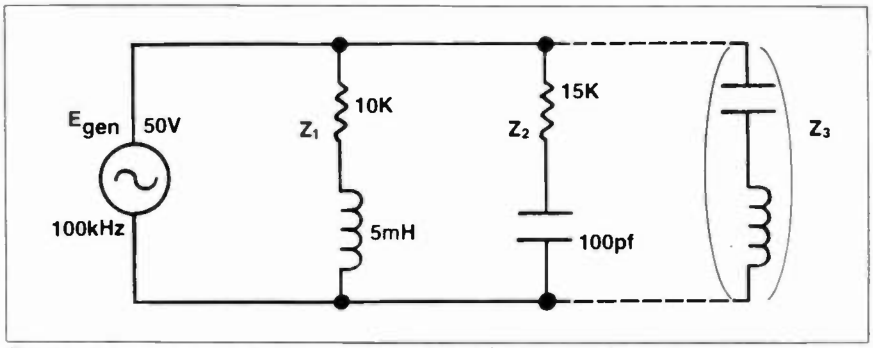


Fig. 16. A (series) parallel component circuit that is given the full treatment.

perpendicularly.

If the frequency is 50kHz and the capacitance 0.001 uF, the reactance (Fig. 12) amounts to:

$X_C = 1/2\pi fC = 1/6.28 \times 0.001 \times 10^{-6} \times 50 \times 10^3$

$= 1/6.28 \times 10^{-9} \times 50 \times 10^3 = 1/6.28 \times .5 \times 10^{-4}$

$X_C = 1/3.14 \times 10^{-4} = .318 \times 10^4$ or 3.18K

so; $I_1 = E/Z_1 = 50V/3.18K = 15.72$ mA

$I_2 = E/Z_2 = 50V/1K = 50$ mA

Now since this is NOT a simple *dc* circuit, these *currents add as vectors,* and so we proceed directly to the old square root equation:

$I_t = \sqrt{I_r^2 + I_c^2} = \sqrt{50^2 + 15.72^2} \times 10^{-3}$

$= \sqrt{2500 + 247} = \sqrt{2747} \times 10^{-3}$

$I_t = 52.4 \times 10^{-3}$

Securing the total current, the resultant can be drawn as in Fig. 13, but the phase angle should be calculated and, as usual, the cosine is used. Instead, however, of using Z, which is not now the resultant, it becomes the quantity below the line. Therefore:

$\cos\theta = I_r/I_t = I_2/I_T = 50 \times 10^{-3}/52.4 \times 10^{-3} = 0.105$

$\cos\theta = 83.97°$

. . . and this is the phase angle between voltage E and current I. If you wish, you may use the sine of θ and I_c/I_t and derive the same result.

To find the impedance, simply use Ohm's law:

$Z = E/I_t = 50V/52.4 \times 10^{-3} = .962 \times 10^3 = 962$ ohms

Rectangular solutions for this same impedance are not only possible but also useful in situations where conditions are not as straightforward as in the above example. And just as current cannot add arithmetically in parallel circuits, impedances cannot either; so the Zs are calculated in parallel just the same—and we need rectangular coordinates (polars can neither add not subtract) to do the job. Here, our individual impedances can be written:

$Z_1 = 3.18K$ or $Z_1 = 0 - j3.18K$

$Z_2 = 1K$ or $Z_2 = 1K + j0$ and $Z_t = Z_1Z_2/Z_1 + Z_2$

Consequently,

$Z_t = (1K + j0)\,(0 - j3.18K\,/(1K + j0) + (0 - j3.18K)$

$Z_t = -j3.18K^2/1K - j3.18K$

then you must take the *conjugate*—the means of matching one reactive circuit with another by mulitplying by its opposite complex reactance—and rationalize the denominator.

$Z_t = \dfrac{-j3.18K^2\,(1K + j3.18K)}{(1K - j3.18K)\,(1K + j3.18K)}$

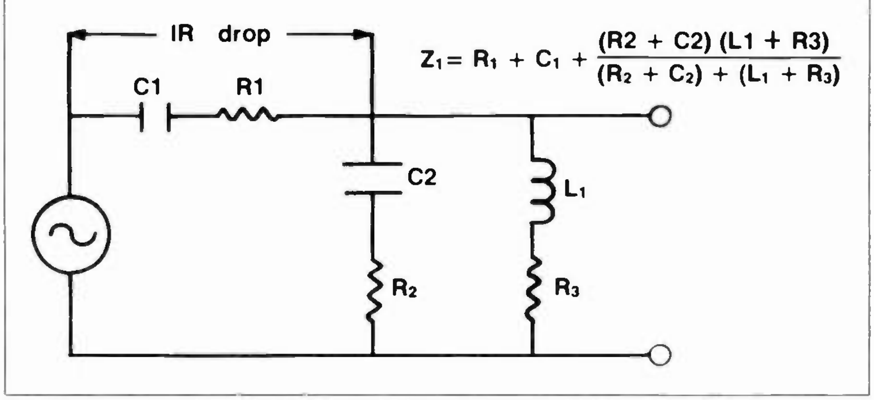


Fig. 18. How to go about calculating a true series parallel circuit. The C's, and L's, of course, must first be reduced to impedances before their vector addition or multiplication occurs.

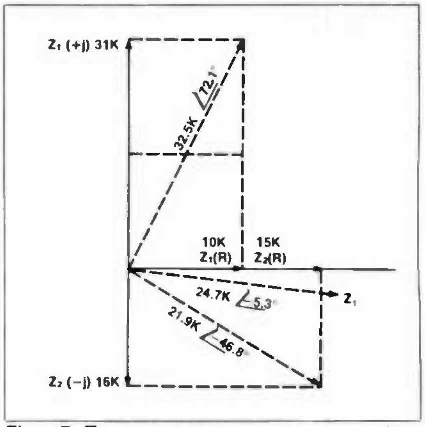


Fig. 17. The two series impedances in Fig. 16 become one. (The figure is not drawn to scale).

$= -j3.18K^3 - j^2 10.1K^3/K^2 - j^2 10.1K^2$

$= 10.1K - j3.18K/1 - (-)\ 10.1$ or $10.1K - j3.18K/11.1$

$Z_t = .91K - j.3K$

Or, in polar coordinates $\sqrt{.91^2 - j.3^2}$ (K) $= \sqrt{.8281 + .09}$ (K) $= .952K$ or 952 ohms

For slide rule accuracy, that comes pretty close to the 962 ohms originally calculated by the simple method—only 10 ohms difference. The phase angle, using the rectangular coordinates now becomes:

$\tan\theta = .3/.91 = .33$, or 18.5°

If you need a moral to rationalize these two ways of calculating the impedance totals, with their slight differences; it is always desirable, if possible, to use the simpler approach. Slide rule errors and arithmetic mistakes can and do make a difference. Obviously in almost 1,000 ohms, 10 ohms is not catastropic. But if the impedance had been 100 ohms, then the 10 ohms miscalculated could have meant a 10 percent difference in the response of the circuit, perhaps much more. Calculators, of course, will help equalize the probability of human error when complex methods have to be used.

Power factor, as usual, is the cosine θ: $R/Z_t = .91/.952$ (K)

$pf = \cos\theta = .957$ or 95.7%

An RL Parallel Circuit

An inductive-resistive circuit similar to the RC parallel combination described in the last paragraph is illustrated in Fig. 14, along with its vector waveform. The purist would describe both Figs. 13 and 14 as "upside down," but convention always shows X_C drawn downward and X_L upward, and a change here, even for the sake of current leads and lags, might be confusing . . . so it shan't be done. Apply clockwise operator j if logic must be overwhelming, or you could transpose the E, X_C and X_L axes and do the same thing using counterclockwise j. At any rate, we'll stand with what's laid out.

Of course, voltage is again the same value across both impedances and remains the constant or reference vector, and Ir has the same phase as voltage E (40V). So if, at a 20kHz frequency, the reactances assumed amounted to:
R = 1.5K and X_L = 7.5K, which becomes Z_1 and Z_2, respectively.
Then Ir = 40/1.5K = 25.7 ma and I_L = 40/7.5K = 5.34 ma

Now $Z_t = Z_1Z_2/Z_1 + Z_2$

and can be done by the simple method or by rectangular coordinates. To aid the reader, we'll again do the calculations by rectangular coordinates.
Z_t = (1.5 + j0) (0 + 7.5 k/ (1.5 + j0) K + (0 + j7.5) K

= j10.25/1.5 + j7.5 . . . K (multiply by conjugate)

= j10.25 (1.5 − j7.5)/(1.5 + j7.5) (1.5 − j7.5) . . . K

= j15.4 $-j^2$77/2.25 − $j^2$56.2 = 77 + j15.4/58.45

Z_t = 1.32 + j.264 . . . K

Then for phase angle,

Tan θ = .264/1.32 = .2 = 12.3°
or Cos θ = I_r/I_t
and $I_t = \sqrt{Ir^2 + IX_L} = 25.7^2 + 5.34^2$ (mA) $= \sqrt{688.7}$ = 26.2 mA

Then

I_t = 25.7 mA/26.2 mA = .982 and cos .980 = 11° + about 1

Not quite an exact check, but within about 1 degree nontheless, all slide rule accuracies.

RLC Parallel Circuits

In complex parallel circuits, just as in simple parallel circuits, the total current is always the vector sum of the individual branch currents, regardless of how many parallel elements are in series in each branch. The impedance of each, then, must be found, followed by its total impedance, then the rectangular or polar coordinates calculated to solve for phase angles and the remaining information. It's only necessary to remember that you're thinking in terms of currents and impedances rather than, in series circuits, voltages and impedances. As an example, if there are three or four single parallel impedances, the I subtotal current though each is the simple Ohm's law of each Z subtotal impedance divided into the constant (source) voltage. The total current is then the parallel sum of these impedances, as shown in Fig. 15, divided into the steady-state voltage. And it is found by the vector addition of the three currents shown:
$I_t = \sqrt{Ir^2 + (IX_L - IX_C)^2}$

Then the phase angle is simply cos θ = I_r/I_t
Let's carry this idea somewhat further and look at a series-parallel circuit with a full compliment of RCL components and an LC pair on the tag end for good measure.

RLC Series-Parallel Circuits

The new circuit is exhibited in Fig. 16 and has inductors and resistors in series as well as the possibility of another parallel LC circuit on the end. This will not be calculated, however, because Z_1 and then Z_2 would have to be seriesed and paralleled and then Z_t would then become the parallel impedance of Z_3 with that derived from manipulations of Z_1 and Z_2. So we'll just use that of Z_1 and Z_2 as sufficient illustration. With an R in Z_3, however, this would simply become a $jX_L - jX_C$, and the R term would amount to O. So if Z_3 became, for instance, j26K, then the entire term would become 0 ± j26K, depending on whether the inductance or capacitance prevailed in overall magnitude. Work it out for yourself, if you'd like to tackle three impedance equations as suggested in Fig. 15. It might not be as difficult as you think, just a little tedious. Here, at 100kHz, the X_L and X_C reactances are calculated as:
$X_L = 2\pi fL = 6.28 \times 10^5 \times 5 \times 10^{-3} = 31.4 \times 10^2$ or 34.1K

$X_C = 1/2\pi fC = 1/6.28 \times 10^5 \times 100 \times 10^{-12} = 1/.628 \times 10^{-4}$ =16K

$X_C = 1.59 \times 10^4$ = 15.9Kohms rounded off to 16K and 31K,

respectively for X_C and X_L
Now the series impedances are found by the straightforward polar method:

Z_1 = 10K + j31K $=\sqrt{100 + 961}$ = 32.5K

Z_2 = 15K − j16K $=\sqrt{225 + 256}$ = 21.9K

and the cos θ phase angles amount to:
R/Z_1 = 10K/32.5K = cos θ = .308 = 72.1°

R/Z_2=15K/21.9K = cos θ = .685 = 46.8°

This is a good comparison between resistance and series impedance: the greater the difference, the wider the phase angle; the less difference the smaller phase angle—and, as you see, either R or the final series impedance can be the decisive factor, since either frequency or the magnitude of R or jX can have a determining effect.

The parallel impedances of Z_1 and Z_2 with their resultant phase angles now need to be calculated so that the various currents through the impedances can be found. Of course, current in any one *branch* is also the series current and passes through both series resistance and reactance equally. Using the basic parallel equation:
$Z_t = Z_1Z_2/Z_1 + Z_2$

$$Z_t = \frac{32.5K\angle 72.1° \times 21.9K\angle -46.8°}{(10K + 15K + j31K - J16K)}$$

(polar coordinates divided by rectangular coordinates)

$$\frac{712K^2\angle 25.3°}{25K + j15K}$$

=

$$\frac{712K^2\angle 25.3°}{29.15K\angle 31°}$$

(Tan. j15K/25K = .6 and 31°)

Z_t=24.7K$\angle -5.3°$

In this instance, 31° brought from below the line becomes a negative phase angle, and this must then be subtracted from 25.3° to determine the final direction of Z_t whose magnitude has already been calculated as 24.7K. This same mechanical numerator-denominator arrangement holds also for currents and voltage drops across the reactances, if you wish phase

continued on page 52

CET Quiz, Part IV

Amplifiers, flip-flops and....

Here are more questions to shake your complacency and make you think about what you really know about electronics.

By Frank R. Egner, CET

If you have been working each of the electronic quizzes that have been appearing in ET/D, you have been getting a good review of many electronic fundamentals. You may be finding areas where you have become a bit rusty. A little review or study in those areas will build confidence and knowledge and will prepare you for the CET examinations.

To become a Certified Electronic Technician (CET), you must pass, with 75% or better, the associate CET exam of 75 questions covering electronic fundamentals plus one option exam. Options currently offered are: Consumer Electronics (radio and TV), Industrial Electronics, Communications, Audio, MATV, and Biomedical. Most options have 75 questions relating to that particular field of electronics.

You'll be proud to join the CETs who have proven their knowledge and competence in their field of electronics. Why not contact the Certification Administrator in your area for further information? Join the professionals!

Here's another quiz on electronic fundamentals. See how well you can do. 75% is a passing score.

For information on CET programs, contact ISCET or ETA-I at 2708 W. Berry St., Fort Worth, TX 76109 or 7046 Doris Drive, Indianapolis, IN 46224, respectively. Some of you might also be interested in NATESA's specialized, practical certification program for consumer electronics technicians. NATESA 5930 So. Pulaski Rd., Chicago, IL 60629.

1. A 3.9v zener diode is rated at 1 watt. The maximum current the diode can pass without exceeding its rated dissipation is:
   a. 256 ma.
   b. 25.6 ma.
   c. 2.56 ma.
   d. 2560 ma.

2. A varactor diode is connected in parallel with the resonant circuit of an oscillator to provide AFC. To increase the frequency of oscillation, the:
   a. Varactor forward bias must be increased.
   b. Varactor reverse bias must be decreased.
   c. Varactor forward bias must be decreased.
   d. Varactor reverse bias must be increased.

3. An oscilloscope is measuring a signal amplitude using the X10 probe. The beam deflects 4.6 divisions on the .005v/div range. The p-p signal amplitude is:
   a. 23 mv p-p.
   b. 0.23v p-p.
   c. 2300 mv p-p.
   d. 0.023v p-p.

4. A demodulator probe would most likely be used with the oscilloscope when observing or measuring:
   a. The composite video signal.
   b. The 3.58MHz color burst signal.
   c. The input signal at the video detector.
   d. The output signal of the video detector.

5. Resistance and reactance are measured in ohms but the reciprocal of ohms (1/ohms) is measured in mhos. Mho is the unit of measurement of:
   a. Flux density.
   b. Conductance.
   c. Permeability.
   d. Luminance.

6. The oscilloscope is a very versatile test instrument, but it's unable to directly measure:
   a. Waveform frequency.
   b. Effective ac voltages.
   c. Both positive and negative dc voltages.
   d. ac and dc voltages simultaneously.

Note: Questions 7 through 13 refer to figure 1.

7. Collector current, IC, of Q1 should measure:
   a. 0.5 ma.
   b. 5.0 ma.
   c. 50.0 ma.
   d. 500 μa.

8. The Q1 emitter voltage, Ve, will

measure:
a. 5000 mv.
b. 0.05 v.
c. 5.0 v.
d. 500 mv.

9. The voltage dropped across RL will set the collector voltage, Vc, at:
a. 9.5 v.
b. 5.0 v.
c. 4.5 v.
d. 1.1 v.

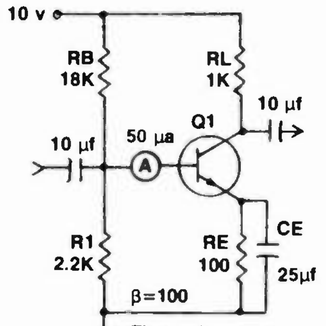


Figure 1

10. A sinewave input signal causes base current, Ib, to increase and decrease by 30 microamps. The signal at the output terminal will be:
a. 6v p-p and inverted.
b. 6v p-p and in phase.
c. 3v p-p and inverted.
d. 3v p-p and in phase.

11. A surge current has caused punch-through in Q1. This defect can be quickly detected because:
a. The output waveform will be distorted.
b. Base voltage will be reduced to zero volts.
c. Base voltage will increase to nearly Vcc.
d. Collector voltage will measure about 0.9 volts.

12. It is determined that Q1 is:
a. a germanium transistor.
b. A silicon transistor.
c. May be either silicon or germanium.
d. Can't be determined with info given.

13. While making tests in the circuit, the Q1 collector and emitter terminals are accidentally shorted together.
a. The transistor will not be damaged.
b. The transistor will be destroyed.
c. Base current increases dangerously.
d. Emitter resistor RE may burn out.

Note: Questions 14 through 19 refer to figure 2.

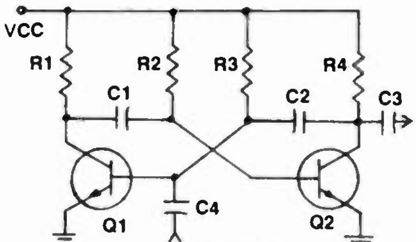


Figure 2

14. The circuit can be identified as a:
a. Cascaded RC coupled amplifier.
b. Monostable multivibrator.
c. Astable multivibrator.
d. Schmitt trigger.

15. The output waveform from C3 will be:
a. Rectangular.
b. Triangular.
c. Sinusoidal.
d. Depends on the input signal.

16. The output frequency is determined by:
a. The input signal frequency.
b. Time constants of C1/R1 and C2/R4.
c. The type of transistors used.
d. Time constants of C1/R2 and C2/R3.

17. If capacitor C1 becomes open:
a. Q1 turns off and Q2 stays on.
b. Both stages become saturated.
c. Q2 turns off and Q1 stays on.
d. The result is unpredictable.

18. To synchronize the circuit operation, the sync frequency should be:
a. Equal to the free-run frequency.
b. Slightly lower than the free-run frequency.
c. Slightly higher than the free-run frequency.
d. An odd-multiple of the free-run frequency.

19. To synchronize the circuit, the sync signal coupled through C4 should be:
a. A positive pulse.
b. A negative pulse.
c. A sinewave.
d. Any of the above.

20. To operate Class C, the bias on a transistor must set the operating point:
a. So the transistor will be driven to saturation.
b. At the zero collector current point.
c. Below the zero collector current point.
d. So the transistor both cuts-off and saturates.

21. Transistor audio amplifiers may only be operated Class B when:
a. The driving signal is very large.
b. They are connected in cascade.
c. Push-pull configuration is used.
d. They are connected in cascode.

22. A primary advantage of an FET over a bipolar transistor is:
a. Higher input impedance.
b. Lower input impedance.
c. Higher current gains are possible.
d. Higher power gain is possible.

23. An N channel junction FET (JFET):
a. Conducts drain current only when the gate is forward biased.
b. Conducts by hole current from drain to source.
c. Must have reverse bias on the source-gate junction for linear operation.
d. Operates linearly with either forward or reverse gate bias.

24. A dual-gate MOSFET amplifier can operate efficiently as:
a. A converter stage in a superheterodyne receiver.
b. An AGC controlled IF amplifier stage.
c. Both a and b are true.
d. Neither a nor b is true.

25. Which of the following most closely relates to a triode vacuum tube in its operation?
a. NPN transistor
b. N channel JFET.
c. PNP transistor
d. P channel MOSFET.

You'll find the answers on page 52

Semiconductor substitutions, Part I

Factors to Consider

Have you ever replaced a transistor with the substitute recommended in one of the replacement guides? Did it work—sort of—but not quite right? Here are some of the reasons why substitutes don't always work. The semiconductor guides are not infallible.

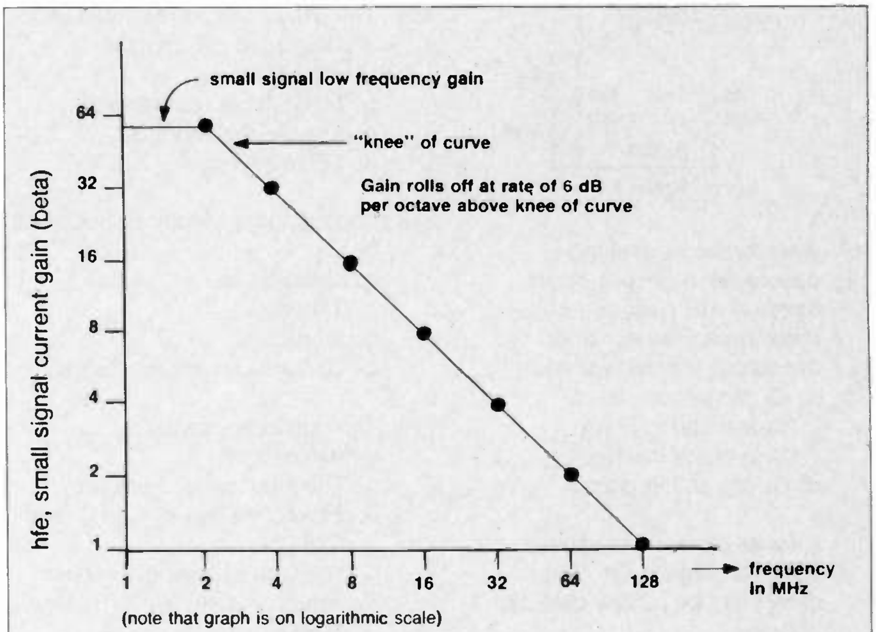
by Bernard B. Daien

For many years technicians have been making vacuum tube substitutions. More recently, semiconductor substitution manuals have become popular, like the older tube "subber" manuals. Unfortunately, semiconductor substitutes, like tube substitutes, don't always work out satisfactorily.

Of course there are reasons why this happens, but most of us don't bother to pursue those reasons . . . which results in repeating the same mistake over and over. Once you know the main factors affecting semiconductor substitution, you can avoid most of the problems.

Semiconductor substitution "detective work" is becoming an increasing factor in servicing, with many shops reporting as much time spent that way as in troubleshooting and actual repair! Thus there is a real incentive, in time and money, for learning the basics of substitution. Many shops are paying needlessly high prices for substitutes, because they have no confidence in their own ability to do the job, and therefore must rely on the recommendations in "subbers."

This article explains the basic facts regarding transistor substitutions, and is useful to anyone making such substitutions.



Transistor specifications for above graph

D.C. Large Signal Gain (H_{FE}) = 50 at 5.00 ma
Small Signal A.C. Gain (h_{FE}) = 60 (at low frequency)
F_T (frequency where gain falls to 1) = 128MHz

Fig. 1 Transistor gain/frequency characteristics.

Bipolar Transistors

This first article on semiconductor substitution is devoted to bipolar transistors, since they are the most commonly encountered devices, and also the least complex, and therefore a good starting point. Perhaps their very lack of complexity is what causes most of the problems in substituting, since technicians tend to treat them too lightly . . . and in order to deal with them, one must go back to the very basics . . . (which most of us have either ignored, or forgotten from lack of use!).

Before we go further it should be pointed out that semi-conductors come in two main categories . . . registered devices, which have 1N . . . , 2N . . . , 3N . . . , or 4N . . . numbers. No matter which manufacturer makes these devices they are the same in the essential characteristics registered. Then there are the the non-registered devices, sometimes referred to as "house numbers" because they are made to the specifications of the house which manufactures them. There is no obligation on the part of other manufacturers to duplicate their essential characteristics. Thus when you buy a house number you are relying upon the the word of the maker . . . perhaps the "advertising" of the maker would be more specific and accurate.

Even registered devices vary somewhat from maker to maker . . . but in general the major characteristics are well defined, while the lesser ones are often permitted to exceed in quality the specified problem, since sometimes "more" is not "better." Thus a transistor which has a better frequency response, may develop parasitic oscillations when used to replace a device with a narrower bandwidth. The narrow bandwidth semiconductor simply did not have enough gain at high frequencies to oscillate. The new device may now require parasitic suppressors of one sort or another to make the circuit stable.

Some Suggestions

This leads to a few simple rules: It is risky to replace transisitors in tuners in FM or TV sets with anything other than the original part, (if it can be obtained). It is better to wait for the original part, than make a quick fix with a substitute. AM broadcast receivers are not too critical and substitutes can usually be used with a high degree of success.

Since TV IFs run at 40MHz, it is advisable to use exact replacements, while FM and broadcast receiver IFs can often be substituted IN THOSE STAGES WHICH DO NOT HAVE AGC APPLIED. Whenever an AGCed stage is replaced it is good practice to use an exact replacement part. There are several reasons for this . . . first, AGC is accomplished in two different ways, "forward AGC" which increases the current through the device, or "starvation" AGC which reduces the current towards cut-off. These different AGC methods result in different effects . . . the input impedance is much higher with stravation AGC than with forward AGC. Similarly, the capacitances vary differently depending upon the way the device is made, and upon the AGC employed. This capacitance variation is very important; it is actually part of the set design, since it affects the IF response curve.

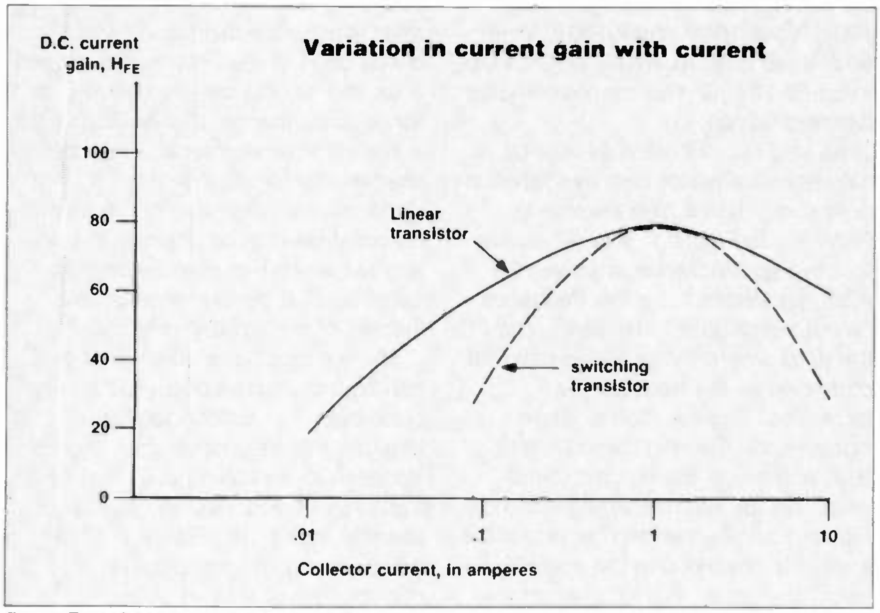


Fig. 2 Transistor current gain variation.

Generally, TV set makers want the response to "peak-up" (become triangular instead of flat-topped, as the signal gets weaker. This reduces the higher video frequencies (snow) on fringe signals. The loss of color is of no consequence since the color killer cuts off the color on weak signals in order to avoid "colored snow." If the transistor being AGCed has the wrong characteristics, the band width of the IF may actually increase on weak signals, accentuating the snow, and making weak signals worse. Even worse, the IF may oscillate, or refuse to permit a decent alignment after part substitution.

I vividly recall an RCA TV set which blew an AGCed IF transistor. I figured that if I used the RCA SK manual, and the recommended RCA substitution, it would be a safe substitution . . . all RCA. But the set wouldn't align, and oscillated. Upon replacing the device a second time . . . this time with the original part, it lined up and was stable on the first attempt.

Another reason for not using substitutes in the front end (tuner) section of receivers is that there is a little specification called "noise figure," which is the figure of merit of the device in such applications. The lower the noise figure, the better the device is . . . i.e., the less noise it contributes. Since the incoming signal is weakest in the tuner, and since any tuner generated noise is amplified by the rest of the amplifier stages in the set, it is essential that the noise figure of the semiconductors in the front end be as low as possible. Substitutes often do not even have specs on noise figure! Many set manufacturers buy their transistors to their own manufacturing specifications; the front end devices often are specially selected for low noise. Since the set maker buys in large quantities, he is able to get this extra service at little extra cost . . . but you can't! Again, use an original part.

Another area where indiscriminate substitutions can lead to odd problems is in high level video amplifiers, which must put out rather large signal swings. These stages have a variety of different frequencies to amplify simultaneously, and at high levels there is a strong tendency towards cross modulation and intermodulation, with the consequent generation of spurious frequencies (mixing action) due to non-linearity. Such stages are usually specified to have low non-linearity at high current and large signals. Again, you do not have access to such test results to aid in device selection, so it is better to use an original part.

The Original Is Not Available

Often, on private label brands, older sets, imported sets, or sets made by companies no longer in business, the original part is not available. In such cases the next best thing is to use a part from another manufacturer, which is used for similar application. Thus the high level video amplifier from an RCA set will probably work well in the high level video stage of another make of set, if the voltages are similar. Tuners are often quite similar . . . and in some cases identical, since some tuner manufacturers sell their products to several set makers. Some Japanese set makers provide sets to private label makers. There are often several sources of identical, or similar parts.

Remember, most of the substitutes shown in "subber" manuals have been made on the basis of theoretical "paper" comparisons, not actual operating tests, and therefore do not have a high degree of reliability in practical servicing.

There are some applications where you can make substitutions with a good degree of success however . . .

When You Can Substitute . . .

The audio amplifiers, sync separators, low level video amplifiers, low level chroma stages, voltage regulators, etc., are candidates for successful substitutions. All have certain things in common, . . . they do not deal with very low level signals requiring low noise figures . . . they do not deal with very high frequencies, . . . and they do not deal with very large signals. They can be described as "run-of-the-mill" applications, and as such, run-of-the-mill transistors will suffice. Since this is where most of your substitutions will be made, you can stock a few types of transistors, in fairly large quantities, taking the advantage of volume buys to keep prices down.

Long ago, most service shops discovered that it did not pay to buy rectifiers in varying voltages and amperages, although a 600 volt 1 amp rectifier is less expensive than a 1000 volt 3 amp rectifier. Practically all the TV shops buy, and stock, the 1000 volt 3 amp rectifier since it covers all TV power supply rectifier needs in tube type sets. (Of course that picture will change as the tube sets vanish and are replaced by the new solid state sets). Similarly, for a few pennies more, you can buy small signal silicon NPN and PNP transistors rated at 60 volts Vceo, and 500 ma Ic, with Fts of 100MHz or higher . . . and that is the equivalent of the 1000V 3 amp recitifier. In power transistors you may find most of your problems are in the different packages used, metal . . . a variety of plastic shapes, etc., . . . however, it would be safe to stock the metal T03 packages in NPN and PNP silicon types in a 80Vceo, 15 ampere type rated for 4MHz Ft, as a general purpose workhorse.

What's All This Vceo And Ft Stuff . . . ?

Now we must go back, briefly, to some transistor fundamentals. Transistor maximum voltage ratings are specified in different ways. Vceo is the rating with the base circuit open . . . the worst case, and the only one to use for servicing, where we always seem to deal with worse cases. Vcb is the rating using the collector and base junctions only, as a diode, and is the best case, and very optimistic. Vcer uses the transistor with a low value of resistor connected between base and emitter, and is also quite optimistic. Vces is with a dead short between base and emitter, and is the same as Vcb. Vcex actually puts a reverse bias between the base and emitter, and is useful only in switching applications. The way a typical transistor's ratings might vary, depending upon which of the above is used, would be: Vcb 100V, Vces 100V, Vcex 100V, Vcer 80V, Vceo 60V. ALWAYS LOOK FOR Vceo RATINGS. You cannot compare different ratings.

As for Ft . . . Ft is the frequency where the transistor beta has fallen to unity (one). It is a high frequency. Referring to Figure 1, you will notice that two specifications are given for most transistors . . . a low frequency "small signal gain," hfe (beta), and Ft, the point where the gain has dropped off to one as the frequency is increased. There is also a "large signal" gain, given in capital letters, HFE, and this is the dc gain (beta) which we are not concerned with now. Figure 1 shows the gain curve, for the transistor described in the specs below the graph. We'll disregard the dc gain, but use the small signal gain spec to establish the low frequency gain. We put Ft at the current gain point of "one" on our graph, and then work backwards, knowing that the current gain will double each time we cut the frequency in half. In this case, with an Ft of 128MHz, the gain (beta) is "one," therefore at 64MHz the gain will be two, at 32MHz 4, at 16MHz 8, at 8MHz 16, 4MHz 32, etc., until we reach the low frequency small signal gain point of 60 which occurs at about 2MHz, and then the gain remains flat as the frequency is lowered. Stated another way, the "knee" of the response curve is 2MHz, and rolls off at the higher frequencies at the rate of 6 decibels per octave.

This educational graph also tells us that Ft is not a very practical figure in our business, since we rarely deal with an ampilifier stage with a current gain of unity! As a matter of fact, if you wish to deal with a 40MHz IF stage, you had better use a transistor rated for around 400MHz, since the gain will only be a little over 8 at 40MHz (you figure it out now that you know how!). Likewise a TV tuner running at 200MHz will require transistors with Fts around 1200MHz to have to have useful gain at the frequency of operation!

I can almost hear some of you saying, "I don't have any real problems with transistor substitutions . . . most of the time they run smoothly" . . . but it's one thing to say that it "works" and another thing to be able to state that the set still meets original performance specs. Too many sets that "work" are snowy on weak signals, do not perform right on very strong signals, etc. Do you test your sets on weak and very strong signals after making a substitution? Most shops don't. If the shop is in a fringe area, the work is usually checked for fringe performance, otherwise not. If in a cable TV service area, it may be checked for strong signal performance, otherwise not. It should be considered good practice to give any set which has semiconductors substituted, a performance check, instead of an "eyeball checkout."

Many shops have discovered that certain transistors appear to be very good buys . . . unfortunately the cheaper transistors are often those intended for switching use. Switching transistors are not usually tested for linearity, noise, etc. Figure 2 shows the current gain versus collector current curves, for two power transistors, one a switching transistor, the other a linear amplifier. Note that the gain of the switching device drops off at both low and high currents. This is of no consequence in switching applications where the transistor is used either fully on, or fully off, and the drive is more than adequate to insure the transistor being full on. In linear applications, the variation of betas will certainly result in severe distortion, unless a very large amount of inverse feedback is used around the stage.

The above examples were given to make you aware of the problems inherent in transistor substitution . . . but there are more. Problems can arise going in the other direction too . . . using a linear transistor to replace a switching transistor, as in horizontal deflection circuits, where rapid rise and fall times must be accommodated in order to meet the horizontal sweep requirements. If the device used, switches too slowly, the device dissipation will be very high, and the performance poor. Switching transistors are well characterized in rise and fall times, whereas linear devices are not. Many of the better linear transistors can handle fast switching, but may not be able to handle the high voltages inherent in deflection circuits, so once again you may well be ahead of the game by using an original part, designed and characterized for the specific application.

Figure 2 has a few more implications for you. Supposing you are using a complementary symmetry output stage, so popular these days in high fidelity and deflection circuits. The biasing is fairly critical in these circuits, and prevents crossover distortion. Now if you look at the way the current gain falls off at low currents, you will quickly realize that the biasing required to produce the same collector current, is quite different for the two typical transistors shown. Using a switching transistor will radically alter the quiescent collector current, defeating the circuit design insofar as biasing is concerned.

Other Devices . . .

Even considering bipolar devices only, every three terminal device is not a transistor in the ordinary sense of the word. Darlington transistors are coming on strong . . . and they have only three terminals. If you have a good Darlington, you can spot it by the fact that there are two diode "voltage drops" in series between the base and emitter . . . but only too often the device being replaced is defective and cannot be measured. Replacing a Darlington with a conventional power transistor often results in the set working . . . but not properly, due to lack of gain. Darlingtons have gains running from 750 to several thousand . . . significantly higher than a transistor, but other than that, they often appear to be interchangeable in many circuits . . . again a case of "working", but not meeting original performance specifications. Be on the lookout for this one, as many set makers use Darlingtons with house numbers on them. One clue is to check the bias voltage with a low current drain voltmeter. Darlingtons use twice the normal bias voltage.

Another indicator is the bias current . . . Darlingtons have less than a tenth of the bias current you would expect to find. Finally, if you have a schematic diagram (which often merely shows a conventional transistor), the input and output signal amplitudes will indicate a greater signal gain for the stage than you would normally expect to find. Transistor listings often carry Darlingtons simply as "transistor" . . . which can mislead you completely.

What About Diodes?

Diodes are bipolar devices too, and deserve a word here. With the advent of solid state apparatus came low voltage power supplies, and as a result, the rectifier diode drop is now one of the major sources of power loss. The twelve volt systems used in automobiles have much the same problem, as a result alternator diodes are now of the Schottky type, which have significantly lower forward voltage drop than ordinary silicon diodes. Replacing such diodes with ordinary diodes result in enough heat at full load to destroy the rectifier. These Schottky diodes are now used in many low voltage supplies in apparatus, and you have to be on the lookout for them. They are not ordinarily used in applications where the reverse voltage approached 100 volts, since they are essentially low voltage devices.

Fast switching diodes are used in horizontal deflection circuits in TV sets, as dampers, and as scan recitified power supply devices. They are also used in high frequency power supplies in the usual range of 20kHz to 40kHz. Although occasionally one hears of a technician successfully using an ordinary silicon rectifier in such circuits, the fact is that most silicon rectifiers cannot work in these circuits due to slow turn on and turn off times. Some manufacturers simply make certain diodes which substantially exceed the specification in speed, and which can be marginally suitable for this service. However the situation can change, and the manufacturer is under no obligation to continue making a product that exceeds his specifications. The same type of rectifier made by another source, or a different lot from the same source, may not work. The only safe route is to use a rectifier characterized for high frequency use, and they usually cost more.

Coming

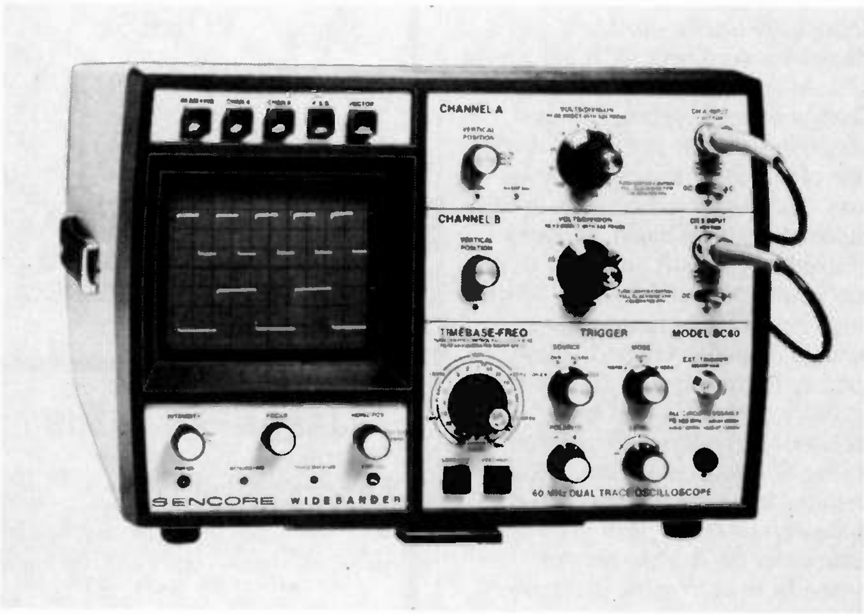
The next article in this series will cover FETs, TV high voltage rectifier assemblies, and, briefly, Silicon Controlled Rectifiers. ET/D

TEST INSTRUMENT REPORT

Sencore's SC60 Oscilloscope

Useful to 100MHz.

by Walter H. Schwartz



The Sencore SC 60MHz Oscilloscope.
For more information circle 150 on the reader service card.

What do you do with a 60MHz scope? Obviously you can see frequencies well into the VHF range—so what? Well, first with the increasing clock frequencies and faster pulses in microprocessor and other digital circuitry you want to be able to see rather fast square waves and other fast rise time pulses. To properly view a high frequency square wave an oscilloscope must have a bandwidth several times the fundamental frequency of the waveforms displayed—to five or seven times it for good waveform accuracy.

With clock frequencies going to 50MHz or higher a widebandscope is becoming quite necessary. Many of the pulses you will find in digital circuitry are equivalent to fundamental frequencies in the 12-15MHz region requiring a scope with response to 75 or 90MHz. Sencore specifies the SC 60 vertical amplifiers to be 3dB down at 60MHz, 6dB down at 80MHz and 12dB down at 100MHz, with a rise time of 6 nanoseconds. Tests with a calibrated output signal generator confirmed these specifications.

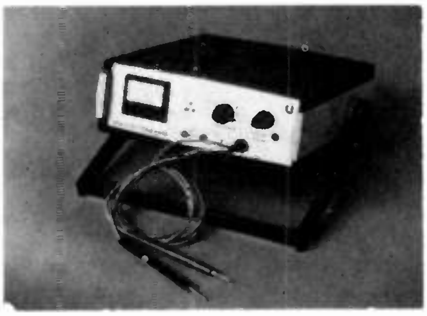
What does this mean in TV servicing? In most cases not a great deal—but it will allow you to observe signals, assuming sufficient amplitude, in the 44MHz video IF. It is very nice to be able to look at both the input and output of the video detector—and you might not realize it but the signal levels in most of the IF's are of adequate amplitude for observation. The alternative is, of course, a demodulator probe, which because of cable and scope input capacitance, really shows nothing but sync pulses—all video is lost. The 60MHz response will also allow excellent, and easy, modulation checking of CB and ham, AM and SSB transmitters thru 54 MHz.

The SC 60 offers most of the features you now probably expect in a general purpose oscilloscope. Besides its 60MHz frequency response it is dual trace (and a vector scope with well matched X and Y channels), has sweep speeds commensurate with its frequency response—and has a X10 expansion of the sweep. The maximum vertical sensitivity is 5mv per division. The input attenuators are calibrated beginning at 0.05v, 50mv, to be direct reading with the X10 probes in use. Trigger can be from either channel A or channel B or from the line or an external source. The SC 60 also has a video preset position on the timebase control and when this is used either vertical or horizontal can be selected by pushbutton switches. In spite of Sencore's statements about the SC 60's trigger circuits, I found it no easier or *harder* to trigger than most other good quality scopes. When viewing waveforms in video IF amplifiers I found it most satisfactory to trigger externally from a horizontal sweep source. (External trigger can simplify triggering in many cases.) A feature that finds particular favor with me is the probes, rated at 2kv. These have more than 3 times the safety factor and input capability of most other scope probes. It is quite useful to be able to look at a horizontal output transistor collector waveform, which may be nearly 1kv p-p.

Are there any disadvantages to such a wideband scope? Not many—a wideband vertical amplifier may generate a little more internal noise resulting in a trace that doesn't appear to be quite as sharp as it could be. It does not seem to really make much difference in operation. You may also pick up your local FM station or some other source of RF and if you do not realize what you have it can be confusing—a minimum length ground on the probe helps.

The panel layout of the SC 60 is very convenient—wide spaced knobs—full sized push buttons, etc.—and there is no problem with clumsy fingers. Sencor provides good manuals with all its instruments; the SC 60 manual is typical. The SC 60 comes complete with two probes in a very nice storage compartment for $1895. **ETD**

NEW PRODUCTS



Audio Shorts Locator

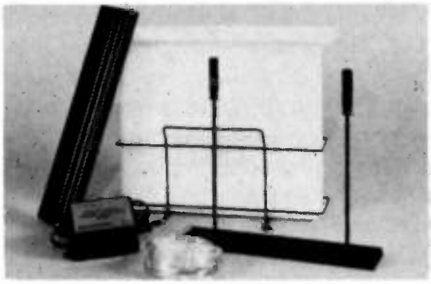
Circle No. 130 on Reader Inquiry Card

Three Phoenix Company's audio shorts locator, the 3PX210 Toneohm, is now available. An audio tone is produced that is frequency dependent upon the resistance between two hand-held probes that locates short circuit faults without disconnecting associated wiring or components. Once the short is located on the PCB, the operator merely reads the resistance on the milliohmeter. The 3PX210 Toneohm reportedly is capable of picking up microscopic, non-visible shorts within seconds. In addition to pinpointing PCB solder and land bridge shorts, the Toneohm can also be used to measure resistance of electrical connections, relay contacts and transformer windings. The price of the Toneohm is $595.

PC Board Power Etching System

Circle No. 131 on Reader Inquiry Card

GC Electronics recently introduced the Professional PC Board Power Etching System. The system includes an etching tank, pump, and heater, and is designed to handle two single-or double-sided boards up to 8″ × 10″ at the same time. The basic tank system, GC Cat. No. 22-394, includes a 1.25 gallon molded polyethylene tank with lid, agitating pump, hose, wire base, PC board holder, and instructions. The base can be mounted on a bench, left portable, or mounted as a bench well. The pump keeps acid agitating for faster, more even etching. PC boards fit into submersible rack with handles that keeps boards separate and hands away from the acid. The tank lid can also be used as an auxilliary lab



tray. The Etching Solution Heater, GC Cat. No. 22-392, greatly reduces etching time. The heater easily attaches to tank, and its thermostat quickly adjusts to solution temperature. Replacement hose and pump diaphragm are also available.

Portable Field Service PCB Repair System

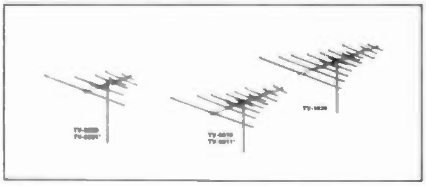
Circle No. 132 on Reader Inquiry Card

Pace, Incorporated has just announced the new Pace Micro™, reportedly the first fully self-contained, completely portable system for PCB repair in the field. Designed specifically for use by repair and field service organizations, it provides a highly portable and lightweight (4-1/2 lbs.) system to perform rapid component removal and replacement in the field, service center or in a van. The system's design permits it to be carried by hand or in a tool case along with a full complement of tools. A single handpiece performs both desoldering and soldering operations using interchangeable tips, with full temperature regulation. The Micro can operate from either standard ac line sources or from 12 vdc power. Its internal, fast-rise vacuum pump is finger-actuated, permitting one-handed operation. The unit warms-up ready for use in under a minute, and is said to be completely spike-free, making it safe for use with static-sensitive (MOS type) components.

Outdoor Antenna Line

Circle No. 133 on Reader Inquiry Card

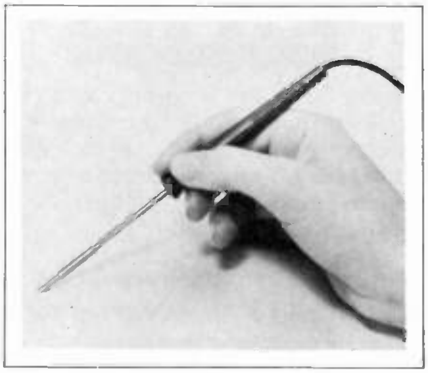
Winegard Company has introduced TV Man, a new line of antennas designed to replace Winegard's Gold-Star, Color Beam and Premier antennas. TV Man is a complete line of VHF/FM, VHF/UHF/FM, and UHF antennas. There are 7 UHF/FM models including two do-it-yourself kits; 11 VHF/UHF/FM models including 3 kits; 2 FM antennas including 1 kit; 1 UHF and 1 VHF antenna and an RV and Scanner antenna. New features of the TV Man antenna line include: a new UHF tetrapole driven element design to provide no-loss coupling between VHF and UHF sections; corner reflectors on two models for greater capture area and utilization of the tetrapole; split boom on several larger VHF/UHF/FM flat-line models so they can be shipped UPS and take up less inventory space; and 82-channel models featuring a full-wave director on the hi-band to increase gain and capture area. In addition all 82-channel models include a free VHF/UHF band separator. A special TV Man brochure illustrating the line is available.



Low Voltage Miniature Soldering Iron

Circle No. 134 on Reader Inquiry Card

Mitchell Hughes Company has introduced its new series GGI Model 14 Miniature Soldering Iron which operates on 6 v, weighs 1/4 oz and provides normal tip temperatures from 360° to 460° C. Although compact in design, the iron's wide range of interchangeable tips allows it to fulfill most soldering operations. The Model 14 features a stainless steel stem which reduces heat conduction back to its self-extinguishing, molded plastic handle. The soldering iron, and specified tip, come ready for immediate use with Mitchell's low voltage transformer, part number 54204T. Catalog available upon request.



Field Strength Meter

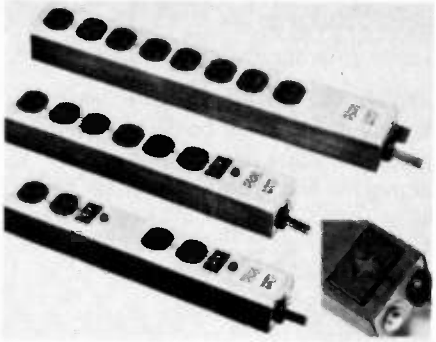
Circle No. 135 on Reader Inquiry Card

PTS introduces a new Mezzer Mark-12 UHF/VHF Field Strength Meter for installing and servicing TV antenna systems. The Mezzer Mark-12 features 12-position detent VHF tuning and 70-position detent UHF tuning. Designed for ac or dc operation, the Mark-12 has a detachable line cord and self-contained nickel cadmium batteries that automatically recharge anytime the unit is plugged in. The size of the Mark-12 is 8-1/2″ wide × 10″ long × 3-3/4″ high.

Multiple Outlet Strips

Circle No. 136 on Reader Inquiry Card

Sockets Plus is a new line of multiple outlet strips just introduced by *Perma Power Electronics, Inc.* Sockets Plus provides additional protected power outlets needed to satisfy diverse power applications in homes, business and industry. Models are available with three to eight 3-wire U-ground outlets, various combinations of control switches with indicator lights, and 6 or 12 foot heavy duty power cords. U.L. listed models have circuit breaker protection to guard against overloading circuits: some also have ground fault protection. Other models are fuse protected. All units exceed the requirements of the NEC and OSHA. They are rated at 1875 watts. All units have a 1 year limited warranty. *Perma Power* offers Sockets Plus in three model groups . . . industrial, residential and commercial. The industrial group units are designed for hard use and versatile applications. The case has a zinc phosphate undercoat treatment, the top has an electrostatically baked



silver enamel finish, and the sides black 14 mil heavy duty vinyl. The industrial units are designed for use in auxiliary work stations, assembly lines, machine shop areas and test and engineering areas. The residential units feature a honey-beige enamel finish with wood grain vinyl sides and are designed for the kitchen counter, home workshop, laundry room or hi-fi center. The commercial group units are intended for applications where moderate price, versatility and styling are important. They are equally practical for office machines, lighting controls, displays, meetings, demonstrations and educational sessions.

Business Machine Repair Kit

Circle No. 137 on Reader Inquiry Card

Jensen Tools Inc., has developed a new kit for the business machine service technician. Designated the JTK-7VT View-Tronic, it features a self contained, micro-fiche viewing system in a two-pallet case. It reportedly eliminates the need for carrying bulky repair manuals while making in-the-field repairs on all types of business machines. The JTK-7VT contains more than 100 tools, including pliers, screwdrivers, nutdrivers, wrenches, hex keys, measuring tools and soldering equipment. Extra pouches and room in the bottom of the case are provided to hold additional tools of your own choice.

Portable 4-1/2 Digit Multimeter

Circle No. 138 on Reader Inquiry Card

Data Precision has recently introduced its new Model 255 4-1/2 digit portable DMM. Model 255 features include five measurement ranges for each of the five functions, a large, high-contrast LCD display and an internal Nicad battery pack that will reportedly operate the unit for up to 100 hours between charges. The Model 255 will measure up to 1000 dc volts with a basic accuracy said to be 0.03%. Ac voltage range is from 10μv to 5000v. Ac and dc current are measurable from 10nA to 2A and resistance from 0.1Ω to 20MΩ. Both ac voltage and current are measured with an "Average sensing" technique which has full accuracy from 50-5000Hz and an extended range to more than 2.5kHz. The Model 255 weighs less than 1.3 pounds and measures 5-1/4" × 1-1/2" × 3-1/2". All 25 ranges are selected with two front panel rotary switches, one to set the function and the second for the desired measurement range. The Model 255 has been designed to accept any of the Data Precision accessories that can increase its range to 1000 amps, 40k volts or from -50°C to +800°C when measuring temperature. The Model 255 is forgiving of circuit malfunction and operator error; protection is provided up to 1000 volts on all voltage ranges, up to 250 volts for resistance measurements. An internal 2-amp fuse protects current measurement on any range to the maximum current capability of the multimeter. In addition, a special internal safety circuit is incorporated to increase the instrument's ability to withstand overloads and protect the operator. The price of the 255 is $279 and includes the rechargeable battery pack, test leads, carrying case, and a recharger which also allows operation from ac while the instrument is in use. ET/D

AC Theory

continued from page 41

angles. The voltage, however, is 0, so any phase angle below the line is just itself with a reverse sign when above the line is zero. For instance:

$$I_t = E/Z_t = \frac{50V\angle 0}{24.7K\angle -5.3°} =$$

$2.025\ ma\angle 5.3°$

$I_1 = E/Z_1 = 50V/32.5K\angle 72.1° = 1.54ma\angle -72.1$

$I_2 = E/Z_2 = 50V/21.9K\angle -46.8° = 2.28ma\angle 46.8$

The IR, IX_L, IX_C voltage drops can then be found by multiplying the currents through each impedance by the reactance of the impedance, and the phase angles found similarly except to remember that the inductor has a +90° phase angle, and the capacitor a −90° phase angle. So they will add to or subtract from each current accordingly.
As an example:

$E_C = I_2X_C = 2.28 \times 10^{-3}\angle 46.8° \times 16K\angle -90°$

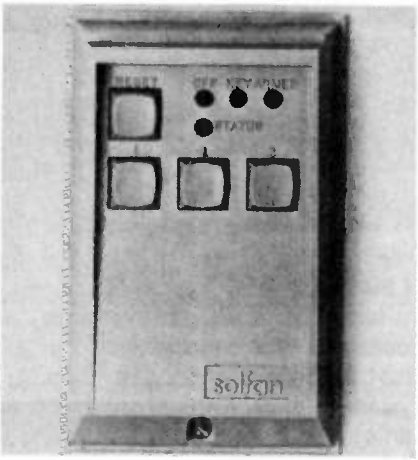
$= 36.5V\angle -43.2°$

Work out the remainder for an exercise, and draw the vector diagrams also, if you wish. You would approach a true series-parallel circuit as shown in Fig. 3-18, adding the resistances and reactances of the series components first, then paralleling the remainder. Remember, however, there would always be a voltage drop across R1 and C1, so the steady voltage for C_2, L_1, R_2, R_3 would be somewhat less than the E generator voltage at the origin. **ETD**

Electronic Quiz Solution

1. a.	6. a.	11. d.	16. d.	21. c.
2. d.	7. b.	12. b.	17. b.	22. a.
3. b.	8. d.	13. a.	18. c.	23. c.
4. c.	9. b.	14. c.	19. d.	24. c.
5. b.	10. a.	15. a.	20. c.	25. b.

SECURITY PRODUCTS



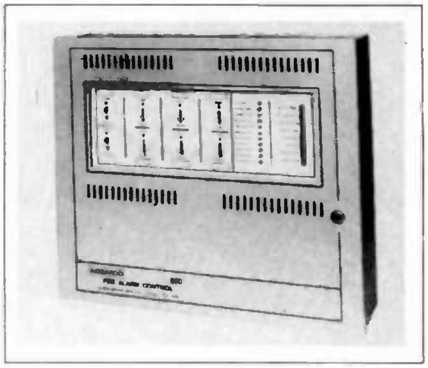
Digital Remote Control

Circle No. 144 on Reader Inquiry Card

The Model 1510 remote digital access station from *Solfan* is designed for use with the Solfan Model 1500 residential alarm control panel or any other alarm control panel that utilizes a momentary closure for arming and disarming. The unit uses a 12 volt dc input and produces a one-second momentary closure output each time the correct code is entered. Four LED indicator lamps give position readouts on the alarm system's status. The "OFF" LED indicates that the system is disarmed and the "ARMED" LED tells that the system is armed. A "STATUS" LED indicates that a protection loop is open. The "KEY" LED indicates each time a key is depressed hard enough to enter a code number. The four key digital access system is used by entering the correct code to arm and disarm the system. To change the status of the system from "ARMED" to "OFF" (disarmed) the "RESET" button is pushed first, followed by the numbered keys being pushed in correct sequence. To arm the system, depress the "RESET" button first, then depress the numbered keys in the proper sequence. To determine the proper code for a Model 1510, observe the lettering on the code module plugged into the internal printed circuit board just below the tamper switch inside the unit. There will be a series of numbers on the module. The first number will be the number of entries in the code, and the subsequent numbers will be the proper code sequence. For example: 6113213 indicates a 6 digit code where button number 1 is hit twice, then number 3, then number 2, number 1, then finally number 3. If "RESET" was hit before this sequence, then the system will have changed status. Codes of from one to seven digits are available to give up to 800 different code combinations. To change the code on a Model 1510, simply pull out the code module and replace it with another.

Fire Control Panel

Circle No. 145 on Reader Inquiry Card



Ademco introduces its 24-volt modular fire control panel, the No. 880. The No. 880 is a 24-volt dc modular automatic fire alarm system supplied in a surface mount cabinet with removable door. The system is supplied with a main circuit board which accommodates many different plug-in printed circuit boards. Connection points are gold plated for maximum reliability. Two 12-volt 5 ampere hour field lead acid batteries are supplied with the system. The 24-volt outlet can be used to power two and four wire smoke detectors. The heart of the No. 880 is a master control board that is designed to accept standard control function modules and cards. The basic system comes supplied with two zones of fire detection. By plugging in additional zone cards, the No. 880 may be expanded to an eight zone system. Each of the double zone cards has provisions for either class A or class B detection circuit wiring. The switch card allows personnel to alter the system status for a test function. The switch card contains the following self-explanatory functional switches: bell disconnect, auxiliary disconnect, remote station, trouble silence, system reset, lamp test, bell test, and general alarm. Also built into this card is a system trouble buzzer. The system indicator card contains a number of LEDs to report the following conditions: ac power, system alarm, system trouble, bell trouble, remote station, municipal box trouble, auxiliary relay trouble, battery trouble, ground fault (both positive and negative)

Circle No. 111 on Reader Inquiry Card

and system interlock. The system alarm LED is red and flashes an alarm condition. All other LEDs are amber and are normally off when the 880 is functioning.

Low Light Level TV Lenses

Circle No. 146 on Reader Inquiry Card

Lenzar Optics Corporation has announced a series of Auto-Iris Lenses for low light level cameras. The units all use use the same construction—a hollow core servo motor with a moving magnet armature. The drive electronics is contained on two integrated chips and the iris is said to be able to go from full open to full close in .2 seconds. A series of

ten standard ratings are offered from 9mm to 150mm in addition to four pinhole models. Documented test results can be furnished showing operation from −30° to +140° F.

New Digital Lock

Circle No. 147 on Reader Inquiry Card

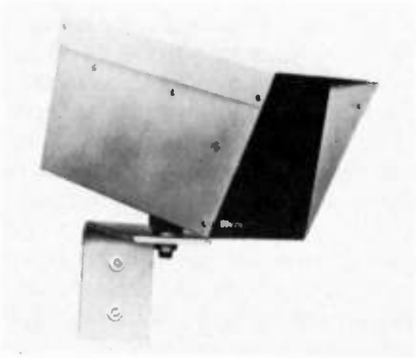
United Security has recently announced that it will market a new pushbutton digital lock which can be used to operate an alarm system or an access control system. The USP Digital Lock reportedly employs state-of-the-art electronics to provide a high security combination lock for use with burglar alarms and access control systems. The new lock is available in both Momentary (DL-767) and Latching (DL-767L) models. A key feature is a 9 digit keyboard which incorporates over 3,000 different combination changes. The combination changes can be made in the field, by simply relocating color-coded jumpers. A quick-disconnect plug for external wiring further simplifies field service. The USP Digital Lock is 3 1/2" wide by 4 1/2" high by 15/16" deep. It can be mounted either inside or outside the

premises, and when activated by entry of the proper four digit combination on the face plate, it momentarily relases the door strike, allowing entry. The lock can also be used to arm or disarm a security system, or momentarily shunt a protection system for access. Other features of the new lock include: wrong number lockout, which delays operation for several seconds if an improper code sequence in entered: changeable output, and versatile flush/surface mount. The lock is completely self-contained, requiring only low power dc for operation, and contains two LED's which can monitor 6 to 15 vdc system status, etc.

Microwave System

Circle No. 148 on Reader Inquiry Card

A new and shorter version of the 13000 model has been added to *Racon's* product line. The Racon 13000-Short is an indoor and outdoor microwave system, available in various range configurations from 75 feet to 350 feet. The system includes a transmitter and a receiver which are RFI and line surge protected. Its protection zone width is adjustable from 1 to 40 feet depending on zone length. Also, beam break, dynamic multipath and frequency jamming methods are used for detection. Unlike the regular 13000, this model does not require a post for installation. Instead, both transmitter and receiver can be installed with a swivel wall mounting



bracket for both indoor and outdoor situations. The 13000-Short is completely enclosed in an aluminum enclosure with built-in standby power supplies. Through signal processing circuitry, nuisance alarms from power fluctuations and random movement are minimized. Temperature changes, humidity, rain or snow reportedly do not affect operation. The Racon 13000-Short comes complete with transmitter, receiver, standby batteries, Class 2 transformers, mounting hardware and installation/operation manual.

Color Video Access Control

Circle No. 149 on Reader Inquiry Card

The Twinguard TG 8000 is a full color CCTV personnel access control system now available from *Visual Methods Incorporated.* A single guard at a master console can now view and control many entrances. The security guard simultaneously sees a color picture of the person desiring entry and a close-up image in color of the person's ID card on the color monitor. Full natural color enhances comparison of personnel and color ID photograph. Color coded photograph backgrounds permit the guard to identify personnel according to security classification. Present electronic cards also can be interfaced to increase security. The monitor presentation can be recorded on a cassette video tape recorder for permanent access record. The new TG 8000 color Twinguard is 5-1/4 in. deep by 21 in. wide and 24 in. high. The system has internal lighting for the person's face and ID card. Neither special lighting nor complicated color adjustments are required. ET/D

CLASSIFIED

RATES: 50 cents per word (minimum charge, $15). Bold face word or words in all capital letters charged at 65 cents per word. Boxed or display ads charged at $60 per column inch (one inch minimum). Agency commissions will be given only when camera-ready art is provided by agency. For ads using blind box number, add $5 to total cost of ad. Send ad copy with payment to Dawn Anderson, ELECTRONIC TECHNICIAN/DEALER, 1 East First Street, Duluth, MN 55802.

BOX NUMBER REPLIES: Mail box number replies to: ELECTRONIC TECHNICIAN/DEALER, Classified Ad Department, 120 W. 2nd St., Duluth, MN 55802. Please include box number in address.

FOR SALE

STEPPER motor evaluation kit contains quality Airpax stepper motor (960 steps/rev), versatile driver control board for manual or computer operation, and instruction handbook. Ideal for robot builders, computer hobbyists, experimenters, etc. $74.69 postpaid. Call or write **SPARKY ELECTRONIC SYSTEMS, INC.,** Dept. 64-62A Dry Harbor Road, Middle Village, NY 11379. 212-894-3000.

SONY-PANASONIC-RCA-ZENITH-EXACT REPLACEMENT PARTS-LARGE INVENTORIES-SEND PART OR MODEL NUMBERS-WILL UPS OR COD-GREEN TELE RADIO DISTRIBUTORS, 172 SUNRISE HIGHWAY, ROCKVILLE CENTRE, N.Y. 11570. TF

DECODER KIT, TV, (sine wave encoder system) Los Angeles chan. 52, Chicago chan. 44, Detroit chan. 20, Florida chan. 50, etc. Latest model, complete kit $139 plus 5% shipping & handling. Catalog free. Write Simple Simon Electronic Kits, 11852 S. Hawthorne Blvd., Hawthorne, CA 90250. Tel. (213) 675-2335. VISA/Mastercharge acceptable.

TUBES—Receiving, Industrial and Semiconductors, factory boxed. Free price list. Low, low prices. **TRANSLETERONIC INC.** 1365-39th Street, Brooklyn, N.Y. 11218E 800-221-5802, 212-633-2800.

POWERFUL universal **CRT** tester/rejuvenator. Simple Circuit, cheap parts! Plans, trade secrets to bring back the "dead" ones! $2.00. **ROBINSON,** 510 Granada Pkwy., Lindenhurst, New York 11757.

TV TROUBLE ANALYSIS TIPS. Over 300 symptoms/remedies by circuit area. Tough ones I found in years of servicing. e.g. Poor sync-C66 shorted-Wards-GEN-12349A-SAMS 995-2. Save time and money. Due to demand, send only $12.50 to CHAN TV, 8151 Grandview Rd., Chanhassen, MN 55317.

SCRAMBLED-TV WHAT IT IS-HOW IT WORKS. New publication explains how the two encoding/decoding systems used today work. Theory, circuits, etc. Send $9.95 to: Workshop, Box 393ETI, Bethpage, NY 11714 TF

SURPLUS ELECTRONIC PARTS-TELEVISION, RADIO, HIFI. Transistors-miniature electrolytics-twist lock FP-speakers-miniature lamps-diamond needles-CB cable assemblies. Call or write Norfolk Electronics (for our up-to-date bargain sheets.), 55 Railroad Avenue, Garnerville, NY 10923. (914) 947-1501/1502.

UNUSUAL electrical, electronic testers. Analog, digital and indicators. Hobbyist, professional. Free catalog. BLUFFTON PRODUCTS, INC., 115 Poplar Road, Bluffton, OH 45817.

AUDIO AMPLIFIERS, 35 to 150 Watts RMS. Complete design manual, $12.50. Includes PC board layouts. Audio Engineering Company, P.O. Box 210, Alda, NE 68810.

SURPLUS catalog 8,000 items: electronics, stereos, speakers, alarms, tools, games, solar autohome, 8 issues $2.00. BNF (ET), 119 Foster St., Peabody, MA 01960.

LEARN Microcomputers on your own computer. Send $5.00 for 2 complete instruction manuals. PACCOM, 14905 NE 40th, Dept. ET 120, Redmond, WA 98052.

PRINTED circuit boards from sketch or artwork. Kit projects. Free details. DANOCINTHS, INC., Box 261, Westland, MI 48185.

SYLVANIA CK 3000 TV TEST JIG with many extra adapters, B&K 1077B Analyst, plus other equipment, all in mint condition. David N. Willis, 801 W. Humphrey, Rock Falls, IL 61071.

FIX IT FAST WITH PHOTOFACT®. Photofact® 1981 Index lists available service data for over 110,000 TV's, Radios, CB's, Auto Radios, Scanner-Monitors, and VCR's produced since 1946. Send $2.50 plus 50 cents shipping to Howard W. Sams Co., Dept. X0116, 4300 W. 62nd St., Indpls., IN 46268. 6/81

SATELLITE TV—the most complete single report—For novices or pros—$7. **SCOTT PALMER,** 9062 Andromeda Drive, Burke, VA 22015.

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 out of New York state (800) 223-8314. TF

TEST equipment lowest prices B&K Leader, Hitachi, Viz, Beckman, OK Tool, Blonder Tongue, RCA parts transistors others, write call collect **L.I. Electronics,** 981 Sunrise Highway, Bayshore, NY 11706. 516-666-7360.

Sams Photofacts ;51-650 in 3-4 drawer filing cabinets $600.00. E.W. Berrey Jr., K & B TV, Rt. 6 Box 29, Powhatan, VA 23139. Phone (804) 598-3067. 4/81

FOR SALE - LIKE NEW, 1-BK-Precision Model 415 sweep marker generator. 1-Telematic Test Rig (PJS-298). 1-Conar Model 255 CRO. 1-Carry all tube caddy. Write ET/D Box 133. 4/81

LIQUIDATING TELEVISION STORE: Diagrams-current and old, parts, tubes, test equipment. Air conditioning parts and charging station. Office furniture, filing cabinets also available. Will divide or sell as one unit. Write ET/D Box 134. 5/81

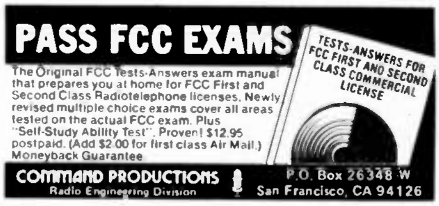
SATELLITE TELEVISION — movies, sports, etc. Build or buy your own earth station. Article gives alot of hard-to-find, necessary information. Send $4.00 for article to Satellite Television, R. D. 3, Box 140, Oxford, NY 13830.

Sencore VA48 TV analyzer like new $895.00. Sencore CR143 CRT tester $50.00. Thordarson Degauuss coil $10.00. EICO Hi-volt probe $20.00. Harley Jansen, 1600 1st Ave., Marion Iowa 52302. 319-377-3141. 4/81

MICRO WAVE SYSTEM, RECEIVE UNEDITED MOVIES, SUPER SPORTS, LAS VEGAS SHOWS, ETC. COMPLETE INCLUDING CABLE SWITCH $225.00. SIGNAL ELECTRONICS, 4027 18TH AVE., BROOKLYN, NY 11218. 212-436-0673. 7/81

SATELLITE spherical TV antenna. Easy to build from local parts for $200.00. Detailed plans $20.00. GEMINI T.V., 183 Lamport Blvd., S.I., NY 10305.

ELECTRONIC BARGAINS, CLOSEOUTS, SURPLUS! Parts, equipment, stereo, industrial, educational. Amazing values! Fascinating items unavailable in stores or catalogs anywhere. Unusual FREE catalog. ETCO-013, Box 762, Plattsburgh, NY 12901. TF

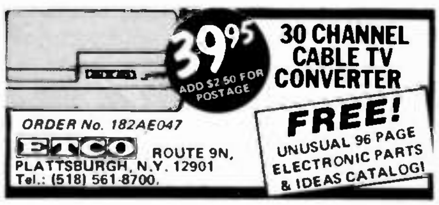


SATELLITE television...Howard/Coleman boards to build your own receiver. For more information write: **ROBERT COLEMAN,** Rt. 3, Box 58 ETD, Travelers Rest, SC 29690.

PICTURE TUBE REBUILDING EQUIPMENT capable of producing four high quality tubes per day (WILL **TRAIN TO OPERATE)** Call or Write Atoll Television, 6425 Irving Park, Chicago, Illinois 60634. ph. 312-545-6667. 6/81

TV AND RADIO TUBES 49¢ EA!! Send for free color parts catalog. Your order free if not shipped in 24 hours. Cornell Electronics 4215-17 University San Diego California 92105. TF

GOVERNMENT surplus receivers, transmitters, snooperscopes, parts, fantastic 72 page catalog 25¢. J. MESHNA, Nahant, Mass 01908.



Go-No-Go Transistor Tester $16.95 Test Probe Housing with test tip $6.95. 2 channel wire tracer $45.95. Send for free catalog quantity discount, dealership. King Electronics, Inc. 600 Tremont St., Boston, MA 02118. 7/81

HELP WANTED

TELEVISION & TWO-WAY RADIO TECHNICIANS WANTED for immediate employment. Excellent salary, fringe benefits, good working conditions with progressive electronic retail-service corporation. Equal opportunity employer. Miller's Electronics, Inc., Highway 24, Goodland, KS 67735. 913-899-2386.

WANTED

MIRROR IN-THE-LID, SPINNING DISK, AND OTHER PRE-1946 TELEVISION SETS, parts, literature wanted for substantial cash. Also need 12AP4, 9AP4, MW-31-3 picture tubes, and any information on projection sets made by **TELICON CORP.** of N.Y. in 1947. Arnold Chase, 9 Rushleigh Rd., West Hartford, CT 06117.(203) 521-5280. 3/82

WANTED: PICTURE TUBE REBUILDING EQUIPMENT working or not. Write or call Atoll Television, 6425 Irving Park, Chicago, Illinois 60634. Phone 312-545-6667.

Wanted for Cash: 7N7, 7F7, 53, 6L6 metal, 6AF6, 6HU8, 304TL, 4CX1000A, all transmitting, special purpose and Eimac tubes, etc. DCO Inc., 10 Schuyler Avenue, North Arlington, N.J. 07032, Toll Free (800) 526-1270. 8/81

FOR RENT

GOLDCOAST COMPUTER RENTAL CLUB. Has thousands of programs free. Also TV management programs for the Apple Family and the TRS 80 Model II. For free details send (SAE) to; Box 181, Bremen, KY 42325.

SCHEMATICS — LIBRARY SERVICE. 30 day rental fee $2.00. Application fee for library card $10.00 **All RIDERS** manuals and **SAMS** available for your use. Send application and order to: **THE TV SHOP,** 530 Minnesota Ave., Fallbrook, California 92028 (Telephone 1-714-723-1302).

SERVICES

MICROCOMPUTER service. Maintenance and repair for all microcomputers and peripherals. Fast. Reasonable. PRAIRIE MICRO CLINIC, Box 325, Herington, KS 67449 (913) 258-2179.

BUSINESS OPPORTUNITIES

Florida's Sun Coast. TV sales & service. New Showroom attached to modern 2 bedroom home in nice area. Plus separate rental house. $90,000. For details call 1-813-541-2039. Or write shop owner: 7744 46 Ave., St. Petersburg, Fla. 33709

MECHANICALLY INCLINED INDIVIDUALS Assemble electronic devices in your home. Knowledge or experience not necessary. Get started in spare time. Above average profits. $300-$600/wk. possible. Sales handled by others. No investment-Write for free details. ELECTRONIC DEVELOPMENT LAB, Box 1560B, Pinellas Park, FL 33565. TF

Ski country U.S.A. TV sales and service business. RCA and Zenith dealer. PO Box 607, Frisco, CO 80443. 303-668-5774. 303-985-3354. 5/81

YOUR OWN Newspaper humor 'Column' carries YOUR byline, your photograph, your tie-in. Wows folks, brings business, makes you a celebrity. Inexpensive, effective PR. Details free. Simon Co., 1280-ETD Sawmill,, Yonkers, NY 10710.

SOUTHERN NEW HAMPSHIRE
Complete TV retail and service center with 6 room home, in-grd. pool plus Quasar/Sylvania Dealer. Prime hi-traffic location in rapid growth area. **NO** state sales or income tax. No competition. Turnkey operation. Excellent business climate. $155,000. Call or write:
Hal Warner, Warner Associates, Realtors, P.O. Box 3, Amherst, NH 03031 603-673-7000

PROJECTION TV DEALERSHIPS OPEN

Expanded production permits company to accept dealer applications.

Demo, sell and service top quality professional video projector. Business and industry market.

To be considered, please forward full information on your company, its corporate officers and staff's level of technical expertise to:

Director of Marketing
ELECTRONIC SYSTEMS PRODUCTS
1 Tico Road
Titusville, Fl. 32780

send a message...
...write here.

1. Number of insertions: (circle) 1 2 3 6 12
2. Start with (month) ________ issue (Copy must be in by 1st of month preceding)
3. Amount enclosed: $________

PAYMENT MUST ACCOMPANY ORDER. WE'LL BILL RATED FIRMS

NAME ________ COMPANY ________
STREET ________
CITY ________ STATE ________ ZIP ________

MAIL AD COPY TO: DAWN ANDERSON, ELECTRONIC TECHNICIAN/DEALER, 1 EAST FIRST STREET, DULUTH, MN. 55802.

RATES: 50 cents per word (minimum charge, $15). Bold face words or words in all capital letters charged at 65 cents per word. Boxed or display ads charged at $60 per column inch (one inch minimum). For ads using blind box number, add $5 to total cost of ad.

AD INDEX

BULLETIN BOARD

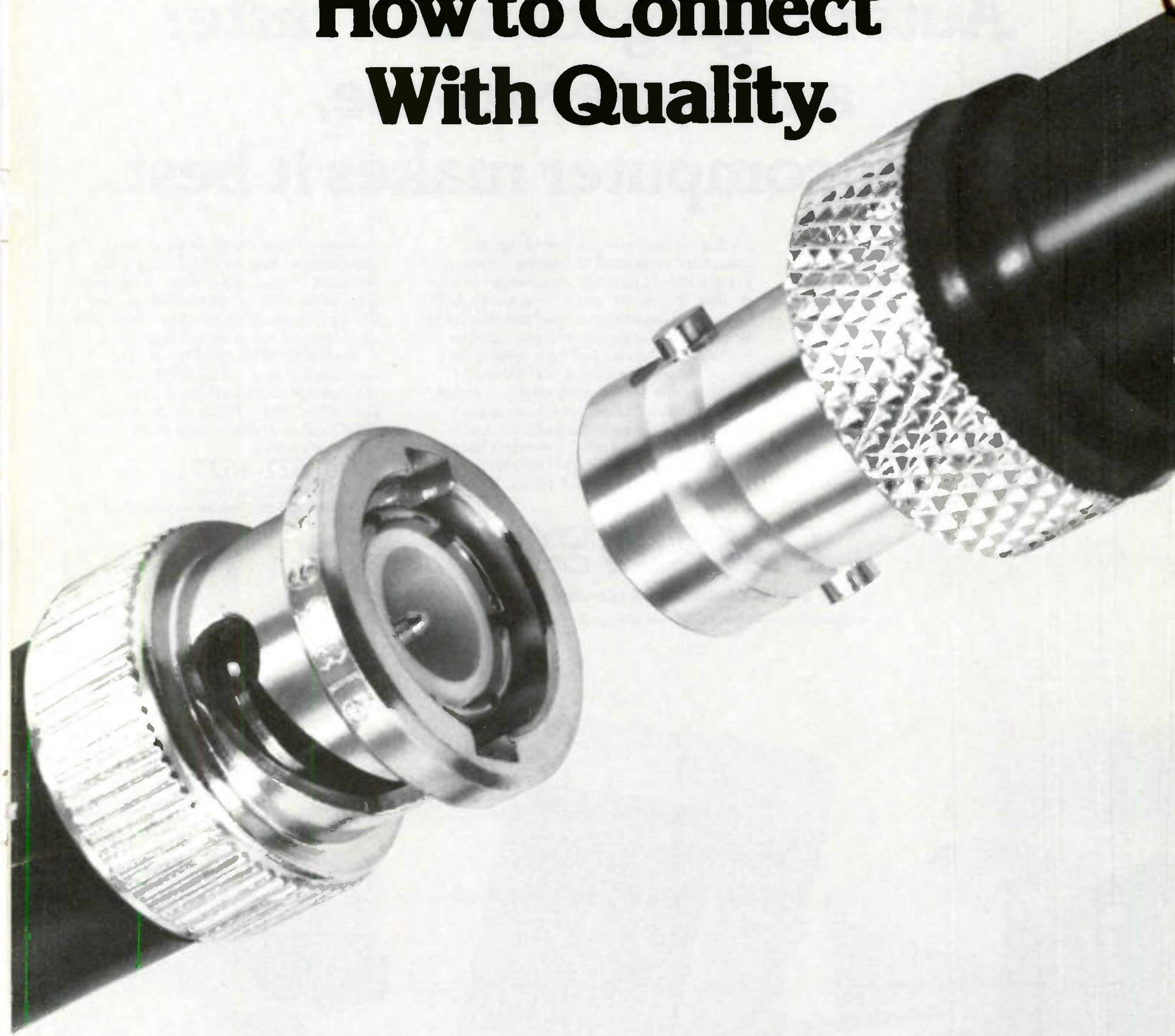
TEST INSTR. RPT.

NEW PRODUCTS

SECURITY PROD.

This index is furnished for the readers' convenience. However, the publisher can not guarantee its accuracy due to circumstances beyond our control.

How to Connect With Quality.



The 1981 Pomona Electronics catalog is your connection to more than 650 quality test accessories.

Our BNC line, alone, is boundless.

To convert coaxial cables to test cables, use our molded breakouts – BNC plugs or receptacles with various test clips or plugs.

There are cable assemblies of every description, utilizing four kinds of shielded cable plus stress-relieved and retractile. Choose regular, right angle, push-on and push-on stacking BNC ends. And choose from other-end options too numerous to mention.

And, of course, we go to great lengths to provide a good choice of lengths.

In addition, you'll find a big selection of shielded black boxes featuring pre-mounted BNC components. Plus plenty of coaxial accessories.

Refer to your copy of the Electronic Engineers Master (EEM) catalog for complete product in–formation, or ask us for a free catalog today.

ITT Pomona Electronics, 1500 E. Ninth St., P.O. Box 2767, Pomona, CA 91766. Phone (714) 623-3463.

In Europe, ITT Industries Belgium S.A., Pomona Division, 250 Avenue Louise, Box 121, Brussels, Belgium. Phone 02/640 . 34 . 00.

AVAILABLE THROUGH YOUR FAVORITE ELECTRONIC PARTS DISTRIBUTOR

Consistent quality for a complex world.

Pomona Electronics ITT

Circle No. 102 on Reader Inquiry Card

Autoranging makes it faster and easier-to-use, a microcomputer makes it best.

Confused about how to select the right DMM? A lot of under $200 hand-held DMMs do look alike and offer similar specs, but only the B&K-PRECISION 2845 gives you microcomputer-controlled autoranging. That's important because autoranging saves time, reduces the chance of reading errors and lets you direct more attention to your project, instead of your test equipment.

B&K-PRECISION uses "smart autoranging," a concept that's years ahead of traditional methods. Range changes are fast, controlled by a four-bit microcomputer; and readings are computer stabilized to prevent ranging instabilities. The 2845 autoranges in all modes. In use, its "micro" monitors A/D converted input signals and automatically skips to the range that will provide the highest resolution. For best reliability, actual range changing is performed by hermetically sealed reed relays. A range lock function permits you to manually hold any range automatically selected.

The 2845 provides 0.1 percent basic DC accuracy; and it's EMI shielded to keep that accuracy in RF fields. For fast continuity checks, there's an audible (defeatable) beeper. A full range of optional accessories are also available. Best of all, with so many features and a $175 price, the only thing you'll be giving up is manual range switching.

Let B&K-PRECISION take the confusion out of your DMM selection. Just ask for the microcomputer-controlled 2845. It's in stock now at your local distributor. For more information call:

(800) 621-4627 toll free;
(312) 889-9027 in Illinois.

Circle No. 104 on Reader Inquiry Card

B+K PRECISION DYNASCAN CORPORATION

6460 W. Cortland Street • Chicago, IL 60635 • 312/889-9087

International Sales, 6460 W. Cortland Street, Chicago, IL 60635 • Canadian Sales, Atlas Electronics, Ontario

Model 2845 $175