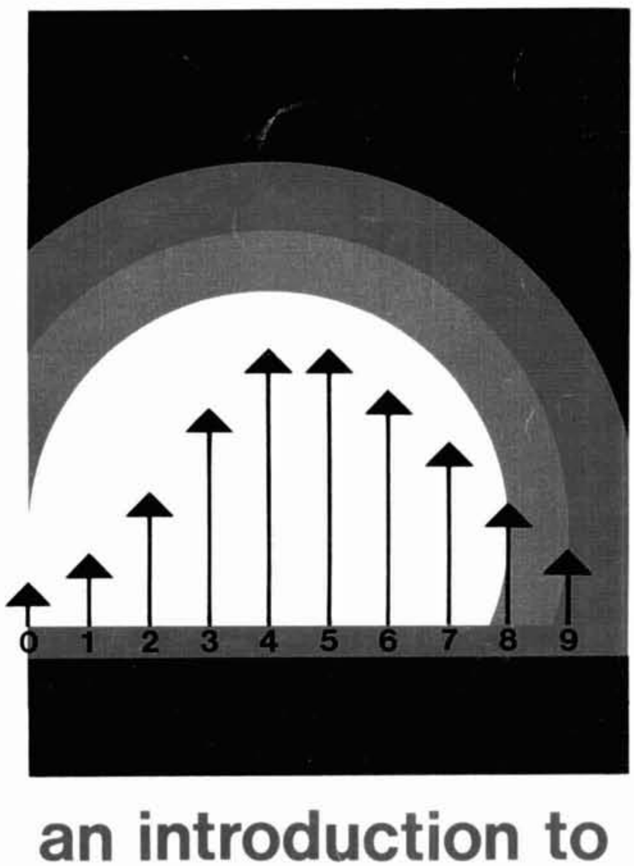
one dollar

ham radio

magazine

JANUARY 1977



an introduction to single-sideband fm

INTRODUCING

The TEMPO 2020

A BRILLIANT NEW SSB TRANSCEIVER PROVIDING AN UNBEATABLE COMBINATION OF ADVANCED ENGINEERING AND UNIQUE OPERATING FEATURES.

YOU MAY NEVER HAVE OWNED A TRANSCEIVER THAT OFFERS SO MUCH.

Send for descriptive information on this fine new transceiver, or on the time proven Tempo ONE transceiver which continues to offer reliable, low cost performance.

*Phase lock-loop (PLL) oscillator circuit minimizes unwanted spurious responses.

*Hybrid Digital Frequency Presentation.

*Advanced Solid-state design...only 3 tubes.

*Built-in AC and 12 VDC power supplies.

*CW filter standard equipment...not an accessory.

*Rugged 6146-B final amplifier tubes.

*Cooling fan standard equipment...not an accessory.

*High performance noise-blanker is standard equipment ...not an accessory.

*Built-in VOX and semi-break in CW keying.

*Crystal Calibrator and WWV receiving capability.

*Microphone provided.

*Dual RIT control allows both broad and narrow tuning.

*All band 80 through 10 meter coverage.

*Multi-mode USB, LSB, CW and AM operation.

*Extraordinary receiver sensitivy (.3u S/N 10 db) and oscillator stability (100 Hz 30 min. after warm-up)

*Fixed channel crystal control on two available positions.

*RF Attenuator.

*Adjustable ALC action.

*Phone patch in and out jacks.

*Separate PTT jack for foot switch.

*Built-in speaker.

*The TEMPO 2020 ...$759.00.

Model 8120 external speaker...$29.95.

Model 8010 remote VFO...$139.00.

Henry Radio

11240 W. Olympic Blvd., Los Angeles, Calif. 90064 213/477-6701
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DenTron amateur radio products have always been strikingly individual. This is the result, not of compulsion to be different, but of a dedication to excellence in American craftsmanship. This dedication now extends to one of the worlds finest high performance Military amateur amplifiers.

Luxury styling, however, would not be fully appreciated without an exceptional power source. The heart of the MLA-2500 is a heavy duty, self-contained power supply.

Compare the MLA-2500. It has the lowest profile of any high performance amplifier in the world. It's modular construction makes it unique, and at $799.50 it is an unprecedented value.

Very few things in life are absolutely uncompromising. We are proud to count the DenTron MLA-2500 among them. And so will you.

MLA-2500 FEATURES

- 160 thru 10 meters
- 2000+ watts PEP input on SSB
- 1000 watts DC input on CW, RTTY, or SSTV
- Variable forced air cooling system
- Self contained continuous duty power supply
- Two EIMAC 8875 external-anode ceramic/metal triodes operating in grounded grid.
- Covers MARS frequencies without modifications
- 50 ohm input and output impedance
- Built in RF watt meter
- 117 V or 234 V AC 50-60 hz
- Size: 5½" H x 14" W x 14" D.

All DenTron products are made in the U.S.A.

Introducing the new MLA-2500

The linear amplifier beyond compromise.

Amplifier in actual operation.

DenTron
Radio Co., Inc.

2100 Enterprise Parkway
Twinsburg, Ohio 44087
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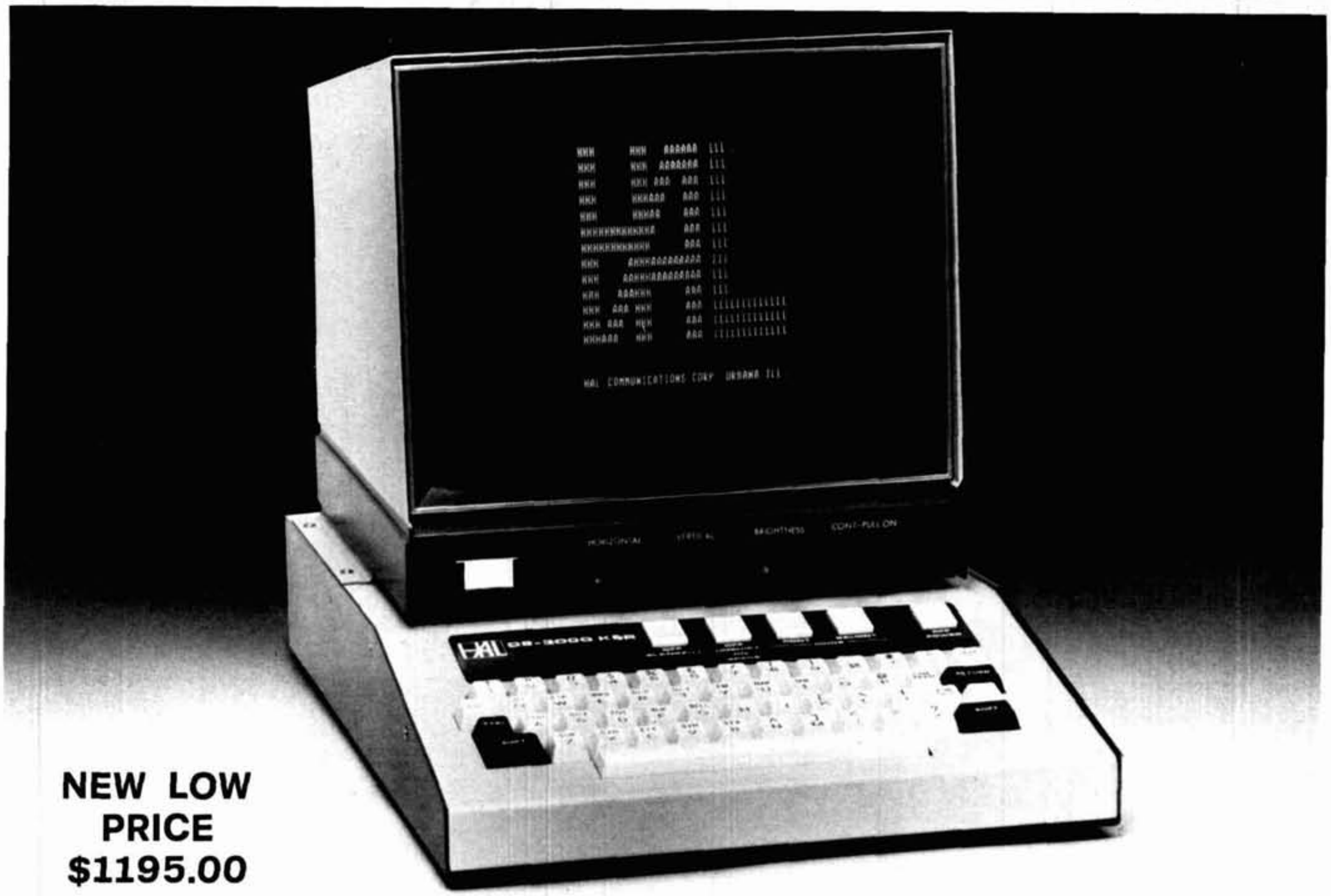
Stay tuned for future programs.

ONLY $595.00



NEW LOW PRICE $1195.00

The HAL ST-6000 demodulator /keyer and the DS-3000 and DS-4000 KSR/RO series of communications terminals are designed to give you superlative TTY performance today —*and in the future.* DS series terminals, for example, are re-programmable, assuring you freedom from obsolescence. Sophisticated systems all, these HAL products are attractively priced—for industry, government and serious amateur radio operators.

The HAL ST-6000 operates at standard shifts of 850, 425, and 170 Hz. The tone keyer is crystal-controlled. Loop supply is internal. Active filters allow flexibility in establishing different tone pairs. You can select AM or hard-limiting FM modes of operation to accommodate different operating conditions. An internal monitor scope (shown on model above) allows fast, accurate tuning. The ST-6000 has an outstandingly high dynamic range of operation. Data I/O can be RS-232C, MIL-188C or current loop.

The DS-3000 and DS-4000 series of KSR and RO terminals provide silent, reliable, all-electronic TTY transmission and reception, or read-only (RO) operation of different combinations of codes, including Baudot, ASCII and Morse. The powerful, programmable 8080A microprocessor is included in the circuitry to assure maximum flexibility for your present needs —and for the future. The KSR models offer you full editing capability. The video display is a convenient 16-line format, of 72 characters per line.

These are some of the highlights. The full range of features and specifications for the ST-6000 and the DS series of KSR and RO terminals is covered in comprehensive data sheets available on request. Write for them now—and tune in to the most sophisticated TTY operation you can have today... or in the future.

HAL

HAL Communications Corp., Box 365, 807 E. Green Street
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More Details? CHECK—OFF Page 126

ham radio magazine

JANUARY 1977

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contents

a second look

by Jim Fisk

In the evening when I'm working down in the shop, I usually turn on the stereo and listen to some nice, easy music. When I get tired of that, I flick on the receiver and tune around the upper end of 75 meters for an interesting round table — I can invariably find an interesting conversation, whether it's about the sorry state of the economy, the high cost of fuel oil, the fine golfing weather in south Florida, or a technical discussion on the merits of quads vs Yagis. Whatever my mood, there's always something on 75 that piques my curiousity, and occasionally something that starts the old adrenalin flowing.

The other night, for instance, two characters with two-letter calls were holding forth on the low end of 75 phone just inside the Extra class segment. The technical topic of the evening was transmission lines, and to hear these guys talk, they were the *original* experts. In reality all they had to offer was a barge full of baloney. Now I'll readily admit that, of all the subjects in amateur radio, transmission lines are among the most difficult to understand, but that isn't a license to run off at the mouth. And to be perfectly blunt, some amateur publications suffer from the same foot-in-mouth disease when it comes to transmission lines and antennas.

I don't know where all the feedline myths started, but I suspect it had something to do with the do-it-yourself swr bridges which first became popular back in the early 1950s. Up until then most amateurs didn't even know about standing waves, and if they did, they didn't seem to care. However, swr bridges soon caught on, and it wasn't too long before being caught with your swr up was synonymous with getting caught with your pants down. At one time someone even suggested that the Q-signal QSW be used with a scale of 1 to 10 to report your latest swr reading as you moved around the band. Fortunately the idea never caught on.

Some amateurs got interested enough in the subject of standing-wave ratios to dig into the books, but when they discovered that swr is a result of power reflected from a mismatched antenna, it only served to reinforce the myth. If a mismatched antenna causes power to be reflected back down the line, they reasoned, this power *obviously* wasn't radiated by the antenna. Some even suggested that the reflected power got back into the transmitter tank circuit and was dissipated in heat; others apparently thought that reflected power was lost forever to some great swr heaven in the sky. A few well-informed amateurs tried to nip these absurdities in the bud, but it was hopeless — the disease spread faster than the cure.

The whole subject of transmission lines is much too complex to be covered in this short space, but it's time to bury some of the myths. First of all, reflected power is not lost nor does it heat up the tank circuit of your transmitter. Secondly, if your feedline has low loss as is the case on the hf bands, increased loss due to swr is so small you can forget about it. Since a 10:1 swr on 100 feet of RG-8/U at 4.0 MHz increases loss by *less than 1 dB*, don't worry about the fact that the swr rises above 2:1 at the band edges — the station at the other end won't be able to tell the difference. If your transmitter doesn't like to load into a mismatch greater than 2:1, buy or build an antenna tuner and save yourself a lot of grief by forgetting the swr on the line to the antenna if it's within reasonable limits, say 10:1. And finally, if you don't understand transmission lines, don't make wild statements before you have your facts straight.

Jim Fisk, W1DTY
editor-in-chief

LEADING THE NEW WAVE... IC-211

THE NEW ICOM 4 MEG, MULTI-MODE, 2 METER RADIO

ICOM introduces the first of a great new wave of amateur radios, with new styling, new versatility, new integration of functions. You've never before laid eyes on a radio like the **IC-211,** but you'll recognize what you've got when you first turn the single-knob frequency control on this compact new model. The **IC-211** is fully synthesized in 100 Hz or 5 KHz steps, with dual tracking, optically coupled VFO's displayed by seven-segment LED readouts, providing any split. The **IC-211** rolls through 4 megahertz as easily as a breaker through the surf. With its unique ICOM developed LSI synthesizer, the **IC-211** is now the best "do everything" radio for 2 meters, with FM, USB, LSB and CW operation.

The **IC-211** is so new that your local dealer is still playing with his demo. Just hang in there and you can grab this new leader for yourself. ICOM's new wave is rolling in.

Frequency Coverage: 144 to 148 Mhz
Synthesizer: LSI based 100 Hz or 5 KHz PLL, using advanced techniques
Modes: SSB (A3J), FM (F3), CW (A1)
Selectivity: SSB ± 2.4 KHz or less at −60db; FM ± 16 KHz or less at −60db
Sensitivity: SSB 0.25 uv 10db SINAD; FM 0.4 uv for 20db Q.S.
Power Supply: Internal, 117V AC or 13.8V DC
Power Output: 10W PEP (SSB), 10W (CW, FM)
Size: 111mm H x 241mm W x 264mm D
Weight: 6.8 kg

VHF/UHF AMATEUR AND MARINE COMMUNICATION EQUIPMENT

ICOM

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More Details? CHECK–OFF Page 126

presstop

FCC CONSIDERS BAN ON LINEAR AMPLIFIERS for all services, including Amateur. FCC Chief Engineer Ray Spence dropped that bombshell in response to a question posed at the Radio Club of America annual banquet's "Round Table 1976 – Personal Communications" session. At the New York meeting, Ray said the continued circumvention of the FCC's ban on "CB" linears by half a dozen or so manufacturers is forcing the Commission to take a much stronger stance which could result in an across-the-board prohibition on amplifiers for everyone.

Alternatives To Be Considered in the proposed rule making include, in addition to the possible ban, putting all Amateur Radio equipment of commercial manufacture under the equipment approval program that presently applies to gear used by other services. Still another approach would be to forbid the sale of an amplifier to anyone not holding a license that authorizes his use of that amplifier, and make the dealer liable for any sales made in violation of that prohibition.

An Industry Group Dedicated to the well-being of linear amplifiers has been formed. Goals of the new group, being spear-headed by Dentron, are to establish "industry regulations" for the proper use of amplifiers, develop marketing techniques to keep them out of the hands of illegal users, and work closely with the FCC to assure enforcement of the Rules regarding linears.

1X2 CALLSIGN APPLICANTS newly eligible January 1 can be assisted by another ARRL prepared chart showing callsign availability. The chart will be available late in the month – send an SASE marked "1X2 Callsign Matrix" to the League for a copy.

1190 1X2 Callsigns have now been granted since July 2, with 227 applications still pending. No NX2s have yet been issued as the computer program is still being worked out, though applications for the new prefix have been received.

FCC REDUCED the number of copies it requires to be filed in Commission rulemaking procedures from 12 to 6 (an original and 5 copies) in an action announced November 9. Anyone wishing a copy of his comments to go to each Commissioner individually may still file an original and 11 copies as before, but the 6 copies specified in the new ruling assures that a filing is distributed to the appropriate FCC staff members.

The Relaxation, which amended Part 1 of the Rules, became effective November 22.

PORTABLE AND MOBILE DESIGNATION use ended officially on Friday, November 26, a Thanksgiving present from the FCC, but you'll still need to have an "active" mailing address so you can answer possible FCC citations or advisories within the required 10-day period. Also, portable and mobile designations will still be required of participants in ARRL-sponsored contests. Though portable and mobile designations are more important to some contests than others, it's likely the Rule will be across the board for League events.

NOVICE LICENSE TURNAROUND time can be sharply reduced, say several sources, by printing "AMATEUR RADIO NOVICE APPLICATION" in large letters on the envelope used to apply for a Novice exam, then returning the completed exam to Box 1120 in the envelope it came in marked "COMPLETED AMATEUR RADIO NOVICE EXAM ENCLOSED."

NOVICE CLASS INSTRUCTORS CAN REQUEST written examinations for their students before the students take the code test under a Rules waiver announced by the FCC. Under the terms of the waiver, which will be in effect until June 30, an instructor with a class of five or more students should request sufficient exams for his students at least 30 days before the date he plans to administer the exam. Present FCC requirements for examiners remain unchanged – 21 or more years old, a General or higher class license – and the examiner will be held responsible for returning unused exams unopened along with the exams that have been taken by the students.

Requests For Group Exams should include a photocopy of the examiner's license along with his name and address, the number of exams required, and the date the exams are to be given. To facilitate processing by the FCC, the ARRL recommends including two mailing labels which include the above information along with each request. Requests should go to the FCC, Box 1020, Gettysburg, Pennsylvania 17325.

15TH ANNIVERSARY OF AMATEUR RADIO IN SPACE occurred in December – OSCAR 1 was launched December 12, 1961. OSCAR 7 has now provided more operating time for users than all previous OSCARs combined, according to W3PK (K3JTE).

Tests Of JAMSAT's 145-435 MHz transponder have been going very well, and the Japanese-built unit has met specs nicely.

ITOS-1 Launch, which AMSAT had expected to provide this summer's OSCAR launch, has been scrubbed. LANDSAT C looks like the probable alternative.

NOW FROM Wilson:

AMATEUR: ANTENNAS • ROTORS • TOWERS

3 CRANK-UP TOWER MODELS AVAILABLE

TT-45 FREESTANDING CRANK-UP TOWER, 45 Ft.
The TT-45 will support 9 sq. ft. at a height of 39 ft. freestanding when properly bracketed to a house or wall at the 8 ft. level. The loads decrease as the tower extension Mast is lengthened. (Loads are based at 50 mph and load permitted on the tower decreases with increases in wind speed over 50 mph). The tower can be completely freestanding with our new concrete or tower rotating bases, which allow the use of our raising fixture. Using these accessories, the towers can be installed by one man easily.

List **$310.00**

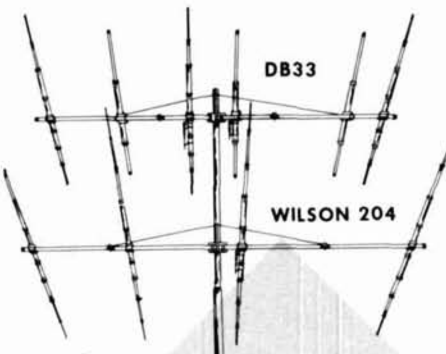
FOR THE TOWERING SIGNAL - WILSON'S SST-64 GUYED CRANK-UP TOWER, 64 Ft.
All steel tubing is galvanized plated and conforms to ASTM specifications for years of maintenance free service. The SST-64 is made of 4 sections, being 4.5", 3.5", 2.5" and 2". These large diameters give unexcelled strength and virtually makes the thin push-up poles a thing of the past. The large loads of today's antennas make the Wilson SST-64 the best value on the market today.

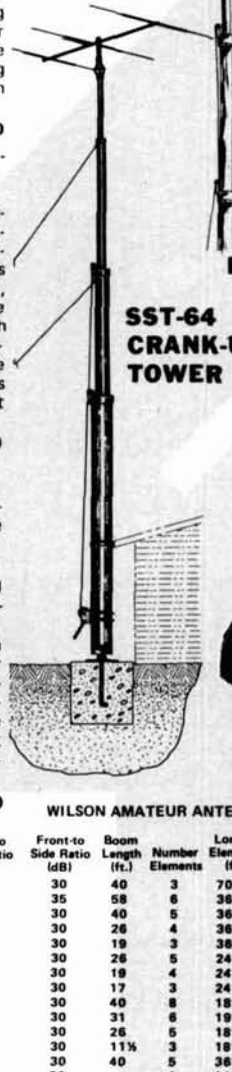
List **$375.00**

THE WILSON GT-46 GUYED CRANK-UP TOWER, 46 Ft.
The GT-46 features quality construction and materials, with the stability of the Guyed System.

FEATURES OF THE GT-46:
• *Low cost* • *High capacity* • all steel. Conforms to ASTM (American Standard of Testing Materials) • Fully galvanized • 800 lb. winch standard • Guy kits available for *factory recommended* installations • 2000 lb. raising cable standard (Aircraft Quality) • Can be roof mounted for extra height • Great looking, slim flag pole design, for the ecology minded.

List **$219.00**



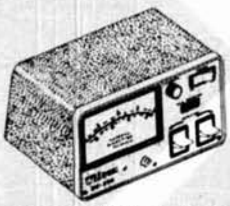


AMATEUR ANTENNAS

The Wilson 204 is the best and most economical antenna of its type on the market. Four elements on a 26' boom plus a Gamma Match (no balun required) make for high performance on CW & phone across the entire 20 meter band. The 204 Monobander is built rugged at the high stress points. Using taper swaged slotted tubing permits larger diameter tubing where it counts, for maximum strength with minimum wind loading.

The DB33 is the newest addition to the Wilson line of antennas. Designed for the amateur who wants a lightweight economical antenna package, the DB33 compliments the M204 for an excellent DXers combination.

All Wilson Monoband and Duoband beams have the following common features:
- Taper Swaged Tubing
- Full Compression Clamps
- No Holes Drilled in Elements
- 2" or 3" Aluminum Booms
- Adjustable 52 Ω Gamma Match
- Quality Aluminum
- Handle 4kw
- Heavy Extruded Element to Boom Mount



WR 1000 ROTOR

The Rotor everyone has been waiting years for — capable of the largest arrays up to 25 sq. ft.—Superior to prop pitches — Full 4,000 inch lbs. of turning torque. Braking system requires 12,000 inch lbs. before over-riding — accepts 2" - 3" masts — Weighs 60 lbs. — Size: 11" diameter, 19" high.

The Finest Rotor in the Market Today
WR 1000 . . . . **$429.00** List

WR 500 ROTOR

The Wilson WR500 Rotor has 780 inch lbs. of turning torque before stalling.

In addition, a Special Braking System requires 1300 inch lbs. of torque before windmilling— This is more than twice the braking ability of the other comparable rotor being marketed.

Full 98 Steel Ball Bearing raceway assures elimination of side torque jamming when Rotor is mounted in line with the mast.

Recommended for antennas of 7.5 sq. ft. or less . . . weighs 20 lbs.

The WR500 Rotor . . $119.95 List

WILSON AMATEUR ANTENNA SPECIFICATIONS

Model No.	Frequency	Forward Gain (dB)	Front-to Back Ratio (dB)	Front-to Side Ratio (dB)	Boom Length (ft.)	Number Elements	Longest Elements (ft.)	Turning Radius (ft.)	Surface Area (sq. ft.)	Wind Loading at 80 MPH (lbs.)	Assembled Weight (lbs.)	Shipping Weight (lbs.)	Price
M340	40	8.5	20	30	40	3	70'0"	39'0"	15	300	180	220	$749.00
M620	20	13.0	28	35	58	6	36'0"	32'0"	10.5	210	98	123	420.00
M520	20	12.0	26	30	40	5	36'4"	27'0"	8.75	175	74	96	299.00
M204	20	10.0	25	30	26	4	36'4"	22'6"	6.8	136	42	48	169.00
M203	20	8.5	20	30	19	3	36'0"	20'5"	5.25	105	35	40	129.00
M155	15	12.0	26	30	26	5	24'3"	18'0"	5.0	100	41	44	159.00
M154	15	10.0	25	30	19	4	24'3"	15'9"	4.0	80	30	33	109.00
M153	15	8.5	20	30	17	3	24'3"	14'0"	3.0	60	21	24	89.00
M108	10	13.5	26	30	40	8	18'0"	22'0"	5.5	110	49	77	219.00
M106	10	13.0	26	30	31	6	19'0"	16'1"	4.0	80	34	36	119.00
M105	10	12.0	26	30	26	5	18'0"	15'8"	3.0	60	29	32	109.00
M103	10	8.5	20	30	11½	3	18'0"	10'0"	2.0	40	10	12	39.00
DB54	20	12.0	26	30	40	5	36'4"	27'0"	12.75	255	94	119	349.00
	15	10.0	25	30		4	24'3"						
DB43	15	8.5	20	30	19	4	24'3"	15'8"	6.0	120	38	43	149.00
	10	10.0	25	30		3	18'0"						
DB33	15	8.5	20	30	17	3	24'3"	12'2"	4.5	90	30	33	109.00
	10	8.5	20	30		3	18'0"						

AVAILABLE THRU YOUR LOCAL DEALER

FOR THE NAME OF YOUR NEAREST AMATEUR DEALER — *OR FOR A FREE CATALOG OF THE ABOVE PRODUCTS, CONTACT:*

Wilson Electronics Corp.

4288 SO. POLARIS AVENUE • LAS VEGAS, NEVADA 89103 • (702) 739-1931 • TELEX 684-522

KENWOOD... *the Pacesetter in*

TS-520 TS-820

HF

The ultimate transceiver . . . Kenwood's TS-820. No matter what you own now, a move to the TS-820 is your best move. It offers a degree of quality and dependability second to none, and as the owner of this superb unit, you will have at your fingertips the combination of controls and features that, even under the toughest operating conditions, make the TS-820 the *Pacesetter* that it is.

Unprecedented demand plus the painstaking care Kenwood lavishes on each TS-820 has created a back-log of orders, but rest assured, it's well worth waiting for. Once you have operated the TS-820 you will not be satisfied with anything else.

Features

Following are a few of the TS-820's many exciting features

SPEECH PROCESSER • An HF circut provides quick time constant compression using a true RF compressor as opposed to an IF clipper. Amount of compression is adjustable to the desired level by a convenient front panel control.

IF SHIFT • The IF SHIFT control varies the IF passband without changing the receive frequency. Enables the operator to eliminate unwanted signals by moving them out of the passband of the receiver. This feature alone makes the TS-820 the pacesetter that it is.

PLL • The TS-820 employs the latest phase lock loop circuitry. The single conversion receiver section performance offers superb protection against unwanted cross-modulation. And now, PLL allows the frequency to remain the same when switching sidebands (USB, LSB, CW) and eliminates having to recalibrate each time.

TS-820 *Specifications*

FREQUENCY RANGE: 1.8-29.7 MHz
(160 - 10 meters)
MODES: USB, LSB, CW, FSK
INPUT POWER: 200W PEP on SSB
160 W DC on CW
100 W DC on FSK
ANTENNA IMPEDANCE: 50-75 ohms, unbalanced
CARRIER SUPPRESSION: Better than 40 dB
SIDEBAND SUPPRESSION: Better than 50 dB
SPURIOUS RADIATION: Greater than -60 dB
(Harmonics more than -40 dB)
RECEIVER SENSITIVITY: Better than 0.25uV
RECEIVER SELECTIVITY:
SSB 2.4 kHz (-6 dB)
4.4 kHz (-60 dB)
CW* 0.5 kHz (-6 dB)
1.8 kHz (-60 dB)
*(with optional CW filter installed)
IMAGE RATIO: 160-15 meters: Better than 60 dB
10 meters: Better than 50 dB
IF REJECTION: Better than 80 dB
POWER REQUIREMENTS: 120/220 VAC, 50/60 Hz, 13.8 VDC (with optional DS-1A DC-DC converter)
POWER CONSUMPTION: Transmit: 280 Watts
Receive: 26 Watts (heaters off)
DIMENSIONS: 13-1/8" W x 6" H x 13-3/16" D
WEIGHT: 35.2 lbs (16 kg)

VFO-820

Solid state remote VFO designed exclusively for use with the TS-820 "Pacesetter". Contains its own RIT circuit and control switch . . . is fully compatible with the optional digital display in the TS-820.

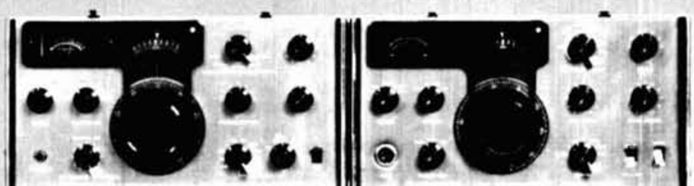
TV-506 **TV-502** **VFO-520** **TS-520** **SP-520**

Subject to FCC certification

As a TS-520 owner, you go on the air with a sense of pride and confidence. Thousands of these precision-built beauties are in operation all over the world . . . in ham shacks, field day sites, in DX and contest stations and in countless mobile installations. No other rig has ever offered the performance, dependability, versatility and value that is built into every KENWOOD TS-520.

You have certainly heard the TS-520's clean signal on the air and have probably heard a lot of glowing praise by other hams. So if you don't already own a 520, maybe it's time you did.

MODES: USB, LSB, CW
POWER: 200 watts PEP input on SSB, 160 watts DC input on CW
ANTENNA IMPEDANCE: 50-75 Ohms, unbalanced
CARRIER SUPPRESSION: Better than −45 dB
UNWANTED SIDEBAND SUPPRESSION: Better than −40 dB
HARMONIC RADIATION: Better than −40 dB
AF RESPONSE: 400 to 2600 Hz (−6 dB)
AUDIO INPUT SENSITIVITY: 0.25μV for 10 dB (S+N)/N
SELECTIVITY: SSB 2.4 kHz (−6 dB), 4.4 kHz (−60 dB), CW 0.5 kHz (−6 dB), 1.5 kHz (−60 dB) (with accessory filter)
FREQUENCY STABILITY: 100 Hz per 30 minutes after warmup
IMAGE RATIO: Better than 50 dB
IF REJECTION: Better than 50 dB
TUBE & SEMICONDUCTOR COMPLEMENT: 3 tubes (2 x S-2001, 12BY7A), 1 IC, 18 FET, 44 transistors, 84 diodes
DIMENSIONS: 13.1" W x 5.9" H x 13.2" D
WEIGHT: 35.2 lbs.



R-599D T-599D

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an introduction to single-sideband fm

Single-sideband fm, though still in its early stages of development, may prove useful for radio communications — here are the basics of the ssb fm system

By Richard R. Slater, W3EJD, RD 3, Cherry Lane, Export, Pennsylvania 15632

During the past decade a new communications system was mathematically shown to be possible, was analyzed in depth, and finally several working systems were built in the laboratory. This system, which will be described in some detail in this article, has come to be known as *single-sideband fm* or (or ssb fm), a term which is also used to describe single-sideband phase modulation.

It is interesting to note that, even though laboratory ssb fm generators exhibit unwanted sideband suppression of 35 dB or more and are relatively straightforward to build, no one ever actually set out to use ssb fm in on-the-air trials. In fact, most professional interest in ssb fm seemed to disappear by 1971 or 1972, perhaps because it was being viewed primarily as a means of saving spectrum space in the commercial fm broadcast band.

Before discussing such details any further, it is necessary to describe the basic system, and to give some historical background as well. Considering the current interest in amateur vhf, fm, the subject of ssb fm should be of general interest, and it is hoped that the following discussion will lead to some amateur experimentation with this mode of communications.

It is not really clear who invented ssb fm, although many people credit it to K.H. Powers, whose work at RCA led to a patent application which was filed in March, 1958.[1] The patent was not granted until September, 1962 — a happenstance which muddied the waters a bit, because E. Bedrosian of the RAND Corporation almost simultaneously published similar results in the *Proceedings of the IRE*.[2] Since Powers' results were never published, Bedrosian was generally credited with the invention. Certainly, Bedrosian's impressive contributions to the theory of signal processing were extremely important (ssb fm was a "spin-off" of his theory, as was an analysis of clipped waveforms in ssb a-m) and it is probably safe to say that it was his work which most directly influenced the subsequent development of the system.

In 1964 Dubois and Aagaard published an article which further analyzed ssb fm and which also contained block and schematic diagrams of a working system, along with appropriate oscilloscope patterns.[3] Although they were only operating at 500 kHz, a practical ssb fm generator had clearly been developed! Less than a year later, Glorioso and Brazeal of the University of Connecticut published further details and discussed the performance of an ssb fm generator they had built.[4] They were among the first to point out the need for a properly designed ssb fm receiver.

The question of how best to receive ssb fm was also getting attention at Princeton University, and during 1966 Kahn and Thomas published an article in which the theoretically optimum ssb fm receiver was discussed.[5] Although the theoretical receiver was impossible to build (as was pointed out in the article), it served as a guide and showed that a modified PLL detection system was the correct route to take.

Hence, by the end of 1966 most of the groundbreaking had been completed, and it seemed inevitable that ssb fm would become a topic of keen interest to professional and hobbyist alike. Paradoxically, by the end of 1971 the system had virtually faded from further discussion in the technical journals, and a search of the standard library reference indices shows that no general-interest electronics or amateur magazine ever published any material on ssb fm.

technical discussion

Throughout the remainder of this article, I am going to assume that you are at least partially familiar with the sideband representation of ordinary fm. (If you wish to brush-up on the properties of fm sidebands, see any recent *Radio Amateur's Handbook*). Also, I intend to avoid the use of any mathematics, even though that means some loss of accuracy in the discussion, and will use as examples only sinusoidally modulated signals with full carrier. The full mathematical details can be obtained by consulting the list of references.

the ssb fm signal

Although most people may be able to guess what the spectrum of an ssb fm signal ought to look like, a true starting point lies in defining the way in which it must behave. From the journal articles already mentioned, it turns out that a true ssb fm signal has two important properties:

1. It must be possible to detect the signal with a device which is sensitive only to frequency deviations (for example, an ideal ratio detector).

2. The transmitted signal must contain only upper or lower sidebands, but not both.

These requirements are not particularly surprising until some thought is given to the second one. If we can really find a way to eliminate one group of sidebands, then it

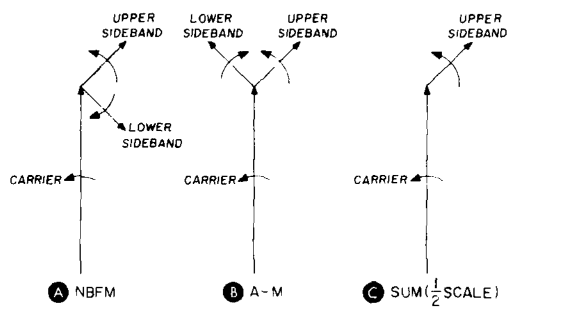

fig. 1. Rotating vector for narrow-band fm (nbfm) and amplitude modulated (a-m) wave at a modulation index of 0.4 and at 40% modulation, respectively. The same oscillator is assumed to produce both carriers, so that the carrier vectors remain in phase.

will no longer be true that, at each instant of time (as in conventional fm), all sidebands add together to give a constant-amplitude signal. Stated another way, a ssb fm signal must have both its amplitude and its frequency change with time. To most people this is the first surprise. The second surprise comes when the first requirement is then re-examined: It implies that, if we run the ssb fm signal through a limiter (and thereby remove the amplitude changes), the signal is converted to ordinary fm. If this were not so, then the detector demanded by the first requirement wouldn't be capable of recovering the modulation.

The amplitude variations in ssb fm can perhaps be made a little more palatable by recalling that a ssb a-m signal also changes in frequency *and* amplitude. In other words, sideband signals of any type are pretty uncooperative waveforms: They simply refuse to retain the familiar characteristics of their parent signals, especially when viewed on an oscilloscope.

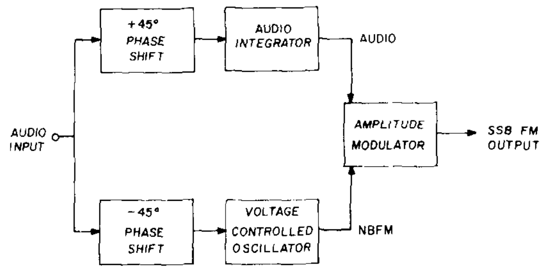

fig. 2. Block diagram of a suggested ssb fm generator (see text).

The ability of a limiter to convert ssb fm to ordinary fm will hopefully seem perfectly reasonable after the actual method of signal generation has been discussed.

generation of ssb fm

Most of us have, at one time or another, seen the rotating vector model for an a-m waveform. This was widely used in the past to explain the operation of the phasing method of ssb a-m generation; it also is a useful way of introducing ssb fm as well because the methods for generating ssb fm introduced to date are all based on phasing systems.* Since fm signals can contain several hundred sidebands when modulated with a single tone, it is necessary that we not consider the general case right away. Instead, to simplify the concept of rotating vectors, consider the problem of "sidebanding" a true nbfm signal. This, by mathematical definition, is an fm signal which has only one significant pair of sidebands present; the corresponding rotating vectors are shown in **fig. 1A.** These vectors are identical to those often used in descriptions of narrow-band phase modulation because they can represent either case.

Fig. 1B *shows a diagram for an ordinary a-m wave* simultaneously modulated by the same audio tone. The implication is obvious: If all of these vectors are added together, the lower sideband will cancel, leaving an ssb signal with carrier. The next problem is to decide which kind of ssb it is, since it is the result of both an nbfm and an a-m wave.

The question can be answered by asking ourselves what would happen if it were run through an imaginary limiter/fm detector. Clearly, the amplitude variations would be removed and only the frequency excursions would remain. The frequency excursions which are still

*For reasons too involved to be explained in this introductory article, filtering methods are not satisfactory.

present occur at the same rate as the original audio so we conclude it is ssb fm.

But what if the same signal is run through an a-m detector? The signal will have only its amplitude variations recovered, but these too, are present and occur at the audio rate. Thus, we must also have ssb a-m!

The point is not made to confuse (though that may be its present effect), but rather to show that, when only one sideband remains, the presence of a properly phased carrier can enable either an fm or an a-m detector to recover the audio.* We are therefore at a departure point and must introduce multiple sidebands if we are to obtain a sideband signal which is distinctively different from ssb a-m. However, the method is basically correct and, for the moment, we can use the vector diagram to investigate some of the problems of actually using simultaneous a-m and fm to produce a single-sideband signal.

The very first problem which arises lies in the nonlinear nature of fm: If everything else is held constant, and only the frequency of the modulating tone is changed, the amplitude of the fm sidebands will still change (recall that, in nbfm, the sideband amplitude is inversely proportional to the modulating frequency). Thus, if the lower-sideband of **fig. 1** has been carefully nulled out at a particular modulating frequency, it will reappear whenever that frequency is changed.

It is obvious that some means is needed to make the system frequency-independent. One method which can be used is to modify the a-m section so that the a-m sidebands will also change in amplitude as the modulating frequency is changed. If this can be done in just the right way, the a-m lower-sideband will exactly cancel the fm lower-sideband at any audio frequency.

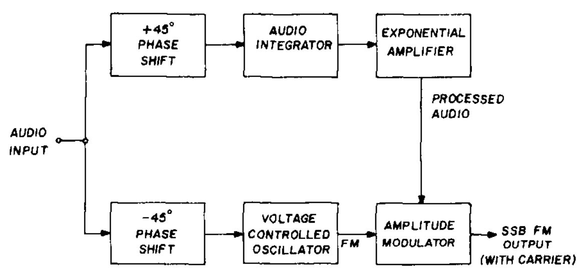

fig. 3. System block diagram of a working ssb fm generator (after Dubois and Aagaard, reference 3).

In the case of frequency modulation, it is known that the modulation index decreases by one-half each time the modulating frequency is doubled. In the narrowband case, the sideband amplitudes are proportional to the modulation index if a constant deviation is maintained. Hence, the nbfm sidebands decrease in amplitude at 6 dB per octave as the modulating frequency is increased. If the a-m sidebands can be made to behave in the same way, then the desired result will be obtained. In principle, this is easily accomplished by inserting a simple R-C lowpass filter into the a-m audio section. However, there is a very real problem which arises whenever an R-C lowpass filter is used in this way – it will be a source of audio phase shift. This phase shift will rotate the a-m vectors of **fig. 1** so that they no longer cancel the unwanted sideband. Furthermore, the audio phase shift may depend upon the modulating frequency.

In order to control phase shift, a particular kind of lowpass filter – known as an *integrator* – may be used. This introduces a constant phase shift of about 90 degrees at all audio frequencies of interest. The problem of phase matching can then be solved by the introduction of another 90-degree, all-pass network somewhere else in the system. An ordinary R-C filter can be used as an integrator provided that its time constant is at least 15 times the period of the lowest frequency component in the audio. However, the very high attenuation which results can be a disadvantage.

Unfortunately, the 90-degree all-pass network cannot be realized in practice, so commercially available audio phase-shift networks are used which produce two outputs of plus and minus 45 degrees with respect to the input audio. **Fig. 2** is a block diagram of a suggested system.

a working system

Throughout the discussion to this point, it has been incorrectly assumed that only two sidebands have to be considered in the case of nbfm. While it is true that only two sidebands are present as long as the modulation index is smaller than about 0.4, it is *not* true that what an amateur calls nbfm always has such a small modulation index.

Recall again that, every time the modulating *frequency is halved, the modulation index doubles.* This means that speech – which contains many audio frequencies – will probably contain a few frequencies which are low enough that the modulation index will considerably exceed 0.4 and which will, in turn, produce multiple sideband pairs. In such a situation, the a-m section won't have a "matching" sideband pair available, and cancellation of all unwanted sidebands will be impossible. In fact, with the fm systems used by most amateurs, nearly every audio frequency produces more than one pair of sidebands. Clearly, the hypothetical system of **fig. 2** will not do the job, and something additional is needed.

the exponential amplifier

It was at this point that Bedrosian's theory made one of its important contributions; If the audio applied to the a-m section is intentionally distorted, you can generate multiple a-m sidebands with frequencies which match those of their fm counterparts (the distortion generates audio harmonics, which in turn generate the required additional a-m sidebands). The distorting of the audio

*Lest an innocent reader attempt to detect *suppressed-carrier* ssb a-m on his fm receiver, let me hasten to add that an injected carrier is unable to maintain the proper absolute phase for fm detection and further, it must be injected before limiting takes place.

signal has to be done very precisely, and the correct way of doing it is not very obvious. It is a direct result of Bedrosian's theory that the proper method of doing this is to use a so-called exponential amplifier in the audio chain of the a-m section. The exponential amplifier is not difficult to build, and it turns out to be a kind of inverse compression amplifier. It operates by increasing its gain as the audio input voltage increases. In fact, the gain should change as the mathematical exponent of its input (hence its name). Luckily, this rather exotic-sounding behavior is obtainable simply by inserting a *properly-biased diode in a feedback loop.*

Fig. 3 shows the corrected system, and this arrangement does produce ssb fm. It is basically the same arrangement used by Dubois and Aagaard in their pioneering experiments in the middle 1960s.[3]

Snider and Schilling[6] have published an IC version of the exponential amplifier (which they called an *exponentiator*); a schematic diagram of their circuit is shown in **fig. 4** to illustrate the ease of construction (the *three transistors are an amplitude modulator*). Note that the 1N205 diode must have a 150 millivolt drop across it to provide correct operation, and that the last IC must be dc-coupled to the amplitude modulator.

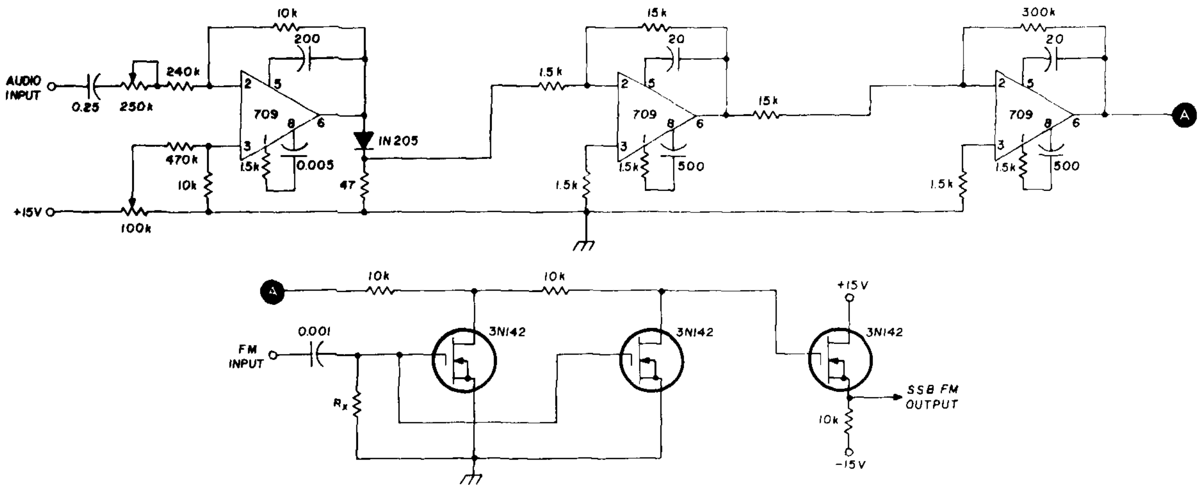

fig. 4. Snider and Schilling's experimental "exponentiator" and amplitude modulator. A dual ±15 volt supply is used. Resistor Rx was not specified by reference 6. Note that this is an example only and is not intended for home construction.

For those who are experimentally inclined, Snider and Schilling's article is recommended since it also contains schematic diagrams of a useful ssb fm amplifier, designed to produce 455-kHz ssb fm. Glorioso and Brazeal[4] give schematics for a discrete exponentiator using four transistors and also for a frequency multiplier. In fact, these two articles contain 90 percent of the constructional material which has been published in the open literature.

bandwidth of ssb fm

Now that I have touched very lightly on the electronic details of ssb fm generation, I will turn to a *question which was never answered to everyone's satisfaction*; namely, what is the bandwidth of a typical ssb fm signal?

The answer is not necessarily "one-half the bandwidth of an ordinary fm signal," and in fact depends upon the modulating waveform.[7] This is because fm produces multiple sidebands for each modulating frequency, so the bandwidth can't be as easily defined as it is for a-m. Usually the bandwidth of an fm signal is considered to equal the spectrum space which contains some fixed percentage (often 90) of the radiated power. When sideband enhancement takes place in an ssb fm generator, sidebands which didn't contain enough power to contribute to the bandwidth of the parent signal may become important. If they do, the resulting ssb fm signal will be wider than one-half of the original signal. Just how much wider, or if the signal is always wider, has never been settled because as shown in **fig. 5**, the redistribution of relative sideband power is quite uneven.

A practical rule-of-thumb would seem to be that, *first*, single-sideband signals derived from wideband fm (modulation index greater than 0.4) are about two-thirds as wide as ordinary fm and, secondly, single-sideband signals derived from narrow-band fm are one-half as wide as nbfm. However, as the later discussion will show, there are many who disagree with this evaluation.

effect of limiting

Recall that the act of amplitude-modulating the parent signal cancelled an unwanted group of sidebands; hence, the amplitude variations present in the ssb fm signal can be thought of as information about how the generator accomplished its goal. If that information is removed, it is equivalent to negating the influence of the amplitude-modulator at the generator so the original sidebands are all restored, and ordinary fm results. It follows that the act of subjecting ssb fm to hard limiting restores it to ordinary fm, and it was this potential compatibility with standard fm broadcast receivers that first attracted the attention of the developers of the ssb fm technique.

As was mentioned earlier, if ssb fm were viewed as an end in itself, you would *not* use an ordinary fm receiver to detect it, but would go in the direction indicated by Kahn and Thomas[5] – detecting both amplitude and frequency changes for later processing. Nevertheless, virtually everyone who worked with ssb fm considered only ordinary (consumer) fm receivers because they saw ssb fm as a possible way to squeeze more stations onto the commercial fm broadcast frequencies. This is an important point to keep in mind, because when you take

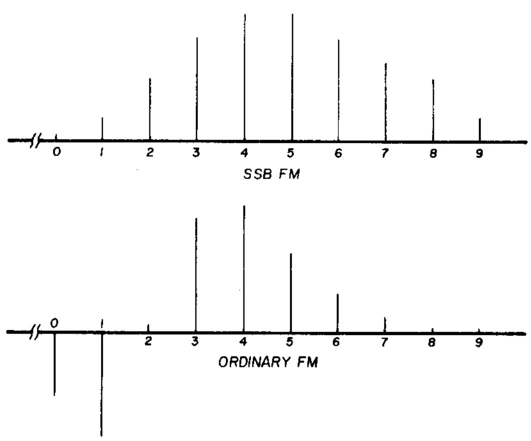

fig. 5. Relative upper sideband amplitudes for ssb fm (top) and ordinary fm (bottom) versus sideband number, where zero indicates the carrier component. Both plots are for a modulation index of 5, but are drawn to different vertical scales. Top: Carrier component equal to unmodulated signal amplitude. Bottom: Carrier component 18% of unmodulated signal amplitude.

only that viewpoint, you can easily "prove" that ssb fm is inferior to ordinary fm. The next section summarizes those arguments.

the case against ssb fm

The bandwidth (however you choose to define it) of an ssb fm signal can depend so strongly upon the modulating waveform that very great differences in its bandwidth were obtained by several workers. Mazo and Saltz,[7] who assumed so-called Gaussian modulation, concluded that ssb fm was often wider than fm whenever the modulation index exceeded three. Hence, they declared that it was of little interest for such purposes as standard broadcasting. Kahn and Thomas[5] reached the opposite conclusion for the case of sinusiodal modulation, declaring that wideband ssb fm is half as wide as ordinary fm but that narrow-band ssb fm is 1.4 times as wide! Both of these papers were entirely theoretical, and neither of them contained supporting laboratory experiments.

On the other hand, Glorioso and Brazeal built a working system and agreed with Bedrosian's earlier conclusion that a narrower bandwidth is to be expected for ssb fm. In fact, the bandwidth rules given earlier in this article are based upon these author's findings, as well as those of Dubois and Aagaard; it is believed that they represent the current best choice among decidedly divided opinions. Nevertheless, it could still turn out that ssb fm is unattractive due to bandwidth limitations.

A more certain criticism of ssb fm arises when you consider the signal-to-noise ratio at a conventional discriminator: The amplitude variations inherent in the ssb fm signal make it more difficult to obtain full limiting, so that the threshold characteristics are poorer and the threshold signal-to-noise ratio is degraded. These problems become particularly troublesome at large modulation indexes, as does an accompanying problem of maintaining phase linearity in the receiver i-f strip.[6] For all of these reasons, Snider and Schilling expressed the opinion that ". . . ssb fm will not find broad practical application, since it is both difficult to generate and does not perform as well as fm does."[6]

the case in favor of ssb fm

It must be repeated that the usefulness of any communications method depends upon the way in which it is configured. Certainly, if you want to broadcast compatible, high-fidelity ssb fm into the home of an audiophile, you have chosen an impractical goal. On the other hand, if you are interested only in communicating information to a *matched* receiver, ssb fm may indeed be attractive. For example, Glorioso and Brazeal held that, even in the wideband case, "Envelope detection, additional nonlinear processing, and filtering . . . offers threshold characteristics similar to conventional fm. . ."[4] Furthermore, they maintained that there is an accompanying saving in spectrum space.

In the narrowband case, ssb fm is readily detected with a conventional receiver and offers an improved signal-to-noise ratio over conventional fm once the detection threshold is exceeded.[4] Even though the threshold signal-to-noise ratio is still slightly poorer than that of conventional nbfm, it is believed that the loss is a very slight one or two dB.[4]

The accusation that ssb fm is "difficult to generate" depends, of course, upon your own viewpoint. Since Glorioso and Brazeal have shown that ssb fm can be generated at low frequencies and then multiplied to a higher frequency (and a higher modulation index), it is slightly simpler than ssb a-m, which must always be moved by heterodyning (mixing) techniques. Ssb fm is very much like ssb a-m in its requirements for generation and linear amplification, but these are routine requirements and constitute no serious difficulty. In short, the arguments in favor of ssb fm roughly counterbalance the negative opinions, and there does not seem to be sufficient information as of yet to make a go/no-go decision.

Particularly intriguing is the question of suppressed-carrier operation – a possibility which has not been discussed in the literature. Unlike conventional fm, it turns out that ssb fm contains a constant-amplitude component at the carrier frequency, so that carrier re-insertion at the receiver appears to be feasible. This is not immediately obvious from the information given in the references, because each author chose to normalize his calculated sideband amplitudes in such a way that the carrier amplitude appears to decrease as the modulation index is increased. Furthermore, Glorioso and Brazeal show a plot of "carrier level" versus modulation index which, at first inspection, seems to imply that the carrier amplitude does change. In reality, the plot is for the signal level, which is something quite different. Anyone who decides to consult the references should keep these facts in mind.

The main point to be made here is that carrier suppression, though apparently feasible, has not been attempted. When you consider where ssb a-m might be if no one ever thought to suppress the carrier, it is natural to wonder if this is not the next logical step to take in testing the usefulness of ssb fm.

It should be mentioned that ssb phase modulation (ssb pm) may be more attractive to amateurs than ssb fm. The reasons for this are twofold:

1. In the case of ssb fm, the peak envelope power (PEP) increases with decreasing modulating frequency, whereas with ssb pm the PEP is independent of modulating frequency (see expression four in the **appendix**). Hence, ssb pm is not as likely to overdrive any following linear amplifiers at low audio frequencies.

2. An ssb pm generator can be built from **fig. 3** by eliminating the audio integrator and replacing the vco with a true phase modulator. Therefore the circuitry is simpler.

Unfortunately, an ssb pm generator has never been explicitly discussed in the open literature so a potential designer is entirely on his own. However, this is not a very serious drawback because any existing ssb fm circuitry can be easily modified as indicated above.

closing comments

During the preparation of this article, several amateurs were asked to review it and comment. It was an almost unanimous opinion that a complete schematic diagram of a working ssb fm transmitter, along with alignment instructions, ought to be included, and I assume that a number of readers will agree. However, it is my feeling that, in addition to being beyond the scope of a preliminary article on the subject, the actual hardware is probably illegal to use in the United States due to its use of *simultaneous* fm and a-m. If the FCC makes its proposed rule changes, then ssb fm may turn out to be legal without special permission. In that case, it would be useful to explore specific equipment after it has been given on-the-air tests, but so far, no one in the amateur community can do this and be sure that it is a lawful activity. Clearly, simultaneous fm and a-m has heretofore been thought of as a sign of sloppy hardware design, rather than a valid means of signal generation, and clarification is needed. By default, ssb fm is emission type F9 (there is no F3a or F3j classification for fm), and F9 emissions are not allowed on any amateur frequency.

It is hoped that readers of this article who have access to a good technical library will be sufficiently attracted to ssb fm to pursue it to the point of designing appropriate equipment. Certainly there is more to be done in the area, and amateurs can make some genuine contributions to the art.

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H. Voelker, "On the Origin and Characteristics of Single-Sided Angle Modulation," *IEEE Transactions on Communications Technology*, 1965, page 555 (see also the discussion following by Bedrosian, Glorioso, and Brazeal).

appendix

For those readers who wish more precise details, here are some mathematical relationships:

1. Single-tone ssb fm signal voltage $v(t)$: $v(t) = V_o \exp(\beta \cos \omega_m t) \cos(\omega_o t + \beta \sin \omega_m t)$

where:

β = modulation index
ω_m = modulating angular frequency
ω_o = carrier angular frequency, and
V_o = unmodulated carrier amplitude

2. Single-tone ssb fm sideband amplitude A_m

$$A_m = V_o \beta^m / m! \qquad m = 0,1,2,\ldots$$

where:

$m = o$ yields the carrier amplitude A_o

3. Peak-to-valley ssb fm envelope voltage, V_{PV}

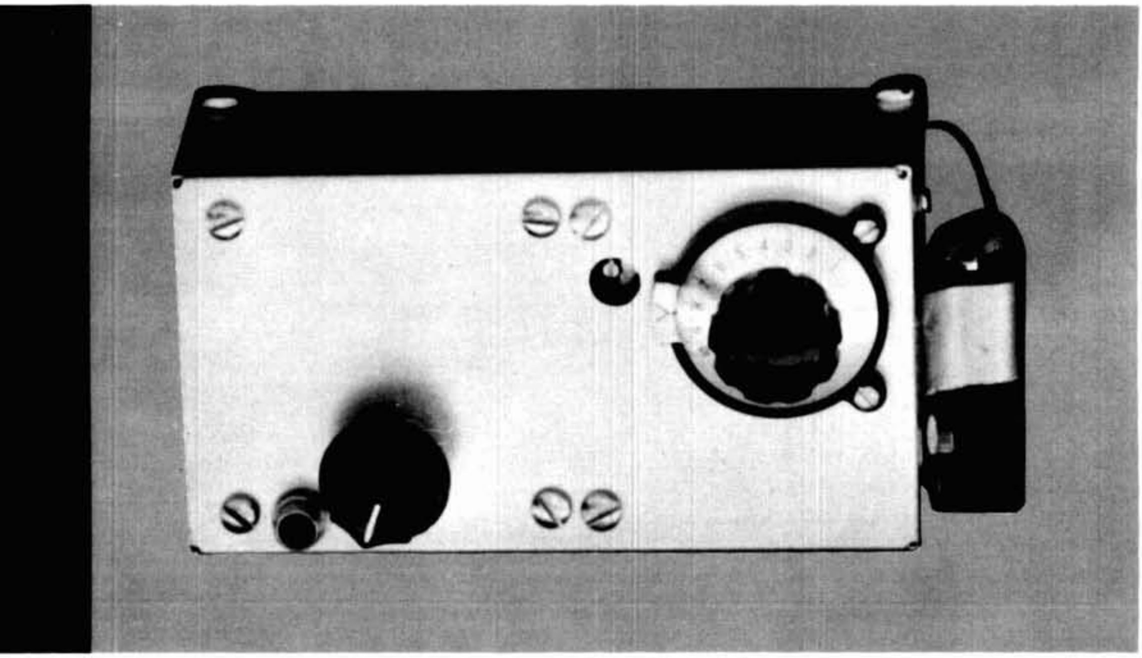
$$V_{PV} = 2V_o \sinh \beta$$

4. Peak-to-peak ssb fm envelope voltage, V_{PP}

$$V_{PP} = 2V_o \exp \beta$$

In all of the above relationships, the ssb pm case may be obtained by replacing β with ϕ, the maximum phase excursion in radians.

ham radio



direct-conversion receiver
for 40 meters

Complete construction and alignment details for a mini receiver that can be built by beginner or old timer

Here's a tiny solid-state receiver with some great characteristics for headphone reception on 40 meters. The receiver has low-noise properties and anti-overload characteristics as good as those found in some of the better vacuum-tube receivers. Idling-current drain is less than 15 mA using a 9-volt transistor battery. For identification, I call it the DCM-1. It uses an rf jfet, a vfo jfet, an audio jfet, and an op amp final audio stage. Reception is best on CW, but single sideband can be received satisfactorily when the band isn't too crowded. A miniature resonant whip antenna can be used for satisfactory reception from all over the United States.

This project was tailored with the beginner in mind. The receiver is ideal for monitoring 40-meter novice stations without requiring an outdoor antenna. The parts list is quite complete and includes many substitutions that will perform equally as well as those given as a first choice. I've included technical expanations for completeness, but don't be alarmed if at first you don't understand this material when you attempt to build this receiver. After all, we all have to start somewhere, and most of us aren't going to make the big league anyway. I was once a beginner and still don't have all the answers.

If you follow the construction directions you'll have a piece of equipment any amateur would be proud to own. A block diagram of the receiver is shown in **fig. 1**.

product detector and rf circuit

Many references have been made to direct-conversion receivers in the amateur literature. The heart of this receiver is a combination of three jfets in a Y connection such as used in a differential amplifier. This combination is almost the fet equivalent of the well-known RCA bipolar IC, type CA3028A, which has been used in product-detector circuits[1] among its many other applications. One advantage of the fets is that a much lighter load is presented to the vfo than when using bipolar transistors, so no buffer-amplifier is needed. Another advantage is that a better noise figure seems to prevail. Still a third advantage is low current drain. In **fig. 2** it's obvious that the total current drain is only that drawn by the third transistor in the Y-connection, Q3. In the case of the prototype receiver, this current was only 8 mA.

In **fig. 2**, Q1 and Q2 are the matched jfets and Q3 is the series-connected rf amplifier. The variable frequency oscillator (vfo), which functions as the local oscillator (lo), is fed to gates G1 and G2 of Q1, Q2 in push-pull

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through conventional trifilar-wound broadband ferrite transformer, T1, with a 4:1 impedance ratio.[2] Q1 and Q2 switch the rf drain current of Q3, producing a mixer output at a frequency difference between that of the vfo and the received signal, which is in the audio range. The audio output is obtained through push-pull transformer T2, whose secondary is resonated to approximately 750 Hz by capacitor C2. I found it essential to use zener diodes CR1 and CR2 across the Q1, Q2 output, otherwise high-voltage switching transients generated in T2 can burn out the twin fets.

The rf signal is fed from the antenna jack to Q3 through a double-tuned resonant circuit consisting of L1, L2. Each inductor of L1, L2 has an unloaded Q of about 220. The two resonant circuits are coupled through C7, a very small capacitor, whose value was found by experiment. Capacitor C7 is merely a twisted pair of plastic-covered solid no. 22 AWG (0.6mm) wires. Resistor R2 was set at 3300 ohms in the prototype, but should be adjusted as described below.

The original circuit was designed for use with the Siliconix E421 dual fet in the Q1, Q2 position and the E304 in the Q3 position. Both are marketed under a different number by Calectro (at least as of this writing). Using the dual fet, the circuit should be sufficiently well balanced in some applications not to require equalization of Q1, Q2 gains. For cases where equalization is desired, or where individual fets are used, the alternative connection at points X, Y, and Z in **fig. 2** should be followed, requiring a slightly different circuit-board layout, which is discussed later.

vfo (local-oscillator) circuit

The circuit of **fig. 3** is a straight-forward series-tuned Colpitts circuit,[3] also known as the Clapp circuit. Biasing diode CR1 was chosen as a germanium diode,

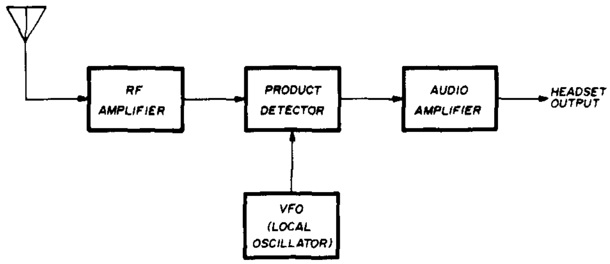


fig. 1. Block diagram of the direct-conversion 40-meter mini receiver.

because in past experiments I found that the oscillator had lower current drain than when using a silicon diode, but the choice is probably not critical. In the Clapp circuit, the impedance is low across feedback capacitors C5 and C6. Therefore it was possible to mount the tuning elements on a separate board from the transistor circuitry, locating the former conveniently close to the variable capacitor and connecting them to the latter through a 50-ohm miniature cable.

Rf chokes L3 and L4 are not critical. In my case they were wound on small ferrite cores as described in **table 1**. Small chokes, such as Millen subminiatures of 10-15 μH would be satisfactory. L2 is a Radio Shack 2.5 mH choke, but a small choke of the order of 50 μH would be satisfactory. Resistor R5 was 3900 ohms in the prototype, but might best be adjusted for the lo output that affords the highest detector audio output, as described later.

The vfo tuning inductor, L1, is a high-Q toroid. The tuning capacitor, C3, is a miniature 365 pF air-dielectric broadcast unit. Since this capacitor tunes through a large range, it was necessary to swamp its effect with fixed capacitor C4, which was 470 pF in the prototype. The

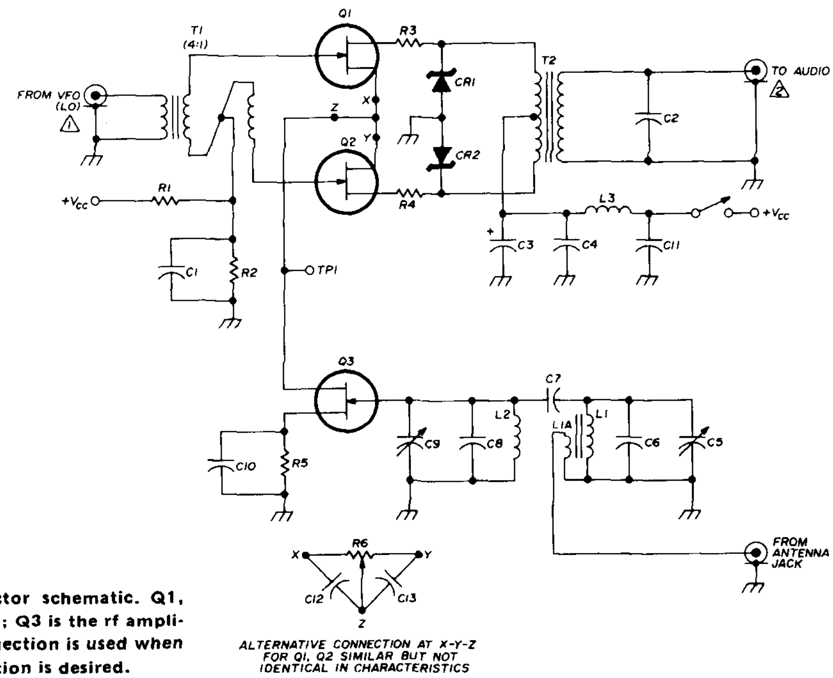


fig. 2. Product-detector schematic. Q1, Q2 are matched jfets; Q3 is the rf amplifier. Alternative connection is used when Q1, Q2 gain equalization is desired.

table 1. Parts list for the DCM-1 40-meter receiver. All resistors are ½ W, 10% tolerance. Alternative parts choices are also given.

product detector:

C1, C4; C10 through C13	0.02 μF, 25 V disc ceramic
C2	0.05 μF, 100 V mylar
C3	100 μF, 15 V miniature electrolytic, radial leads
C5, C9	5-30 pF ceramic trimmer
C6, C8	100 pF polystyrene or silvered mica
C7	coupling gimmick, twisted pair of solid no. 22 AWG (0.6mm) plastic-coated wire, 3½ in. (89mm) long
L1	30½ turns no. 24 AWG (0.5mm) on T50-6 toroid core
L1A	2½ turns no. 24 AWG (0.5mm) wound over ground end of L1
L2	31½ turns no. 24 AWG (0.5mm) on T50-6 toroid core
L3	rf choke, 2.5 mH (Radio Shack 270-1713) smaller unit OK
Q1, Q2	twin rf fet in one package (Siliconix E421 or Calectro Equivalent). Alternatively, any two hf-vhf n-channel jfets reasonably similar and used with alternate source-current balancing circuit.
Q3	Siliconix E304 or Calectro equivalent. Alternatively, a third jfet similar to Q1, Q2 may be substituted.
R1	47k
R2	Set for dc voltage source-to-drain across Q3. Use high-impedance voltmeter. Prototype receiver value was 33k
R3, R4	10-22 ohms; not critical
R5	47 ohms
R6	source-current balance pot, 100 ohms (miniature Bourns type)
T1	13 turns no. 30 AWG (0.25mm) trifilar wound on Indiana General ferrite core CF102-Q1 or Amidon T25-6 core. Impedance ratio, 4:1
T2	Push-pull audio transformer, Calectro D1-722 or equivalent
CR1, CR2	18V, ½ W zener diodes

vfo (local oscillator):

C1	small 180 pF polystyrene or silver mica (see text)
C2	5-30 pF ceramic trimmer
C3	365 pF broadcast-band capacitor
C4	470 pF polystyrene or silver mica (see text)
C5, C6	560 pF polystyrene or silver mica
C7 through C11	0.02 μF, 25 V ceramic
CR1	any germanium receiving diode
L1	49 turns no. 24 AWG (0.5mm) on Amidon T50-6 toroid core
L2 through L4	choke, 18½ turns no. 26 AWG (0.3mm) on CF102-Q1 ferrite core. Not critical. Alternative: fill T25-6 toroid with no. 32 AWG (0.2mm) wire
Q1	any good hf-vhf n-channel jfet (Siliconix E304 or equvalent)
R1	47k
R2	330 ohms
R3	4.7k
R4	10 ohms
R5	3900 ohms in prototype; see text

audio amplifier:

C1, C2	0.01 μF, 50 V
C3, C5	25 or 30 μF, 15 V miniature electrolytic, radial leads
C4, C8	same as above, but 50 μF
C7	same as above, but 10 μF
C6	0.1 μF mylar
C9	0.005 μF mylar
Q1	n-channel jfet (2N3819, HEP801 or similar)
R1	100k miniature volume control with on-off switch
R2	43 ohms
R3	27k
R4	22ks,
R5	2.7k
R6	2.7 megohm
R7, R8	5.6k
R9	220 ohms
U1	type 741 op amp

miscellaneous:

aluminum box, 5¼ x 3 x 2-1/8 (13x8x5.4cm). Bud CU3006A or Radio Shack 270-238

phone jack (size depends on plug size)

phono jack for antenna connection

dial drive, Calectro E2-744, diameter 1½ in. (38mm)

battery and battery terminal. Use heavy-duty 9-volt unit

4 spacers, 3/4 in. (19mm) tapped for 6-32 (M3/5) to support product detector panel

2 spacers, ½ in. (12.5mm) tapped for 6-32 (M3/5) to support vfo tuner panel

4 spacers, ½ in. (12.5mm) to accomodate 6-32 (M3/5) screws to support rear panels

2 or 4 4-40 (M3) binder-head screws, ¼ in. (6.5mm) long to mount variable capacitor

8 6-32 (M3/5) binder-head screws, ¼ or 3/8 in. (6.5mm or 9.5mm) long

4 6-32 round-head screws to mount rear panels

2 no. 4 sheet-metal screws 3/8 in. (9.5mm) long to secure dial drive to front panel

lockwashers: 12 6-32 (M3/5) and 4 4-40 (M3)

1 circuit board, fiberglass-epoxy, 2½ x 2½ in. (64 x 64mm), copper foil one side

3 circuit boards as above but 2½ x 1-1/8 in. (64 x 29mm)

3 ft (1m) RF-174/U coax cable

10 ft (3m) hookup wire no. 22 AWG (0.6mm) solid

2 transistor sockets

1 14-pin dip IC socket

overall capacitance of the combination was too high, so C1 was inserted in series (180 pF in the prototype). Capacitor C2, a 5-30 pF ceramic trimmer, sets the tuning at a reference frequency and dial position using a wand applied through a hole in the front panel. The prototype oscillator current drain was about 3 mA.

audio circuit

This circuit, **fig. 4**, is simple yet is the fourth one tried. The small broadcast transistor radios of the pre-IC days employed transformer-couple push-pull Class B output stages to obtain reasonably undistorted speaker output at only 200 mW. However, I noted that the overall drain of such a receiver was 7-8 mA, increasing to 16-17 mA on audio-modulation peaks. I found that even at comfortable headphone volume, a single output transistor produced intolerable distortion. An audio fet, Q1, is biased to draw only a few tenths of a milliampere. Its output feeds a type 741 operational amplifier, U1, which works satisfactorily even on a 9-volt battery, drawing about 2.5 mA. The overall receiver current increases at most about 2 mA on loud signals with the volume turned up. The circuit is the same as that of reference 4, except that resistor R6 was increased to 2.7 megohms from 0.82 megohms, affording about 10 dB more signal gain.

construction

Circuit boards. Fig. 5 is a layout of the product-detector board for the twin-fet circuit without balancing adjustment. It shows component location and drilling points. **Fig. 5** is an etching template. **Figs. 6A** and **6B** are for the product detector where a balance control is desired, whether a twin fet or individual fets are used. Mounting holes for adjustable ceramic trimmers C5 and C9 may have to be changed, depending upon the style available.

Fig. 7 shows etching templates for the small panels: **fig. 7A** the vfo oscillator; **fig. 7B** the vfo tuner; and **fig. 7C**, the audio amplifier. **Fig. 8** shows component and drilling locations for these panels. Note that the audio-amplifier layout is for the 14-pin DIP package socket. For the TO-99 package, stretch the leads to the proper hole numbers, as indicated in **fig. 7**, and solder. A separate layout is needed for the mini-DIP package. Use care to identify leads from the top of the IC, if this is what the manufacturer's diagram specifies. All boards should be of fiberglass-epoxy resin, such as G-10, with fiberglass paper as a possible substitute, and should have copper foil on one side.

In the type of construction I favor, the conductors are placed like islands surrounded by insulating material, all in a grounded matrix of copper. If this language

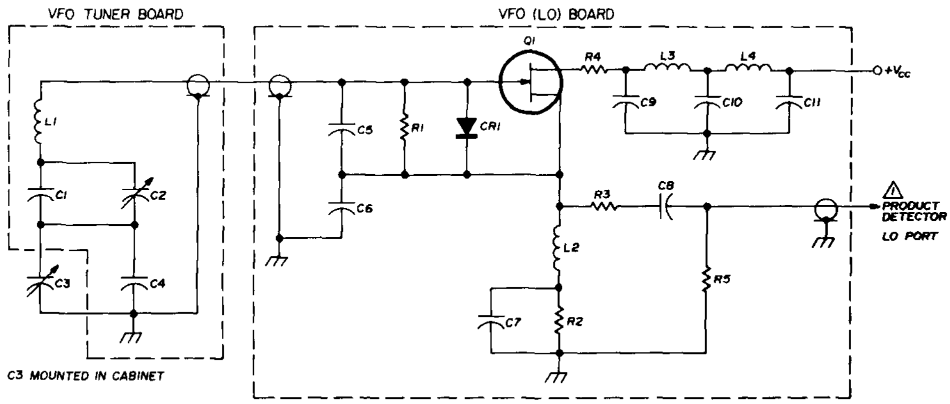


fig. 3. Vfo (local oscillator) schematic. A simple series-tuned Colpitts circuit is used for low current drain.

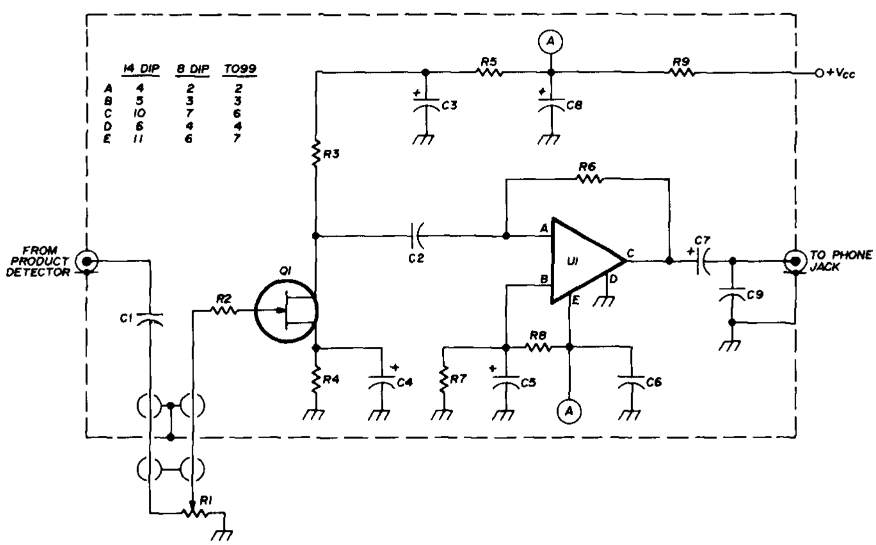


fig. 4. Audio-amplifier schematic. Circuit is similar to that in reference 4. R1 is mounted on front panel.

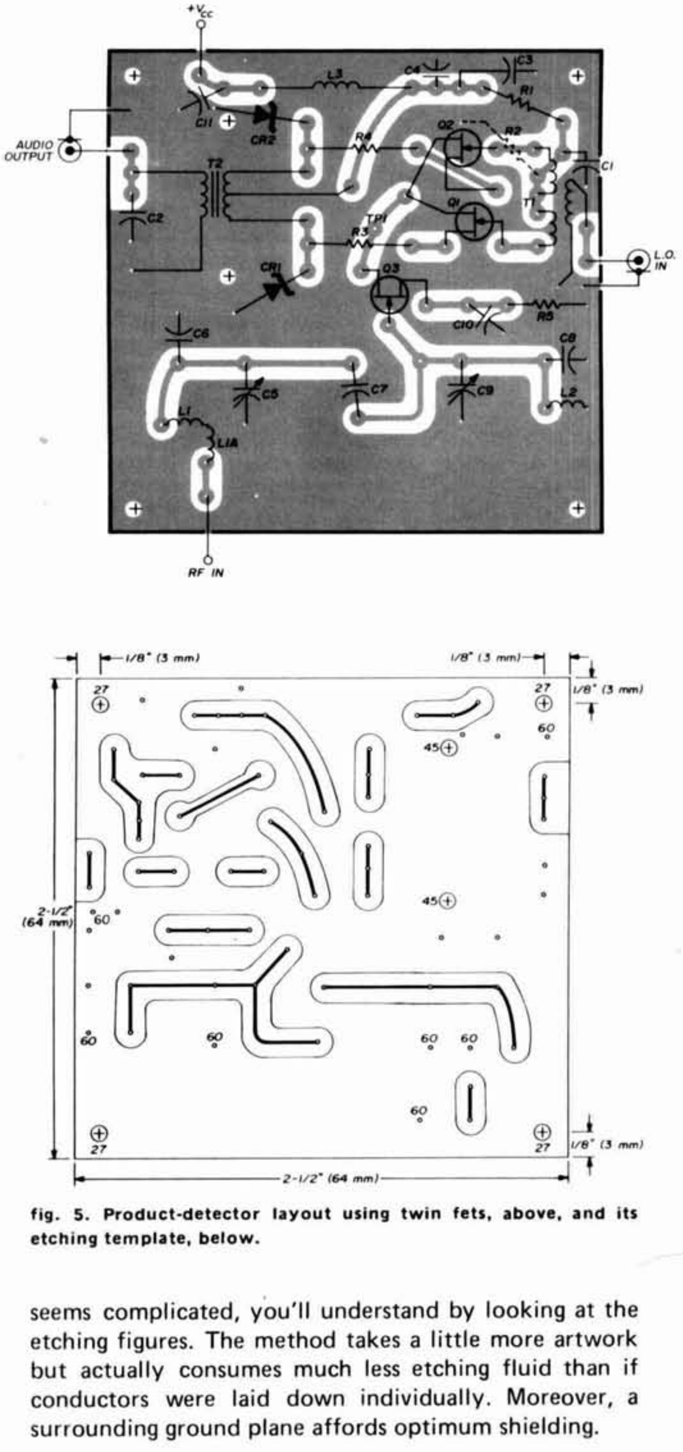


fig. 5. Product-detector layout using twin fets, above, and its etching template, below.

seems complicated, you'll understand by looking at the etching figures. The method takes a little more artwork but actually consumes much less etching fluid than if conductors were laid down individually. Moreover, a surrounding ground plane affords optimum shielding.

Drilling and soldering. Drills should be of the hardest possible steel, since fiberglass is an abrasive material. At least one source of such drills in quantity at reasonable prices has been advertised.* All small holes not specified in the diagrams are to be drilled with a no. 65 (0.9mm). A stable floor- or table-mounted drill press will work satisfactorily. Some of the holes marked for no. 60 (1mm) are obviously (from inspection of the board diagrams) to be used for grounding the braid on cables terminating adjacently, so that they may need to be still larger, perhaps no. 54 (1.4mm). Before mounting components, check all islands for shorts to ground and remove any with a knife or scratch awl.

Use care not to apply too much heat in soldering; conductors etched on the best boards can strip off! Boards made of fiberglass and paper, and others with more of a paper composition, tend to smoulder with excess heat. A pencil-type iron for circuit-board work is desirable. Use a quick, firm push with a clean iron tip into the joint, bringing the solder up simultaneously and withdrawing quickly. For best results, the copper should be cleaned immediately before soldering to inhibit corrosion. Plating the finished board with tin or silver will improve soldering effectivity. (A chemical tin-plating kit is sold by Burstein Applebee). The small battery-operated soldering irons are great for getting into small places, and there is an advantage in not dragging a cord around.

After a board has been completed care must be taken to clean off any rosin that bridges the insulating space between conductors and ground. This is important on high-impedance circuits and if the equipment is to be used in a humid climate.

A question arises as to whether to solder transistors and ICs in place or to use sockets. Space and cost are saved by not using sockets, but plugging semiconductors in and out makes it a lot easier to use cut-and-try procedures. In the product-detector board, I soldered the units in place, mainly because the E421 fet would have required an awkward socket wiring arrangement; the other boards are laid out so that sockets may be used if desired. Protect semiconductor leads from heat when soldering and desoldering.

Circuit changes and repairs are not too difficult if you remember not to apply too much heat and to heatsink semiconductors whenever necessary. If a removed component leaves a hole plugged with solder, the solder blob may be removed easily with rosin-coated copper braid sold under the name of *Solder Wick*.

testing and adjustment

Product detector and rf amplifier. The first test and adjustment procedure applied to the product detector is to determine the equality of dc voltages across the upper transistor pair and the lower transistor. Voltages should be measured using test point TP1 (**fig. 2**), which is a short tinned wire to which small clips may be attached. Measurements should be made with a high-impedance voltmeter. No vfo voltage should be applied to the lo port of **fig. 2**. Leads to a 10k pot can be temporarily attached in lieu of R2. The correct setting of the pot determines the value of R2 to the nearest fixed value available. Equalizing the dc voltages is desirable to avoid running Q1, Q2 at too-low voltage. Under these conditions, an fet will be driven into regions of the operating characteristics considerably below pinch-off, resulting in excessive distortion. This was especially true with the E421s and E304s tested, where the zero-bias saturation drain current, I_{dss}, was not reached until the drain voltage was close to 6 volts; i.e., V_p, the pinch-off

*Trumbull, 833 Balra Drive, El Cerrito, California 94530.

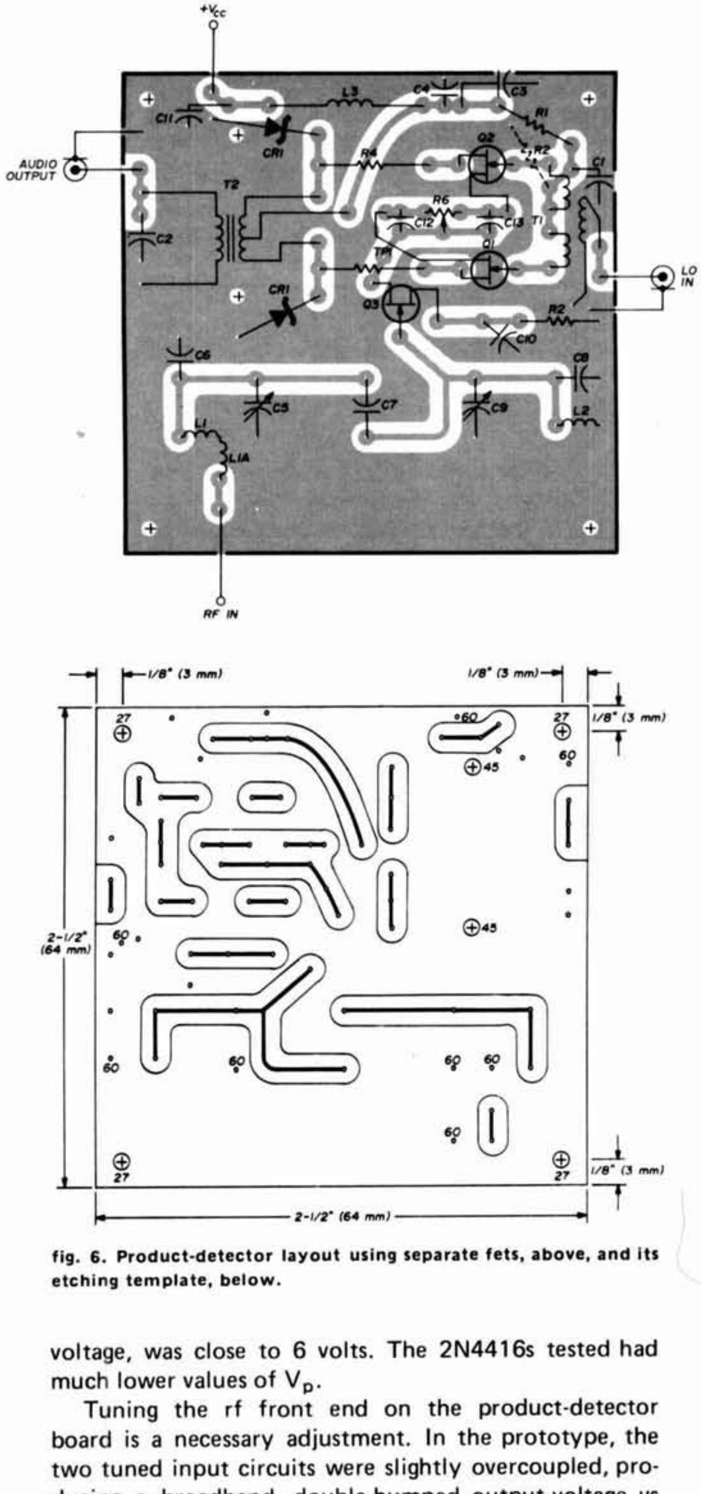


fig. 6. Product-detector layout using separate fets, above, and its etching template, below.

voltage, was close to 6 volts. The 2N4416s tested had much lower values of V_p.

Tuning the rf front end on the product-detector board is a necessary adjustment. In the prototype, the two tuned input circuits were slightly overcoupled, producing a broadband, double-humped output-voltage vs frequency response, covering 7.0-7.3 MHz. The mixer was operated again without vfo input. In my tests the output of Q3 was measured at TP1 with an rf probe attached to a vacuum-tube voltmeter. Q3 output can also be measured with an oscilloscope probe if the oscilloscope vertical amplifiers will pass 7 MHz. Yet another way is to fashion a probe with a piece of coaxial cable. A small capacitor is placed in series with the center conductor and touched to TP1. At the probing end of the cable the shield should be grounded to the board with a short clip lead. The other end of the cable should go to a receiver, and the output is read on an S-meter.

Still another way to read Q3's relative output is to operate the mixer as a mixer and read the audio output at the beat-note frequency that gives maximum audio output. Many test voms have an ac response up to 1000 Hz. One could be used at the 741 output with the headset disconnected. This method requires a minimum of test equipment but is a little more critical in adjustment.

With the relative-output technique determined, the actual adjustment of the tuned circuits is best accomplished by the following method. Use a signal generator or other equivalent shielded source with a means of attenuation. Attach small clips to short leads of a capacitor of about 470 pF. Tune the signal generator to the center of the desired frequency range and feed its output into the antenna input. Short-circuit L2 and its capacitors with the test capacitor. Force a large signal through and adjust C5 for maximum Q3 output, making sure Q3 is not overloaded. Next, clip the capacitor across L1 and tune C9 for maximum. Always make sure that the maximum occurs in two places as the capacitor is rotated through 360 degrees, otherwise the circuit must be altered to produce resonance.

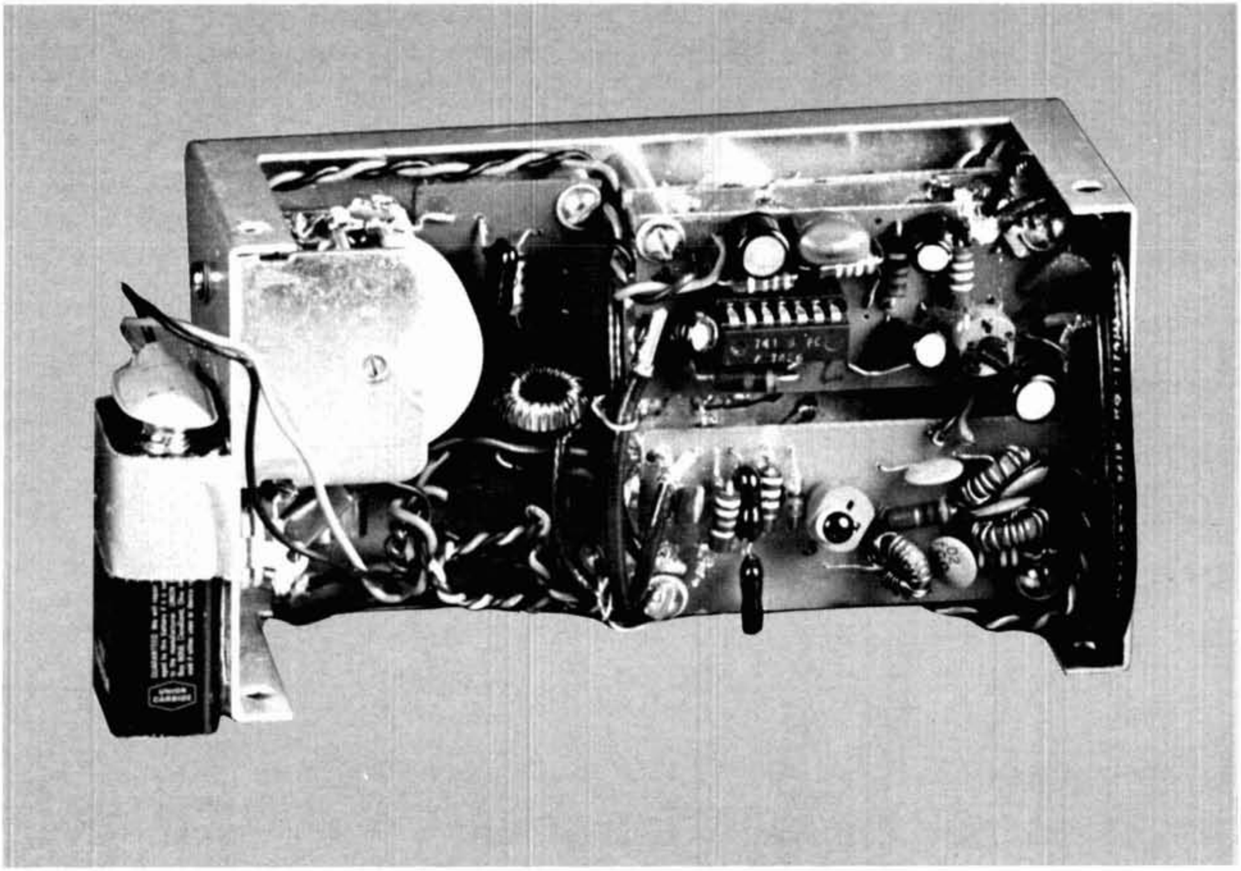
After both sides are resonated, the auxiliary shunting capacitor is discarded. Then it should be possible to measure output with a small-signal input, and it will be necessary to reduce the input to prevent overload. As frequency is changed the output should be a double-humped curve if C7 is large enough to cause overcoupling. If C7 is reduced to a value equal to or less than that needed for critical coupling, the curve will be single humped at the original frequency of tune up. A too-small value of C7 will make the front end resonance curve too narrow for some purposes, and as C7 is made still smaller, the signal-to-noise ratio will deteriorate.

At this point it's evident we're going to have to test several units in conjunction with one another. It should be observed from the diagrams that all rf and audio leads connecting the boards to each other and to the cabinet are coaxial cables, whereas dc leads are pairs of wires braided together. A ground wire braided with battery leads affords some shielding. In the final layout, the units using coaxial cables should be joined by miniature cable lengths just long enough to enable servicing the receiver with boards removed, and the same applies for the dc leads. Earlier, somewhat longer pieces of coax can be used for convenience in bench-testing the newly built units.[5] Temporary dc leads are no problem. It's a good idea to use a current-limited power supply with a milliammeter in series with the line to any new unit to be tested. Gradually bringing up the voltage lets you know whether or not the current drain is reasonable.

Vfo (local oscillator). Vfo alignment is fairly straightforward, although the variable capacitor presents some problems. Before aligning the vfo, it's necessary to have the variable capacitor and the vfo tuning board fastened in position in the aluminum box, so this procedure is described with reference to **fig. 9.** (Drilling and removal of burrs should have been done before mounting was started).

The prototype receiver was designed to use a small, imported 1-1/2 in. (38mm) dial drive with an 8:1 gear ratio, turning a miniature 365-pF air-dielectric capacitor. Difficulties arise from the fact that sizes and mounting-hole positions may vary in different shipments of the better form of dial drive seemed possible but could not be developed in time. Note that in rotational alignment, before drilling and tapping for set screws, the dial should read approximately 0 with the plates fully meshed.

The tuning-capacitor plates are quite close, so *great care* should be used to prevent metal chips from lodging between the plates and in the ball bearings. While drilling or filing, vulnerable places should be covered with masking tape. When drilling into a cabinet or chassis that



Interior view of the direct-conversion receiver. Audio board is at upper right, with vfo board mounted below. Printed-circuit layouts are shown in fig. 7.

same units. The worst problem, however, is in aligning the capacitor shaft with the dial-drive collar. Even if the shaft could be perfectly aligned, the hole in the collar would probably be a poor fit for the shaft. In the prototype I hack-sawed the capacitor shaft to the proper length and drilled and tapped the collar and the shaft at right angles for two 4-40 (M3) screws. The result was a capacitor that doesn't rotate quite all the way to the closed position (the shaft slipped while drilling). Worse, some drive eccentricity occurred. With the capacitor screwed tightly to the cabinet side, the lateral pressures on the shaft were enough to cause plates to short circuit. The solution was to loosen the capacitor mounting screws and ground the capacitor frame to the vfo tuner board with a short piece of braid. *Solder Wick* was used as the braid. Eccentricity was still present, causing some annoying backlash during frequency calibration. A already contains boards and components, it's frequently beneficial to stuff areas to be drilled with small pieces of paper towling or rag. Chips can be removed from odd corners in the same way that small hardware can be removed from tight places: wrap a piece of masking tape with the sticky side out at the end of a pencil and probe.

After mounting the capacitor and dial drive, the vfo tuner board should be mounted, foil side down, on two ½-inch (12.5mm) threaded spacers. A short piece of solid, tinned no. 18 or 20 AWG (1.0 or 0.8mm) wire should protrude from the top of the board, to be soldered to the stator section of C3. See **figs. 7B, 8B,** and **9.**

Now let's resume the vfo test. One sure indication that the vfo is oscillating is that, as the dc voltage is raised, the current will increase until oscillation occurs. When this happens, the meter will jump to a lower value of current. When the vfo is oscillating and voltage is reduced, the current will jump up when the oscillator quits oscillating, but at a lower voltage than where oscillation started as voltage was raised. Never plan on operating an oscillator at a supply voltage below that required to start oscillation, or even close to that upper point on the high-voltage side.

When the oscillator is working and feeding the product detector, the lower limit of the desired tuning range should be set by turning the dial to, say, **5** or **10**, allowing some leeway for oscillator drift. Then frequency-set capacitor C2 should be adjusted for this frequency as received on a receiver. If it's not possible to hit the desired frequency and bandspread, remember that increasing C4 and decreasing C1 together increases the bandspread, but increasing C4 lowers the frequency and decreasing C1 raises it, so you have considerable leeway in setting the frequency and bandspread. For

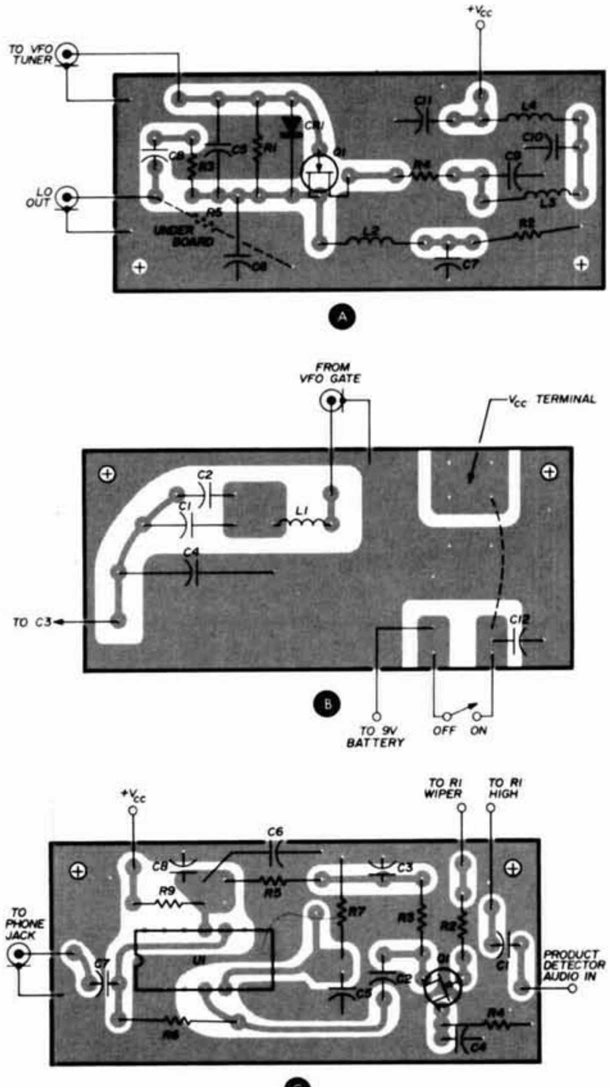


fig. 7. Component placement and etching templates for the small panels. Vfo oscillator board, vfo tuner board, and audio-amplifier board are shown in A, B, and C respectively.

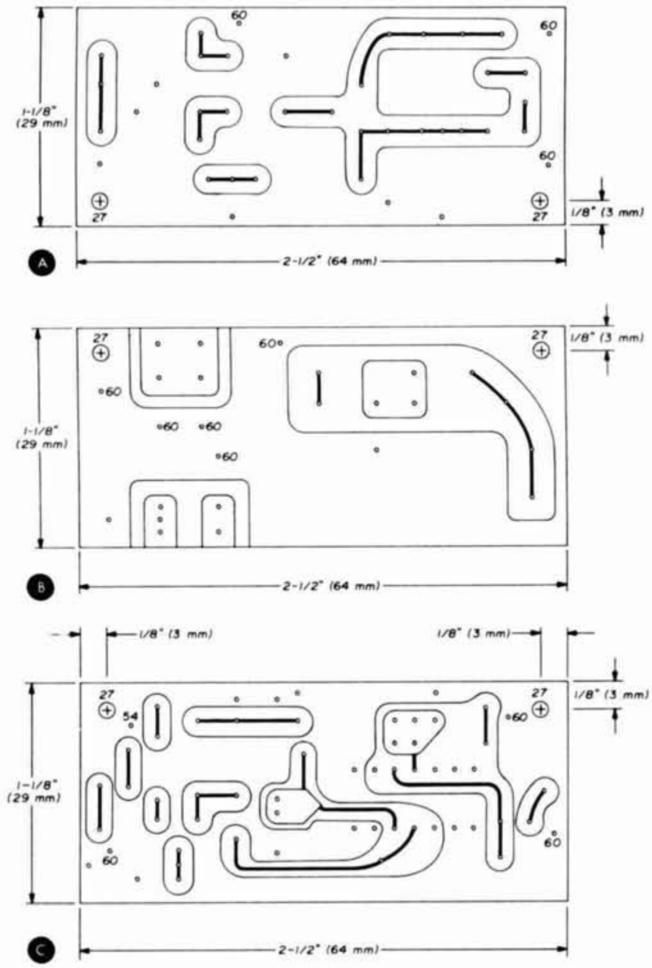


fig. 8. Circuit-board layout and drilling locations for the small panels. Vfo oscillator board is shown at A; vfo tuner and audio boards are shown in B and C.

instance, to cover a limited portion of the 40-meter band (like the novice band), you might first try reducing C1 to 120 or 150 pF and increasing C4 to 510 or 560 pF.

The vfo local oscillator output voltage can be adjusted by varying R5. The local oscillator drive voltage to the product detector is not especially critical, but values of R5 in **fig. 3** can be chosen by experiment for maximizing audio output. In my case 3900 ohms was found to be the best, producing an input voltage of 0.9 volts rms to each gate of Q1, Q2.

Audio amplifier. Audio board construction is straightforward. although components are a little crowded. Initial tests can be made with the volume control, R1, hanging loose. Although the output of the product-detector audio transformer is at high impedance, the 50-ohm shielded cables to the 100k volume control can be used, because they contribute in part to the capacitance that resonates the audio transformer secondary (i.e., at audio frequencies, a short length of cable is merely a small capacitance). Using these cables is necessary to prevent the high-gain audio circuit from self oscillating under certain conditions.

Final assembly into the small cabinet should be done by reference to **fig. 9**, and is much easier than it looks; it is a gradual process of fitting panels and shortening leads and cables. The 365-pF variable capacitor and the vfo tuner board have been previously mounted. After the volume control and antenna jack are mounted, the four 3/4-inch (19mm) threaded spacers are mounted to the rear end of the front panel. The product detector panel between the variable-capacitor frame and the cabinet cover, but the pressure caused the capacitor to short in some positions. The battery was finally mounted on the outside of the cabinet with wires passed through a notch on the cover plate.

a miniature antenna

The receiver was designed to work with a 50-ohm

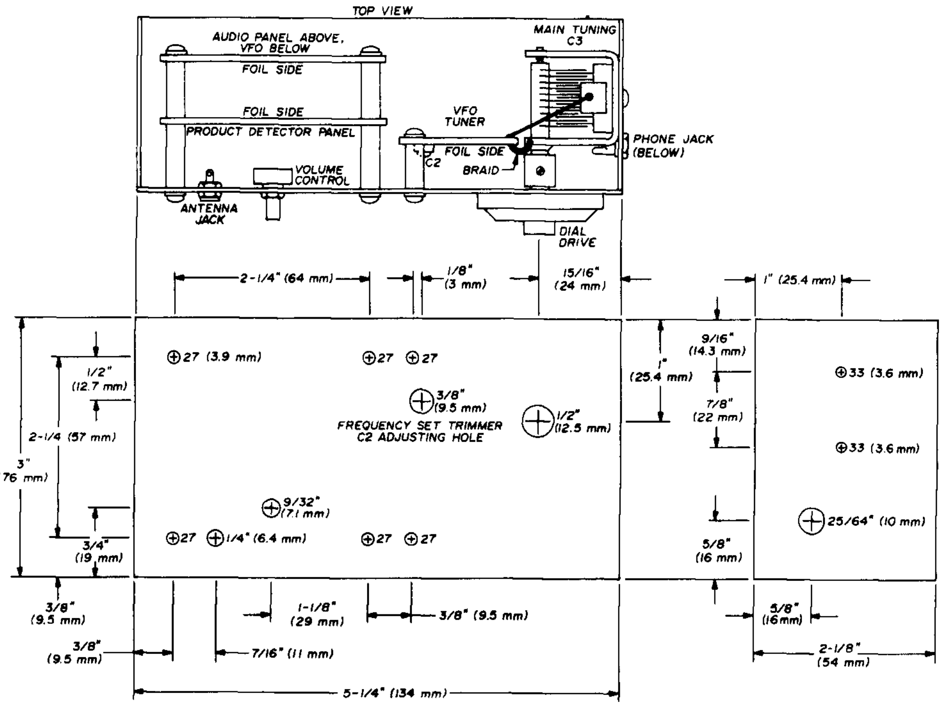


fig. 9. Cabinet layout showing drilling and component-mounting details.

is then laid in position against these spacers. The foil side must face the rear, the bulky components occupying the space between the epoxy side and the cabinet front.

The audio and vfo boards are positioned behind the detector. The audio board mounts on top and the vfo board below, with the foil sides facing inward. They are spaced from the product detector by four 1/2-inch (12.5mm) spacers that are not threaded but pass 6-32 (M3/5) screws. The whole assembly is then secured by four 3/4-inch (19mm) 6-32 (M3/5) screws, which go into the original four threaded spacers, as shown in **fig. 9**. Lockwashers are used at front and rear.

The cables and dc wire pairs can be tucked into the space between the spacers and the box at the edges. Dress the wires and cables away from tuning inductors and the high-voltage side of all rf circuits.

The V_{cc} wires should terminate at the V_{cc} terminal, located for convenience on the vfo tuner board, **fig. 8B**. The ground wires can be soldered in the appropriate adjacent holes on the ground-foil area. A twisted pair should go to the on-off switch on the volume control. The 9-volt battery connects to a standard snap-on terminal with red and black wires, which go to points indicated in **fig. 8B**. Originally, the battery was forced

outdoor antenna, but excellent results can be had with small antennas for indoor and outdoor use. Even a piece of wire strung up in the room and connected to the antenna jack will bring in many signals. A small, resonant loaded-whip antenna was designed that works very well for outdoor portable use and also indoors when not too near pipes, wires, heat ducts, and flourescent lights.

Fig. 10 illustrates the antenna. A section of RG-58/U coaxial cable with a phono plug at the lower end is strapped to a 3-foot (1m) piece of dowel. The dowel can be mounted in a board as a strand or fastened to the receiver with cable clamps, but in the latter position, there may be some chance of the lightweight reciever overturning. A fiberglass rod could also be used.

A small insulating board of fiberglass or phenolic is mounted flat to the top of the dowel. On one side is mounted a slug-tuned coil form such as J.W. Miller no. 43A001CB1, with the winding space filled with no. 28 AWG (0.3mm) enamelled wire. The end nearest the mounting nut is fastened to the cable center conductor. The shield at this point is not connected anywhere. The hot end of the coil is connected to a pair of galvanized-wire "antlers" spead horizontally from a screw on the other side of the board. Sections of hard-drawn tinned busbar would be even better. The antlers provide top loading. At resonance, the antenna has a resistive impedance near 50 ohms, but it would be difficult to determine what part of this resistance is due to losses.

Approximate resonance can be found with a grid dipper and final resonance determined on background noise or with a signal generator on a small antenna. Tuning, of course, is with a tuning wand, keeping your body, phone cord, and other wiring as far away as possible from the system. A lighter weight antenna could be made using a toroid core on a T50-6 form, adjusting the turns to something near desired resonance. The slug-tuned coil can be protected by a plastic pill bottle.

summary

One outstanding feature of this receiver is its large dynamic range. With a signal inserted directly at the gate of Q3 in the prototype, the output was linear with input up to a 1-dB saturation fall-off[6,7] at 850 mV rms input, representing an output audio voltage of 8.5 volts rms at about 750 Hz into the 100k volume-control load. Since the audio transformer has a turns ratio of about 2.24, this represented a push-pull drain voltage of 8.5/2.24 = 3.8. In the more linear portion of the characteristic, at lower inputs, the overall voltage gain was 13.3, or 22 dB (from the Q3 input to the transformer output). Of course, Q3 may have a gain of the order of 20 dB, leaving the conversion gain of switching pair Q1, Q2 small, but much better than if diodes had been used.

The double-tuned high-Q rf input has a voltage gain of 50, or 26 dB, so that the signal gain from the antenna jack to the audio-transformer output was 22+26, or 48 dB. Additionally the noise figure appeared to be very good. It was estimated that only about 0.2 mV input was needed for a 10-dB signal-to-noise plus noise ratio. Of course, you'd want to use the full resonant gain of the front end when using the small antenna. With a large antenna, you might be concerned that the saturation voltage is the original 850 divided by 50 (gain of the resonant circuits), or only 17 mV. Yet in practice, with an excellent outdoor antenna, I've failed to notice any great blocking of the receiver by strong signals – and here it must be remembered that the receiver has no agc circuit. When signals are too strong, merely turn down the audio volume. If blocking is a problem, an rf attenuator can be switched into the antenna input.[8]

The most obvious problem in this receiver is that the audio beat note appears on both sides of zero beat and selectivity is poor. DX can be received well when nearby stations are skipping over. Selectivity can be made comparable to that of an expensive receiver by using a good active audio filter, such as that made by MFJ Enterprises, if you can afford the extra 8 mA current required. However, the backlash in the present tuning system makes it easy to lose the signal. A high-Q resonant transformer might be a good compromise.[9]

One disappointment with the original design was finding more than 100 mV rms of lo signal at TP1 in the product detector with the equipment running at 1.8 volts gate-to-gate lo voltage on Q1, Q2. This represents an unbalance voltage of unknown origin, which could be due either to unbalance in the transformers, phase unbalances, or even differing gains of each of the twin fets despite identical dc drain currents. Although back leakage through Q3 to the antenna must have been smaller than a few millivolts, such leakage could be detected as a signal comparable with low background noise, with the prototype receiver on the miniature antenna and a standard receiver on my big antenna. With two adjacent

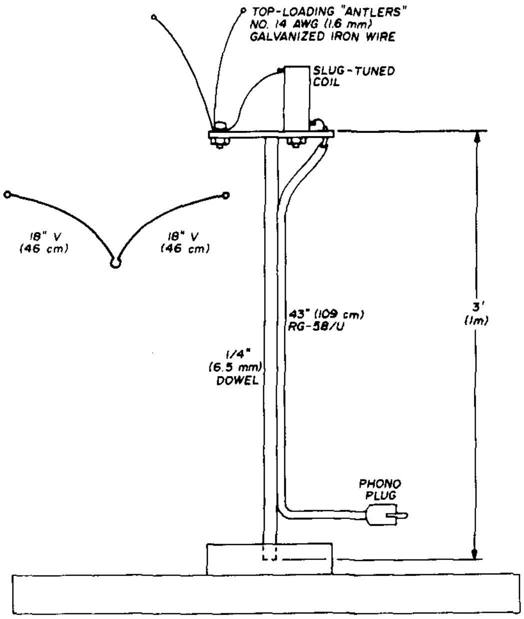


fig. 10. Miniature resonant antenna for indoor use or as a portable outdoor antenna. Tuned circuit has a voltage gain of about 50, or 26 dB. At resonance, the antenna has a resistive impedance near 50 ohms.

large antennas, the effect would be more serious, although the radiation would still be only microwatts. So I recommend, where amateur stations are close together, using the alternative product detector and adjusting R6 of **fig. 2** for minimum antenna output, which should correspond to minimum lo unbalance voltage at TP1.

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ham radio

the ground-plane antenna: its history and development

Some useful information for those interested in the design and adjustment of this popular antenna

This article will be of value to those interested in designing and adjusting ground-plane antennas. The article describes the original invention of the ground-plane antenna, points out an error in assumptions regarding radiation resistance, and includes formulas for designing a simple matching network.

background

A study of 30 - 60 MHz antennas made in 1936 by Dr. George H. Brown and J. Epstein of RCA brought to light two principal defects in most types of such antennas used at that time: the transmission line was not terminated properly, and sizable standing waves occurred on the outside of the coaxial transmission line. The J-antenna and the sleeve or coaxial antenna (both popular at that time) were found to be particularly susceptible to such standing waves.

Brown and Epstein found that the use of horizontal quarter-wavelength ground rods extending from the base of the vertical antenna established a virtual ground plane and shielded the coaxial line from the rf field of the antenna. Two types of coaxial matching networks were developed. Both supported the antenna rod mechanically, insulated it from ground at rf but grounded it at lightning and dc frequencies, and at the same time provided a good impedance match between antenna and transmission line at the operating frequency. Two patents resulted from this work: the original[1] was issued in 1941, and another was issued on an improved design[2] in 1942.

The original design, **fig. 1**, was built and tested in 1938 in Camden, New Jersey. It was my privilege to witness some of these tests. The first design used a quarter-wavelength antenna rod, four quarter-wavelength ground rods, and a quarter-wavelength coaxial support stub shorted at the bottom end. The coaxial transmission line was matched to the antenna base resistance (the reactive component was negligible when the antenna was exactly one-quarter wavelength long) by a quarter-wavelength coaxial line connected between the antenna base and the antenna end of the transmission line.

This quarter-wavelength line had a characteristic impedance of

$$Z = \sqrt{R_a Z_l} \qquad \textbf{(1)}$$

where

Z = characteristic impedance of the quarter-wavelength matching section (ohms)
R_a = antenna resistance (ohms)
Z_l = transmission-line characteristic impedance (ohms)

This coaxial matching section can be compared to the so-called Q-section used by many amateurs years ago as an impedance transformer between an open-wire transmission line and a center-fed antenna.

improved design

In the improved ground-plane design, **fig. 2**, the coaxial Q-section was eliminated, the transmission line was connected directly to the antenna base, the antenna was shortened to present an impedance of 19-j29.5 ohms, and the previous quarter-wavelength support section was shortened to about one-sixth wavelength. This shorted stub then had an inductive reactance of about +42 ohms which, in parallel with the capacitive antenna impedance of 19-j29.5 ohms, resulted in a parallel impedance of 65 ohms – the characteristic impedance of the coaxial transmission line used at that time. Each of the four horizontal ground rods remained a quarter wavelength long. Tests showed that their length was not too critical.

The values above were calculated as follows, as stated in Dr. Brown's article in *Electronics*:[3]

By Harold C. Vance, Sr., K2FF. (Mr. Vance became a silent key in August, 1976.)

The parallel inductive reactance of the matching stub required for parallel resonance with the capacitive reactance of the antenna is

$$X_s = \frac{R_a^2 + X_a^2}{X_a} \tag{2}$$

where

X_s = stub reactance (ohms)
R_a = antenna resistance (ohms)
X_a = antenna reactance (ohms)

The parallel impedance of the antenna, a pure resistance at resonance, is

$$R_p = \frac{R_a^2 + X_a^2}{R_a} \tag{3}$$

where

R_p = terminating resistance presented to the transmission line at the antenna base.

In his *Electronics* monograph[3] Dr. Brown points out that, ". . .it is practically possible to present a resistance that will match a concentric transmission line of any characteristic impedance above 25 ohms. . .but the antenna length becomes extremely critical when resistances in excess of 100 ohms are desired."

The evolution of the ground-plane antenna design is described in detail in an article by Dr. Brown and J. Epstein in the July, 1940, issue of *Communications* magazine.[4] This article also shows a ground-plane antenna with a close-spaced reflector. A gain of approximately 3 dB was obtained. The antenna and matching-stub lengths were changed slightly to maintain a match between antenna and transmission line when the reflector was added.

erroneous assumption

In an article on the ground-plane antenna, Stephens[5] refers to an article by Hassenbeck[6] giving formulas and curves that claim to be values of resistance and reactance of a vertical antenna supported above four one-quarter wavelength ground rods. Hassenbeck states that data given by King and Blake[7] was used in establishing his curves.

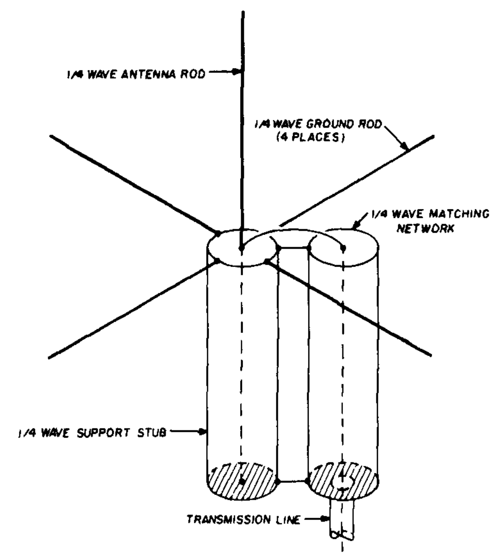


fig. 1. Original ground-plane antenna design, which was built and tested by RCA in Camden, New Jersey in 1938. The coax matching section may be compared to the familiar Q-section transformer used by amateurs years ago to match open-wire transmission lines to center-fed wire antennas.

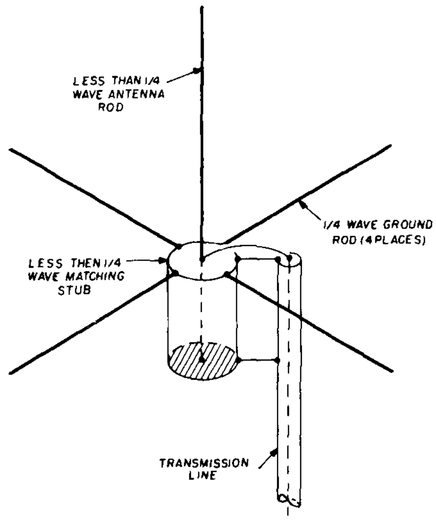


fig. 2. Improved ground-plane antenna. The coaxial Q-section was eliminated, and other innovations resulted in an antenna that was easier to match and adjust.

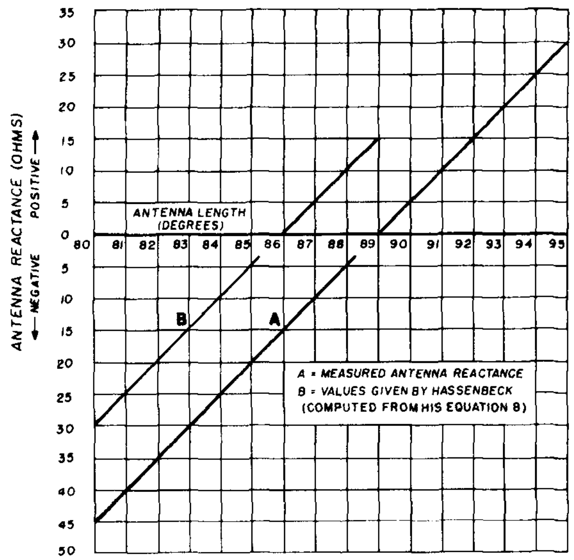
Dr. Brown pointed out[3] that, "the data given by King and Blake apply to a symmetrical antenna fed at its center or to a vertical antenna operating against an infinite metal sheet. . .there is a fundamental difference in the impedance of an antenna operating with four ground rods and an antenna operating over a semi-infinite sheet."

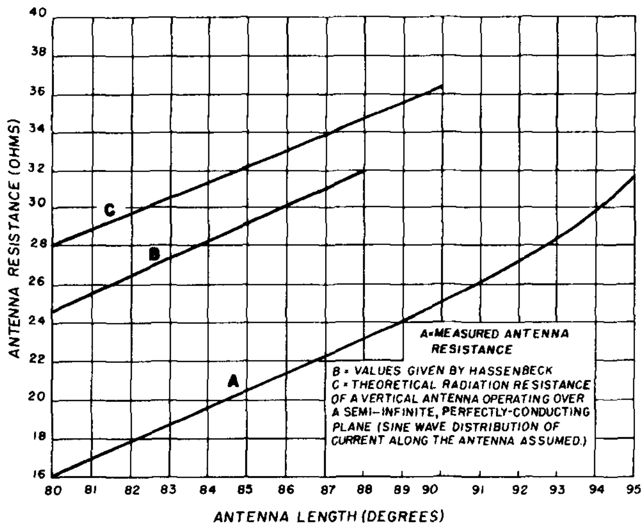
Actual measurements made by Dr. Brown showed that an antenna using four ground rods "has an appreciably lower radiation resistance than is generally assumed for the same antenna operating over a semi-infinite conducting plane." He stated that, "with an antenna exactly one-quarter wave in length, replacing the four ground rods by a metal disc one wavelength in diameter changed the actual measured radiation resistance from 25 ohms with the ground rods to 37 ohms with the one-wavelength-diameter disc."[3] Measurements of an earlier experimental unit[4] showed an antenna resistance of 21 ohms with ground rods.

The actual antenna resistance and reactance values shown in **fig. 3** were measured at 60 MHz. The ground rods were one-quarter wavelength at 60 MHz. The antenna-rod diameter was 0.625 inch (16mm), and its length was varied to those shown in the curves.

In Hassenbeck's article[6] the characteristic impedance of the support stub was assumed to be 70 ohms. In the RCA MI-7823-A antenna,[3] Dr. Brown used a stub having a characteristic impedance of only 41 ohms "to lengthen the support section when low frequencies requiring long antenna sections were used, and to make the adjustment of the shorting plug less critical."

In the case of the MI-7823-A antenna the length, S, of the inductive matching and support stub in electrical





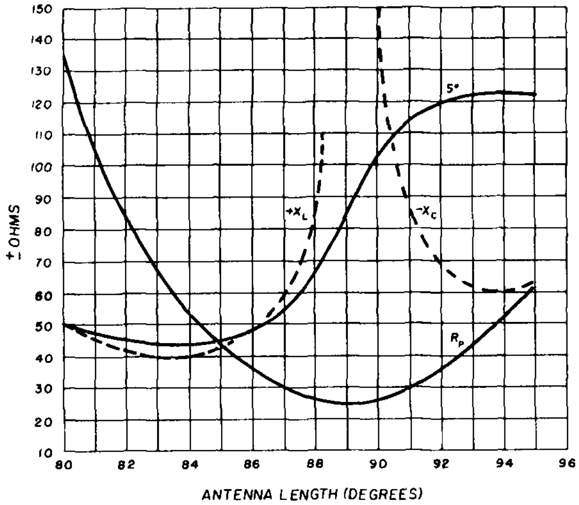


fig. 3. Actual resistance and reactance values of the ground-plane antenna measured at 60 MHz compared with values given by Hassenbeck in reference 6 (top two graphs). Bottom set of curves shows characteristics of the RCA MI-7823-A ground-plane antenna including parallel-resonance resistance, R_p; shunt reactances, X_L and X_C, required for resonance; and matching-stub length, S^o, required for the various values of reactance and resistance.

degrees (360° = one wavelength) is given as:

$$tan\ S^\circ = \frac{X_{stub}}{41} \qquad (4)$$

where X_{stub} is the reactance of the matching stub (ohms) and *41* is the characteristic impedance of the MI-7823-A matching stub (ohms).

In more general terms,

$$tan\ S^\circ = \frac{X_{stub}}{Z_{stub}}, \qquad or\ S^\circ = arctan\frac{X_{stub}}{Z_{stub}} \qquad (5)$$

where Z_{stub} is the characteristic impedance of the stub (ohms).

That is, the stub length, *S*, in electrical degrees equals the angle whose tangent corresponds to the value obtained when X_{stub} is divided by Z_{stub}.

conclusion

The need for actual experimental measurements is well illustrated by the error of Hassenbeck's assumption that the radiation resistance of the ground plane antenna would be the same as that of an antenna operating over a semi-infinite sheet. Many factors such as proximity of other objects, incorrect assumptions, and structural differences can cause actual values to vary widely from calculated values. An R + jX bridge, such as those described in *QST*[8] and *ham radio*[9,10] will prove invaluable for this purpose.

acknowledgement

I wish to thank Dr. Brown for furnishing me with copies of the referenced articles by him and J. Epstein.

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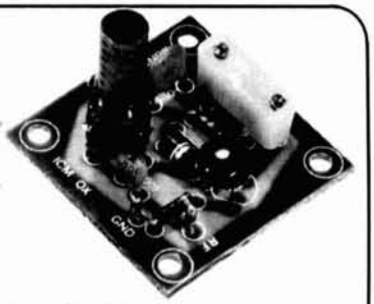

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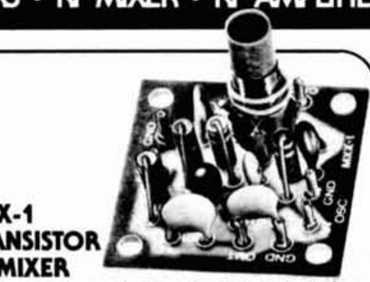

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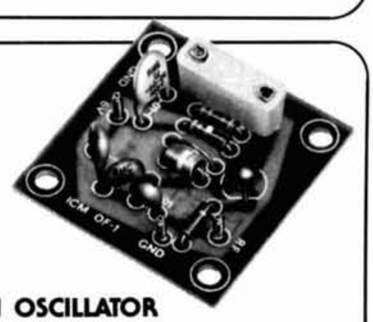

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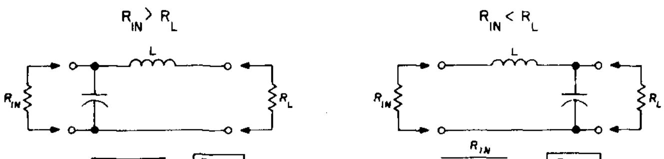
More Details? CHECK—OFF Page 126

broadband matching techniques for transistor rf amplifiers

The ins and outs of transistorized rf amplifiers can be effectively matched by using broadband matching techniques

Ever since the introduction of the transistor, there has been considerable interest in using the low-impedance characteristic of these devices to advantage in the design of broadband amplifiers. The most critical parts of a multi-octave amplifier are the input and output impedance transformation networks. In general, it is more difficult to accomplish large impedance transformation ratios, or to design networks which can transform low impedances. The latter because transmission-line transformers require a very low line impedance, which usually limits them to impedance ratios of less than 16:1 in 50-ohm systems; other types of transformers require tight coupling coefficients (or excessive leakage inductance will reduce the effective bandwidth).

Numerous methods have been successfully used in broadbanding vacuum-tube amplifiers. However, most of *these methods yield relatively poor results when applied* to low-impedance transistor circuits. Shunt-peaking, which works quite well with high-impedance tube circuits, becomes very difficult to use in transistor circuits because of the presence of $r_{bb'}$ and $r_{b'e}$ and the loading effect of C_i. In addition, the improvement obtained is significantly less than that realized for tube circuits.



$$X_L = \sqrt{R_L R_{IN} - R_L^2} = R_L\sqrt{\frac{R_{IN}}{R_L} - 1}$$

$$Q \approx \frac{X_L}{R_L} = \sqrt{\frac{R_{IN}}{R_L} - 1}$$

$$\text{FOR } \frac{R_{IN}}{R_L} = 4 \Rightarrow Q = \sqrt{3} \approx 1.7$$

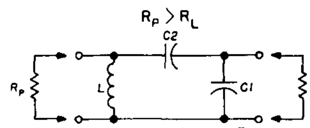
$$X_L = \frac{R_{IN}}{\sqrt{\frac{R_{IN}}{R_L - R_{IN}}}} = R\sqrt{\frac{R_L}{R_{IN}} - 1}$$

$$Q \approx \frac{X_L}{R_{IN}} = \sqrt{\frac{R_L}{R_{IN}} - 1}$$

$$\text{FOR } \frac{R_L}{R_{IN}} = 4 \Rightarrow Q = \sqrt{3} \approx 1.7$$

fig. 1. L network calculations of Q.

The L-network (**fig. 1**) which is a very simple network, suffers from two serious drawbacks with regard to broadband applications: first, the overall Q of the circuit is determined by the ratio of the impedances to be matched and *cannot* be set independently. Further, the higher the ratio of impedances to be matched, the higher the overall circuit Q. For a ratio of only 4:1, $Q = 1.7$, which is much too high for multi-octave use. The tapped-tuned circuit (**fig. 2**) allows the overall circuit Q to be set independently of the terminating impedances. However, there is a restriction on the minimum allowable value for Q which eliminates this circuit from consideration in multi-octave applications. The pi-network (**fig. 3**) suffers from essentially the same unacceptable restriction on minimum circuit Q as does the tapped-tuned circuit.



$$X_{C1} = \sqrt{\frac{R_P R_L^2}{R_L(4Q^2+1) - R_P}}$$

FOR PRACTICAL VALUES OF C1

$$R_L(4Q^2+1) > R_P$$

$$\text{OR } Q_{MIN} = \sqrt{\frac{1}{4}\left(\frac{R_P}{R_L} - 1\right)}$$

$$\text{FOR } \frac{R_P}{R_L} = 4 \Rightarrow Q_{MIN} = \sqrt{0.75} = 0.866$$

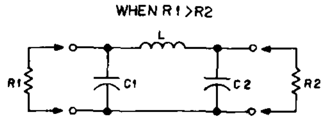
fig. 2. Tapped-tuned circuit calculations of Q.

By Bill Leonard, WA7WHZ, Technical Staff, Hughes Aircraft Company, 6573 Debs Avenue, Canoga Park, California 91307

transmission-line transformers

The availability of high-frequency, high-permeability ferrites has prompted the development of wideband toroidal transformers which are ideally suited for multi-octave, low-impedance applications. There are numerous versions in use today, the more popular of which have been described in principle by Granberg.[1] Only the most popular of these, the transmission-line transformer, will be discussed here.

A wideband model of a toroidal 4:1 impedance-matching transformer was first investigated by Ruthroff,[2] and more recently by Pitzalis and Couse.[3] Transmission-line transformers yield nearly the best performance in terms of bandwidth and power handling capability. Units with bandwidth ratios of 20,000:1 (i.e., a Q of 0.007) and power capabilities in excess of 300 watts have been built. **Figs. 4** and **5** show 1:1 and 4:1 impedance transformers. It is customary to show both the conventional and the transmission-line equivalent circuits since the parameters which determine the lower cutoff frequency are very different from those which determine the upper cutoff frequency.



$Q_T \approx \frac{R1}{X_{C1}}$ CHOOSE X_{C1} FOR GIVEN R1, Q

FOR LOW Q ⇨ LARGE X_{C1} ⇨ SMALL C1

$$X_{C2} = R2\sqrt{\frac{R1/R2}{Q_T^2 + 1 - (R1/R2)}}$$

FOR PRACTICAL VALUES OF C2

$$Q_T^2 + 1 > R1/R2$$

$$Q_T > \sqrt{\frac{R1}{R2} - 1}$$

$$\text{FOR } \frac{R_1}{R_2} = 4 \Rightarrow Q_{MIN} = \sqrt{3} \approx 1.7$$

fig. 3. Pi-network calculations of Q.

In conventional transformers, the interwinding capacitance resonates with the leakage inductance to produce a loss peak. This limits the high frequency response. In transmission-line transformers, the coils are arranged such that the interwinding capacitance is a distributed component of the characteristic impedance of the line. This characteristic makes the construction of low-impedance lines possible by use of close spacing (many twists per inch) of the wires which form the twisted pair. Although, in principle, any type of transmission line may be used, twisted pairs have the advantages of low cost and small size, while coaxial lines yield the best response due to their having relatively constant impedance as a function of length.

frequency response

Analyzing the frequency response of broadband transformers is not a trivial exercise. The upper frequency limitations are related to the length of the transmission line and to the ratio between the characteristic impedance of the line and the load impedance. Usually, the length of the transmission line is chosen to be λ/8 or less at the upper frequency desired. For a 4:1 impedance transformer, the characteristic line impedance (Z_o) should equal $\sqrt{R_L R_S}$. The shorter the physical length of the line, the less important exact matching becomes. The exact expression which describes the high-frequency behavior of the 4:1 impedance transformer can be found in references 2, 3, and 4. The result for matched impedances is

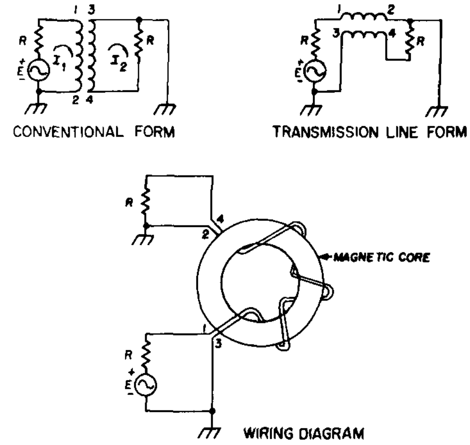


fig. 4. 1:1 impedance transformer shown in the conventional and transmission-line form along with the wiring diagram.

$$\frac{P_{in}}{P_{out}} = \frac{(1 + 3\cos\beta\ell)^2 + 4\sin^2\beta\ell}{4(1 + \cos\beta\ell)^2} \qquad (1)$$

where β = phase constant of the line $\left(\frac{2\pi}{\lambda}\right)$
ℓ = line length (same units as λ)
$\beta\ell$ measured in radians

Fig. 6 displays this expression as a function of line length. It can be seen that the upper cutoff (−3 dB) frequency occurs at a line length of 0.3λ for matched loads. However, in practice it is customary to keep $\ell < 0.125\lambda$ to minimize effects of mismatch.

For analysis of the lower cutoff frequency, the

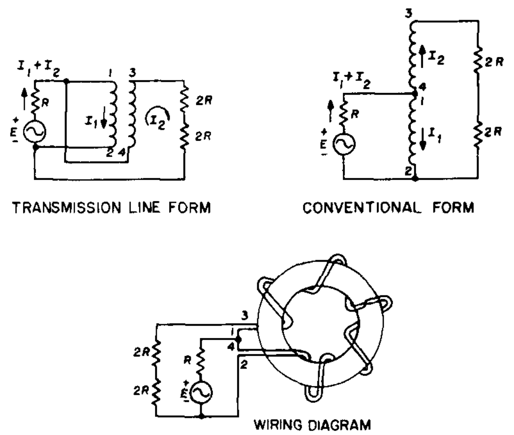


fig. 5. 4:1 impedance transformer shown in the same manner as the 1:1 transformer.

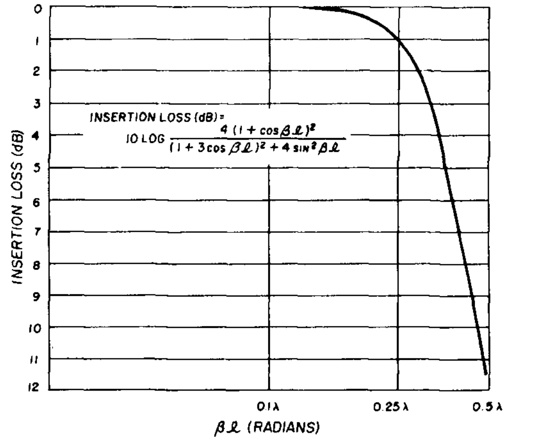


fig. 6. Insertion loss versus line length for a matched broadband transformer.

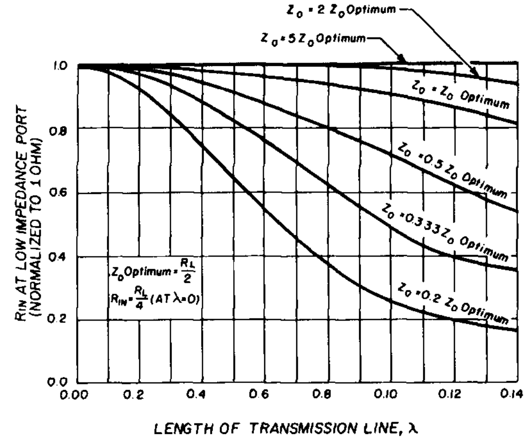


fig. 7. The effect of various mismatched conditions shown as input impedance versus transmission-line length.

conventional form of the equivalent circuit (**fig. 5**) is used. The lower cutoff frequency is determined by the falloff of primary reactance as the frequency is decreased. This reactance is determined by the series inductance of the transmission-line conductors. Therefore, the longer the line length, the greater the series inductance, and the lower the cutoff frequency. This is in direct conflict with extending the upper cutoff frequency which, as previously noted, is enhanced by shortening the physical length of the transmission line. Minimizing the overall length, consistent with achieving the necessary reactance for the low-frequency requirements, can be accomplished with high permeability materials such as ferrites. The inductance of a conductor is directly proportional to the relative permeability of the surrounding medium. A high permeability material placed close to the transmission line acts on the external fringe field in such a way as to significantly increase the effective inductance, thereby greatly lowering the lower cutoff frequency. The key point is that there is no influence upon the characteristic impedance of the line. Therefore, there is no degradation of the high-frequency cutoff characteristics. Also, power transferred from input to output is not coupled through the ferrite material, but rather through the dielectric medium separating the transmission-line conductors. This is an important characteristic since it allows for relatively small cross-section ferrite materials to be operated at very high power levels without danger of saturation. This is in contrast to the conventional transformer which couples power from primary to secondary entirely through the core which must be chosen to handle the total power without saturating.

In summary, the low-frequency cutoff requirements[3] can be related in the following expression

$$\ell \geqslant \frac{20R_L}{(1+\mu)f_L} \text{ inches} \qquad (2)$$

Thus, the minimum allowable transmission line length can be specified in terms of the load resistance (R_L), the lower cutoff frequency (f_L *in MHz*) and the relative permeability (μ) of the core material.*

Impedance ratios in excess of 4:1 are easily obtained

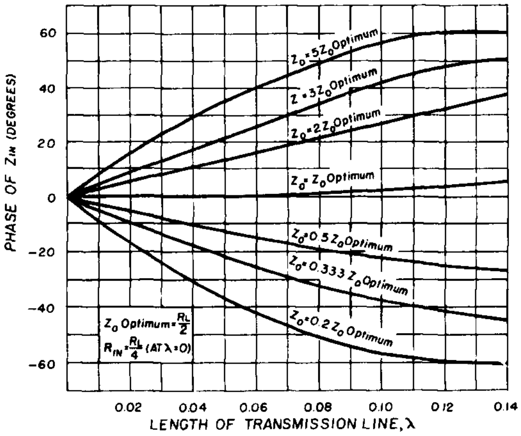


fig. 8. The phase of input impedance, Z_{in}, versus transmission-line length for mismatched conditions.

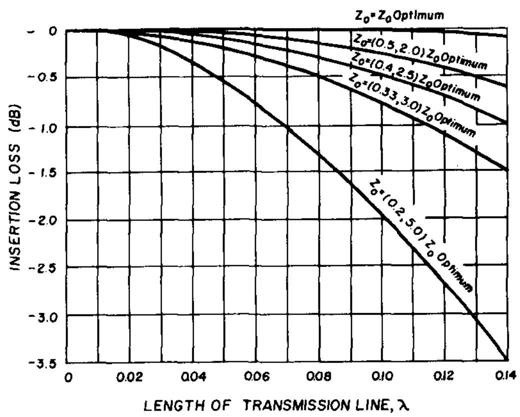
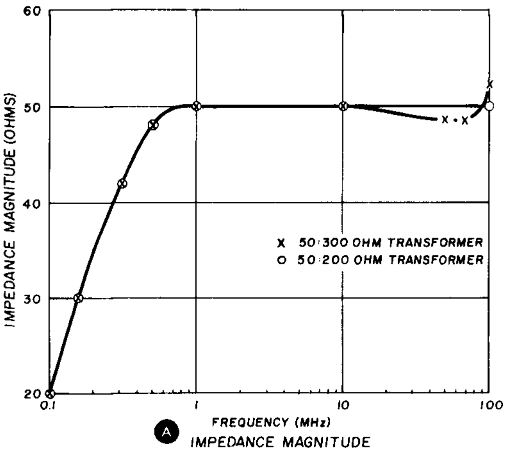


fig. 9. The insertion loss versus line lengths for mismatched conditions.



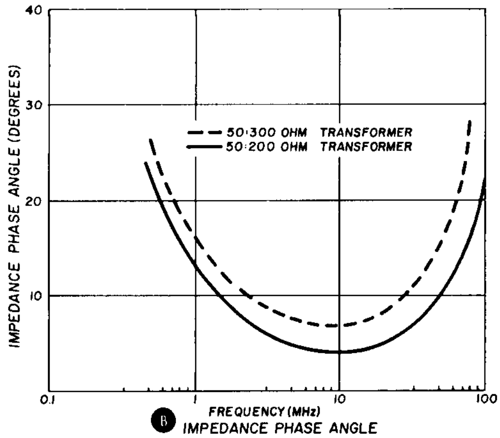
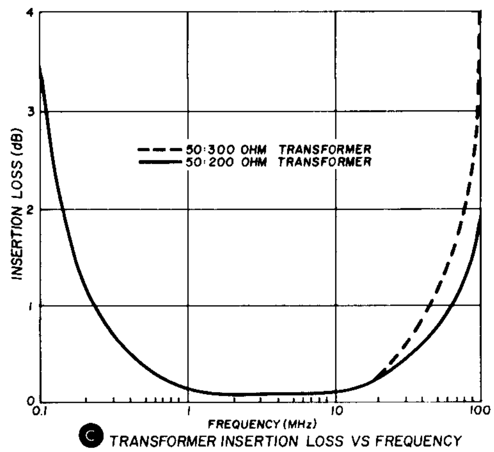


fig. 10. A comparision of two broadband matching transformers. Each transformer was wound on 2 Ferroxcube 266T125 3D3 cores. A_T = 330±20% mH per 1000 turns, μ = 750 ±20%, A_c = 0.183 cm^2. The winding for the 4:1 transformers is made from two no. 30 (0.25mm) vinyl-coated wires with 7 twists/inch. The length is 5.7" (14.5cm) and 10 turns. The winding for the 6:1 transformer has a third 2.5" no. 30 (6.5cm) wire added to form a three-wire transmission line. The transformers were designed for operation from 150 kHz to 100 MHz.



by using the methods described in references 1, 3 and 4 when integer ratios (1:1, 4:1, 9:1,. . ., n^2:1) are acceptable. In addition, Krauss[4] discusses the construction of a three-wire transmission line for use in transformers which yields a nearly continuously variable (up to 6:1) ratio transformer. In general, characteristics such as bandwidth, passband ripple, and insertion loss began degrading as higher transformation ratios are required.

mismatching

One question that immediately arises is the effect of a mismatch. Doherty and Hatley[5] have investigated this problem for a complex mismatch. Pitzalis and Couse[3] have resolved the question for a 4:1 impedance transformer encountering a resistive mismatch. These results are presented graphically in **figs. 7, 8** and **9**. These curves are normalized to Z_o and ignore the low-frequency cutoff effects. They clearly demonstrate the relative insensitivity of the transformation with respect to a resistive mismatch for mismatches as high as 2:1. They also show that for $Z_o > Z_o$ (optimum), the input impedance is a series R-L circuit, while for the case where $Z_o < Z_o$ (optimum) the input impedance is that of a parallel R-C circuit. These facts can sometimes be used to advantage when compensation is necessary for stability or other reasons.

*To find the minimum line length in metric terms, use the following formula

$$\ell \geqslant \frac{51R_L}{(1+\mu)f_L} \quad cm$$

In conclusion, a comparision of two representative impedance transformers, as designed and tested by Krauss,[4] is presented in **fig. 10.** A conventional 4:1 impedance transformer is compared with a similar unit which uses a three-wire transmission line to obtain an impedance ratio of 6:1. It can be seen that, as was previously mentioned, the higher impedance ratio unit is slightly inferior in terms of overall performance.

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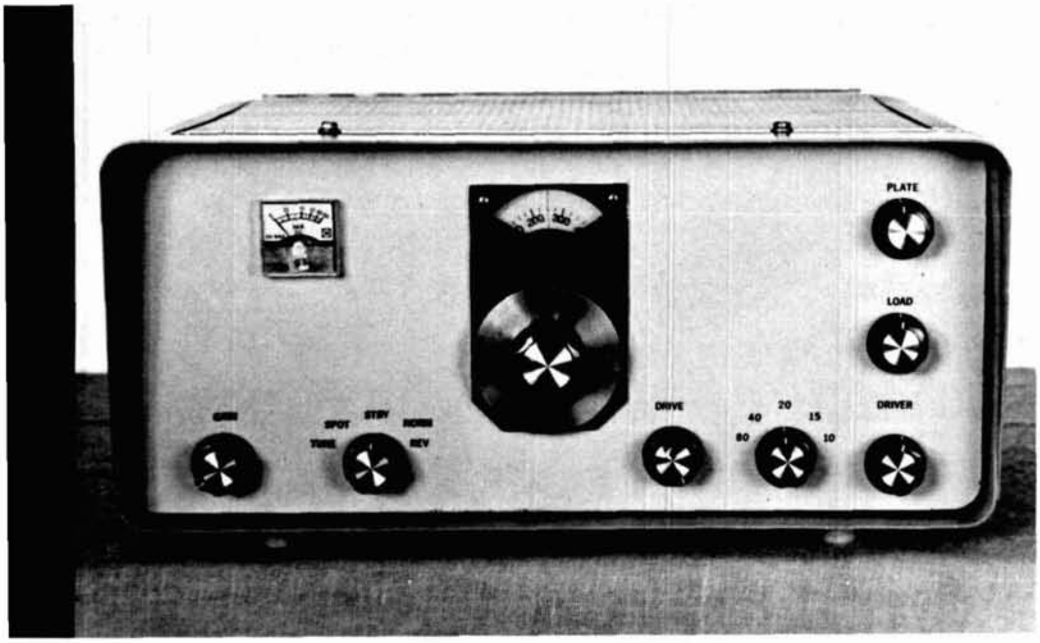


100-watt PEP five-band transmitter for CW and ssb

Except for driver and final this rig features solid-state stages, low cost, and easy construction

With the prospect of obtaining my general class license in the future, the need for an ssb transmitter arose along with the question of whether to build or buy. Considering the fact that a lot of experience and pleasure can be derived from homebrewing, I decided to build and came up with the following objectives:

1. Solid-state devices where practical.
2. 100 watts PEP.
3. Five-band coverage with CW and upper and lower sideband.
4. Low cost.
5. Easy construction.

After searching through various publications and not being able to find an article that fit all my requirements, I decided to design each stage separately using standard circuits and/or circuits from other articles.

By Harold Peters, WN3WTG, P. O. Box 1264, Tipton, Pennsylvania 16684

description

A block diagram is shown in **fig. 1**. A 9-MHz dsb signal is generated with the speech amplifier and carrier oscillator, the carrier is removed by the balanced modulator, and the filter then removes one of the sidebands. The vfo and high-frequency oscillator (hfo) signals are mixed to produce the signal needed to heterodyne the 9-MHz ssb signal to the desired amateur band. This method results in less bandswitching than most other schemes.

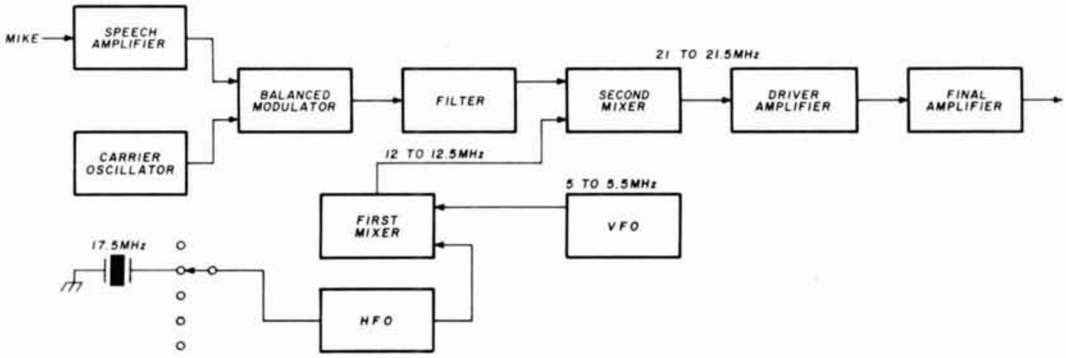
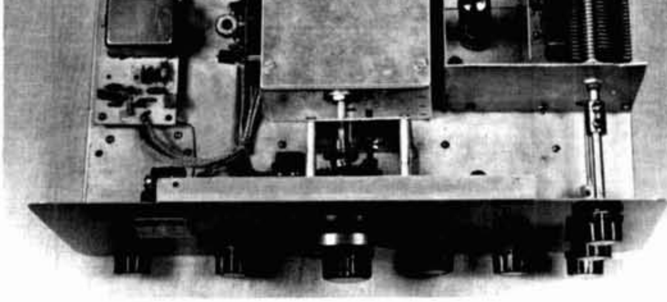


fig. 1. Block diagram showing the five-band transmitter in the 15-meter position.

The only disadvantage to this mixing scheme is that a sideband inversion occurs on 40 meters, and a tuning inversion occurs on 15 meters. On 40 meters the upper and lower sideband selection is reversed, and on 15 the low end of the band starts at the high end of the dial. But this isn't a major problem and one easily becomes accustomed to it.

The 9-MHz ssb signal and the output of the first mixer are mixed in the second mixer. The driver then amplifies this signal, and the Class AB final increases the signal level to 100 watts PEP output. Tubes are used in the driver and final to keep the cost down.

Top view of transmitter with cover removed to show component location. The PC board on the left shows the sideband filter.



The entire transmitter was built a stage at a time and checked for proper operation before going on to the next stage. Each stage represented in the block diagram was built on a separate PC board or in the case of the vacuum-tube stages, in a separate compartment. Besides making construction and testing easier, this method allows for easy removal of a stage should it become defective.

speech amplifier and carrier oscillator

The speech amplifier (**fig. 2**) consists of Q1, U1, and Q2.[1,2] The MPF102 provides a high-impedance input, and the 741 op amp and the 2N3053 provide ample audio power to drive the balanced modulator.

The speech amplifier as well as the carrier oscillator, high-frequency oscillator, and first and second mixer stages were constructed on double-sided glass epoxy PC board. The components were mounted on one side of the board, and the copper was left intact on the reverse side to act as a ground plane for added circuit stability.

The carrier oscillator (**fig. 2**) uses diode switching for selection of upper or lower sideband.[1,3] The trimmers for the crystals vary the carrier frequency to the desired location on the 9-MHz crystal filter skirt.

The operation of the carrier oscillator was verified by listening for the signal in a general-coverage receiver. The speech amplifier was tested by applying an audio signal to the microphone input and listening for the output with headphones.

balanced modulator and filter

The outputs of the speech amplifier and carrier oscillator are mixed in the MC1496 balanced modulator[2] and

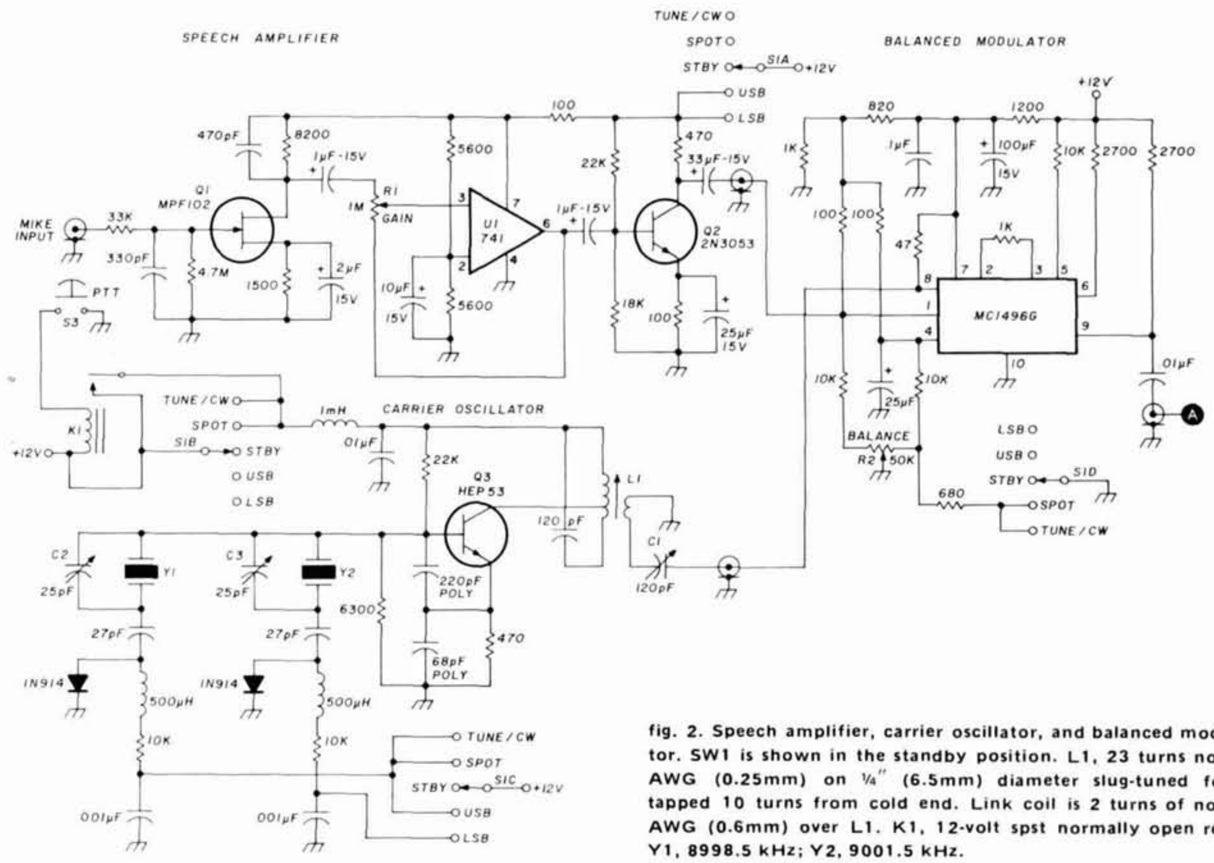


fig. 2. Speech amplifier, carrier oscillator, and balanced modulator. SW1 is shown in the standby position. L1, 23 turns no. 30 AWG (0.25mm) on ¼" (6.5mm) diameter slug-tuned form, tapped 10 turns from cold end. Link coil is 2 turns of no. 22 AWG (0.6mm) over L1. K1, 12-volt spst normally open relay. Y1, 8998.5 kHz; Y2, 9001.5 kHz.

the carrier is suppressed (**fig. 2**). In the CW mode, balance is upset and the carrier is allowed to pass through.

The 2N2222 (Q5) of the filter stage (**fig. 3**) acts as a buffer and also serves as the keying point for CW by applying keyed +12 volts from Q6.[4,5] Q7, a 40841 gate-protected dual-gate mosfet, makes up for filter signal loss and acts as the ALC control point.[1]

These stages were constructed on single-sided glass epoxy PC board. Care was taken during construction to ensure that no signal leak through would occur to destroy the carrier and opposite sideband suppression.

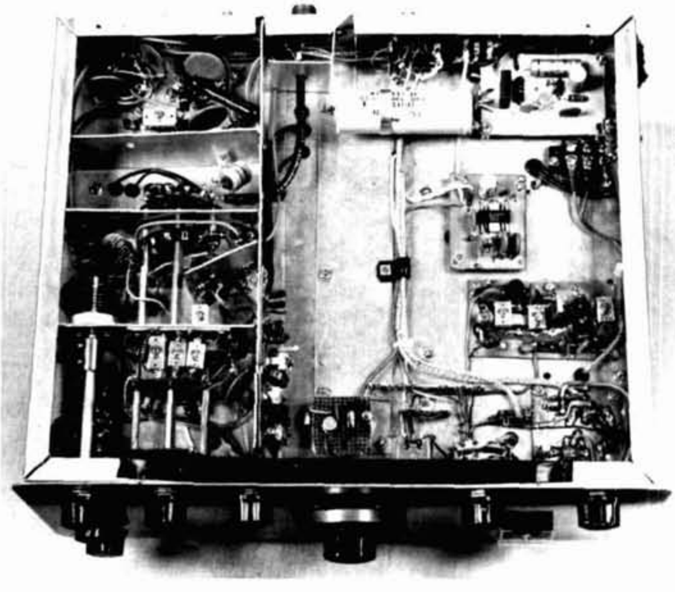
With the previous stages operating properly, the output of Q7 is a 9-MHz ssb signal, which can be monitored on a receiver. L1, C1, and R2 (**fig. 2**) are adjusted for maximum carrier suppression and C2, C3, C4, and C5 are adjusted for best voice quality consistent with good carrier and opposite sideband suppression. L2 is adjusted for maximum output.

vfo and hfo

The schematic for these stages is shown in **fig. 4**. The vfo, Q8, is a series-tuned Clapp circuit and includes a two-stage buffer amplifier, Q9, Q10, and a lowpass filter for a very stable and clean output.[1,6] Voltage to the MPF102 is regulated by a 9-volt zener.

The vfo PC board was mounted in its own enclosure with angle brackets, and the box was mounted in the center of the chassis. Phono jacks couple power and vfo output to the enclosure to make for easy removal of the vfo for testing and temperature compensation. Using a receiver or frequency counter, the vfo was adjusted to

Bottom view of the transmitter. The audio and modulator stages are located in the lower-right corner. The power regulator is in the upper right.



tune from 5-5.5 MHz by adjusting the bandset trimmer and L9.

The hfo was also mounted in a separate enclosure. The crystals are diode switched so that the hfo could be mounted away from the bandswitch.[3] This stage is not used on 80 or 20 meters, as the vfo 5-MHz output is mixed with the 9-MHz ssb signal for output on these bands.

placed on the bandswitch, and the mixer PC boards were placed close by to keep lead lengths short.

With the aid of the grid-dip meter, the toroid/trimmer assemblies were checked and adjusted for approximate frequencies before placing them in the circuit.

driver and final amplifier

The driver stage, shown in **fig. 3**, uses a 6GK6 power

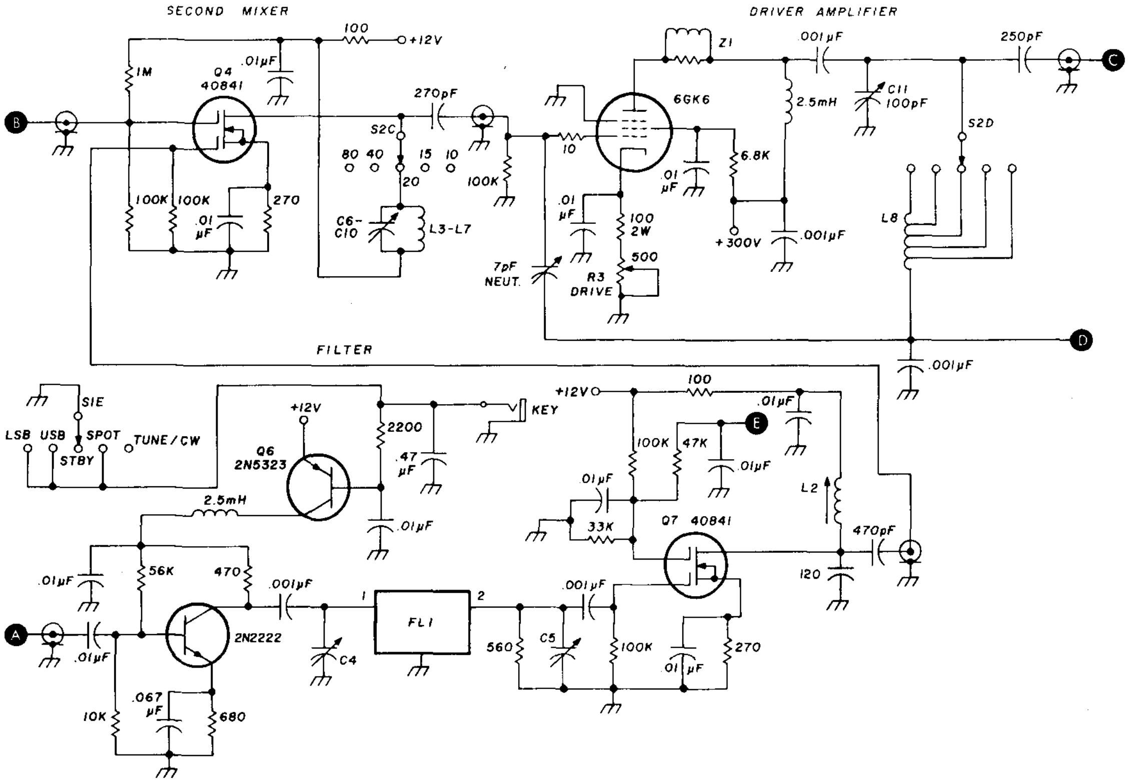


fig. 3. Second mixer, driver, and filter. FL1, 9-MHz crystal filter, KVG XF-9A. C4, C5, 35-pF trimmer. Z1, 4 turns no. 20 AWG (0.8mm) on 47-ohm, 1-watt resistor. L2, 20 turns no. 30 AWG (0.25mm) on T-50-6 form; C6, 250 pF. L4 (40 meters), 22 turns no. 28 AWG (0.3mm) on T-50-6 form; C7, 250 pF. L5 (20 meters), 14 turns no. 22 AWG (0.6mm) on T-50-2 form; C8, 120 pF. L6 (15 meters), 12 turns no. 22 AWG (0.6mm) on T-50-2 form; C9, 120 pF. L7 (10 meters), 9 turns no. 22 AWG (0.6mm) on T-50-2 form; C10, 120 pF. L8, 60 turns no. 28 AWG (0.3mm) on T-68-2 form, tapped at 30, 12, 6, and 3 turns for 40-10 meters respectively.

first and second mixers

The first mixer[7] uses a 40841 to mix the vfo and hfo outputs. The proper tank circuit is switched by the bandswitch, with the same tank used for both 80 and 20 meters. The output frequencies of the first mixer are: 5-5.5 MHz for 80 meters, 16-16.5 MHz for 40 meters, 5-5.5 MHz for 20 meters, 12-12.5 MHz for 15 meters, and 19-19.5 MHz for 10 meters.

Q4, another 40841 (**fig. 3**), serves as the second mixer and uses a circuit similar to that of the first mixer. Second-mixer output is a low-power version of the ssb signal to be transmitted.

All coils in the mixer tanks are wound on toroids for compactness and self-shielding. The windings were spaced on the toroids to occupy the entire circumference of the core. Each toroid and its trimmer were

pentode tube.[8] A drive control is included to vary the amount of drive to the final. The driver tank coil differs from the previous tank coils in that it is was wound on a single toroid, tapped for each band, and tuned to resonance with C11 from the front panel of the transmitter.

The final stage (**fig. 5**) uses two 6146Bs in a class-AB parallel configuration. Plate voltage is supplied through RFC1, a Johnson 102-572 transmitting-type rf choke. Meter M1 measures plate current.

The ALC voltage is obtained from the grid bias. It is rectified and applied to the filter stage through R4, which controls the amount of ALC voltage. The ALC circuit was adjusted with the aid of an oscilloscope. A two-tone test signal was injected into the microphone input, and the transmitter rf output was monitored on

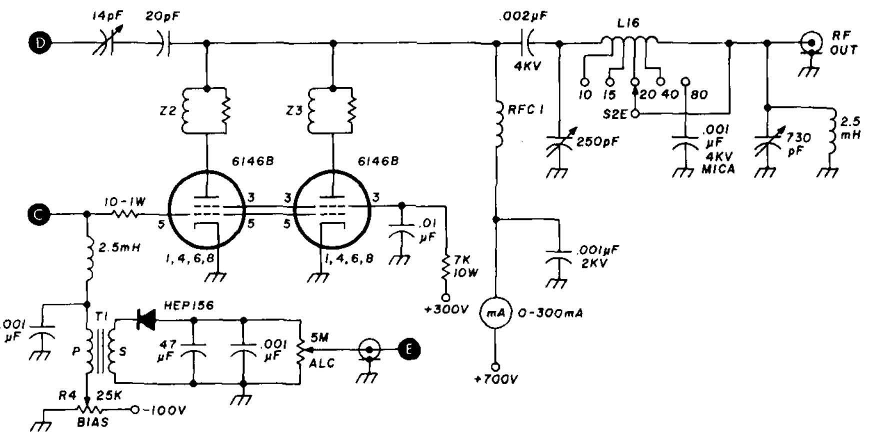


fig. 5. Final amplifier. T1, audio transformer; primary 600 ohms, secondary 2000 ohms. Z2, Z3, 5 turns no. 20 AWG (0.8mm) on a 47-ohm 1-watt resistor. L16, 38 turns no. 12 AWG (2.1mm) on T-200-2 form, tapped at 4, 6, 11, and 22 turns for 10-40 meters respectively.

the scope. Audio gain control R1 was advanced until flat-topping just started to occur; then R4 was adjusted to eliminate this distortion.

Conventional procedures were used in adjusting the neutralizing and the final plate and loading capacitors. Plate current at maximum output is about 220 mA.

12-volt power supply

Fig. 6 shows the regulated 12-volt power supply, which was included on the chassis so that during non operating periods the power to the vfo can be left on. A 723 IC regulator and a 2N3772 pass transistor provide about 3 amps at 12 volts.[9] R3 sets the output voltage.

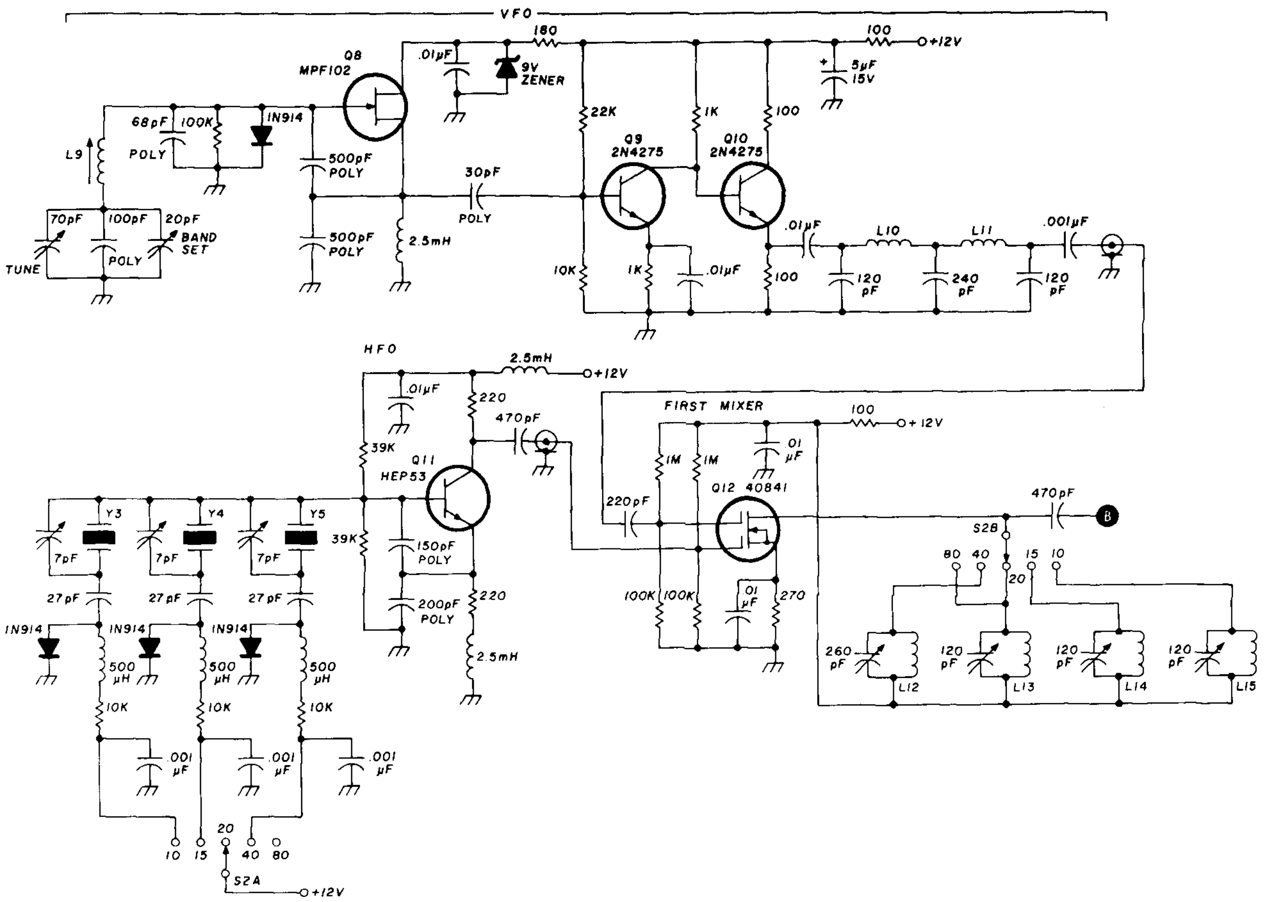


fig. 4. Vfo, hfo, and first mixer. S/2 is shown in the 20-meter position. L9, 35 turns no. 32 AWG (0.2mm) on ¼" (6.5mm) slug-tuned form. L10, L11, 38 turns no. 32 AWG (0.2mm) on T-37-2 form. L12, 12 turns no. 22 AWG (0.6mm) on T-37-2 form. L12, 31 turns no. 28 AWG (0.3mm) on T-50-6 form. L14, 16 turns no. 22 AWG (0.6mm) on T-50-2 form. L15, 12 turns no. 22 AWG (0.6mm) on T-50-2 form. Y3, 14 MHz. Y4, 17.5 MHz. Y5, 11 MHz.

The 2N3772 was mounted on the back of the chassis, which acts as a heat sink.

closing remarks

A small change to be made in the future is to place the spot function on a separate front-panel switch. As it

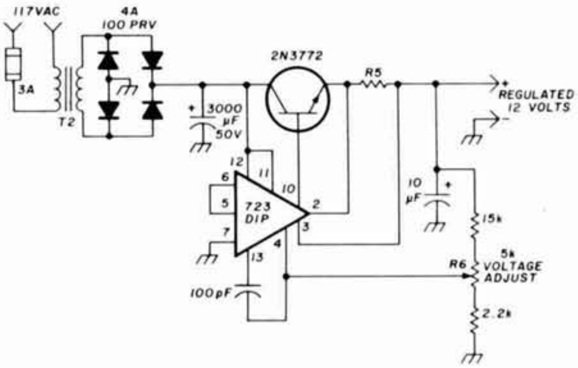


fig. 6. Regulated power supply for the solid-state stages of the transmitter. T2, 24-volt 2-amp power transformer. R5, 0.1-ohm resistor consisting of 8 feet (2.4m) of no. 22 AWG (0.6mm) wire wound on a wooden dowel.

is now, the spot function works only in the upper sideband position. But the opposite sideband can be heard in my receiver because of the close proximity, so it poses no real problem.

acknowledgements

I would like to thank all of the authors whose ideas and circuits I borrowed for my transmitter. Special thanks go to Howard Stark, WA4MTH, for his encouragement and assistance.

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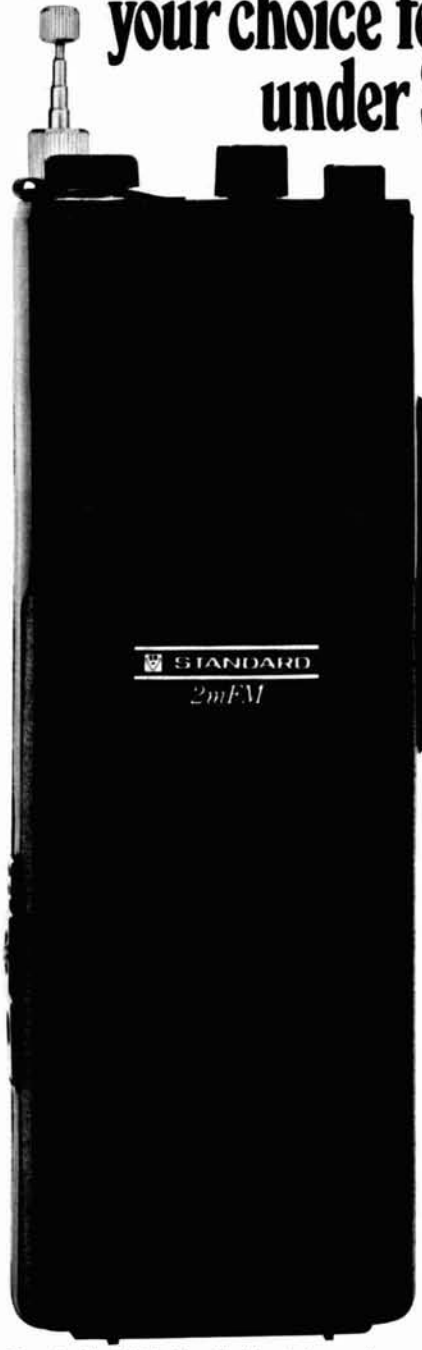

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automatic 600-kHz up/down repeater-mode circuit for two-meter synthesizers

Although designed for use with the GLB 400B Channelizer, this circuit may be used with other synthesizers using BCD coding to their divide-by-n counters

By Paul Quinn, WB4PHO, Route 2, Box 323D, Carrollton, Georgia 30117

With the continuing increase in the number of repeaters appearing on two meters, most amateurs are finding that being "rock bound" leaves a lot to be desired, not to mention the cost of filling those crystal sockets in most two meter rigs. The trend seems to be that more amateurs are finding that synthesizers allow them to work the entire band, and, in most cases, that they can work it in 5-kHz increments.

Some synthesizers on the market today use a pair of ganged switches, one to set the repeater input, the other the output frequency. This arrangement doesn't pose a problem except when it comes to mobile operation. Changing repeater frequencies while "threading the needle" in rush hour traffic can be exciting, if not downright hazardous.

This article deals with my answer to improving the ease of operation of the GLB 400B Channelizer, but the circuit may be used with other synthesizers using BCD coding to their *divide-by-n* counters.

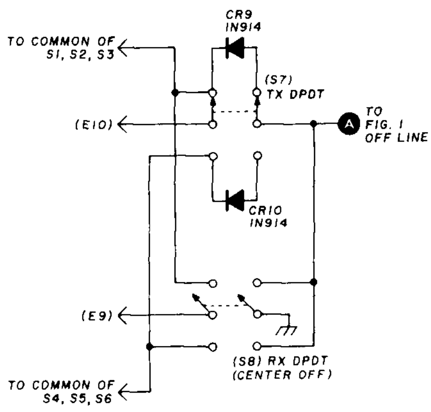


fig. 1. Wiring diagram of the replacement switches for S7 (transmit select) and S8 (receive select). Rear view is shown.

features

The addition of the circuit of **fig. 2** provides an automatic 600-kHz *up* or *down* shift of the receive frequency and the ability to work repeaters on just one

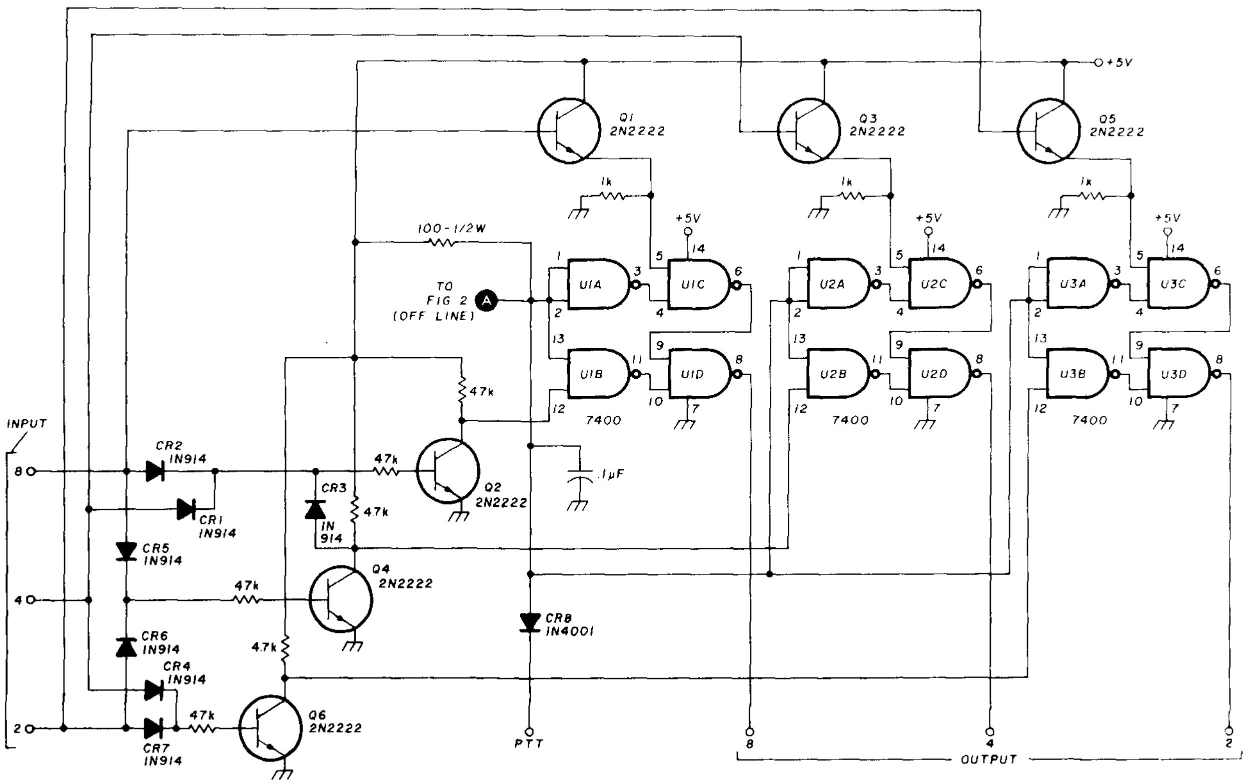


fig. 2. Schematic of the automatic 600-kHz up/down repeater-mode circuit. The 100-ohm resistor is ½ watt; all others are ¼ watt.

control head. The other set of switches can be left on a favorite repeater or simplex frequency and monitored by a simple flick of the transmitter select switch.

This circuit will work with all standard repeater pairings of 146.01 to 146.37 MHz and 147.60 to 147.99 MHz input and will shift to the simplex mode when the control switches are set to the standard simplex frequencies of 146.40 to 146.59 MHz and 147.40 to 147.59 MHz.

Upon setting the repeater input in the control head, such as 146.28 MHz, the circuit changes the BCD input to the 100-kHz divide-by-n counter from a 2 to an 8, which offsets the receiver 600 kHz *up* and allows the receiver to operate at 146.88 MHz. Setting the repeater output frequency in the control head allows paralleling the repeater by offsetting the receiver 600 kHz *down*. In either case, the transmitter will always be on the frequency that appears on the control switches when the microphone PTT switch is depressed. Repeaters in the 147.00-MHz segment, such as 147.63 MHz in and 147.03 MHz out, are working in the same manner.

The combination of transistors Q2, Q4 and Q6 and their associated diodes provides the logic to the circuit. ICs U1, U2 and U3 act as three separate spdt switches that place the logic function in or out and are controlled by the *center off* position of the receive select switch (S8). Q1, Q3 and Q5 act to interface the ICs.

construction

A full-size PC board layout for the automatic up/down repeater mode circuit is shown in **fig. 3**; **fig. 4** shows component location. Price information on etched and drilled PC boards may be obtained by sending a self-addressed stamped envelope to the author; however, the circuit is not critical and can be built on Vector board if desired. I would advise against substituting

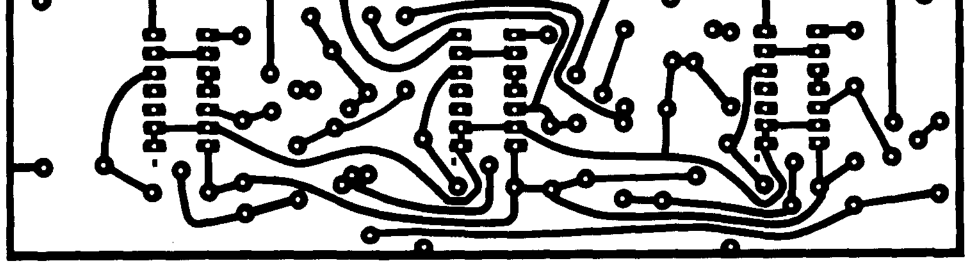


fig. 3. Full-size PC-board layout for the automatic 600-kHz up/down repeater-mode circuit. Send a self-addressed stamped envelope to the author for prices on etched and drilled boards.

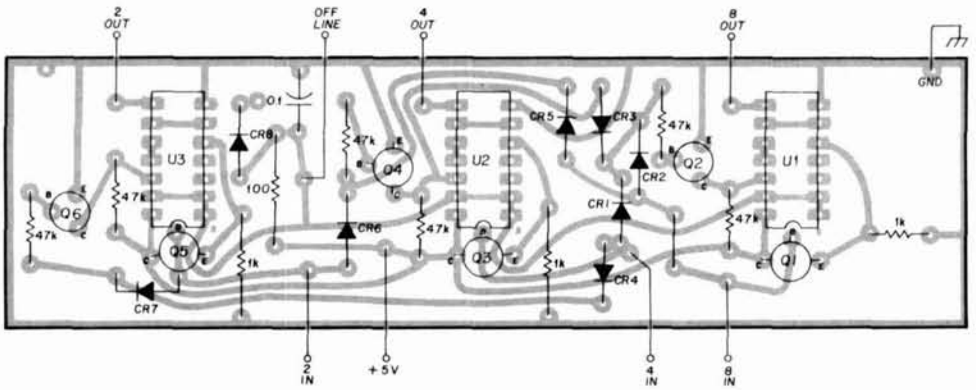


fig. 4. Reverse side of PC board showing parts location. CR8 is a type 1N4001; all other diodes are 1N914s. Use a ½-watt resistor for the 100-ohm unit; all others may be ¼ watt.

components or resistance values. The use of IC sockets is a must when using surplus ICs.

The Channelizer requires no outward change to its appearance, and only the transmit select switch (S7) need be changed from an spdt to a dpdt. The receive select switch (S8) is changed from an spdt to a dpdt (center off).

Rewire the new switches, S7 and S8, as shown in **fig. 1**. Diode CR9 and CR10 mount on S7. The ground shown on S8 and the 600 kHz offset should be connected to the ground of the Channelizer main board. The "off line" connects to the 600-kHz offset circuit board.

checkout

The circuit should be checked out before installation as follows. Connect 5 volts to the V_{cc} point and apply a ground to the circuit. With a voltmeter connected to pin 8 of U2, an indication of 4 or more volts should occur. U3 pin 8 should indicate the same positive voltage. U1 pin 8 should read less than 1 volt.

Now connect 5 volts through a 1k resistor to the BCD 2 input and note that pin 8 of U1 is now at 4 or more volts, while pin 8 of U2 and U3 are less than 1 volt. With this connection to the 2 input, place 5 volts through another 1k resistor to the BCD 4 input. Now pin 8 of all ICs should indicate less than 1 volt. Disconnect the resistors and touch one of them to the BCD 8 input. Pin 8 of U1 and U2 should be less than 1 volt, while U3 pin 8 should be 4 volts or more. Place a ground connection to the *off* line and note that when the voltage is again applied to the inputs (one at a time), the corresponding outputs will be high, while the others remain less than 1 volt.

installation

The board is connected to the synthesizer by grounding it to the main board of the Channelizer and applying 5 volts to the V_{cc} point from E5 or some other convenient source. Connect the PTT switch to E8 of the main board. Connect the *off* line to the switch as shown in **fig. 1**. Cut the wire from the junction of CR15 and CR16 to E20 and connect the end nearest the diodes to the BCD 8 input. Connect the other wire, nearest E20, to the BCD 8 output. Likewise, cut the wire going to E19 and connect to the BCD 4 input and output. Cut the wire to E18 and connect to BCD 2 input and output (see **fig. 5**).

operation

Selecting the center position of the receive switch (S8) on the front of the Channelizer enables the 600-kHz repeater mode circuit. Changing the transmit switch (S7) to either up or down position selects the control head to be used, and, as mentioned earlier, two

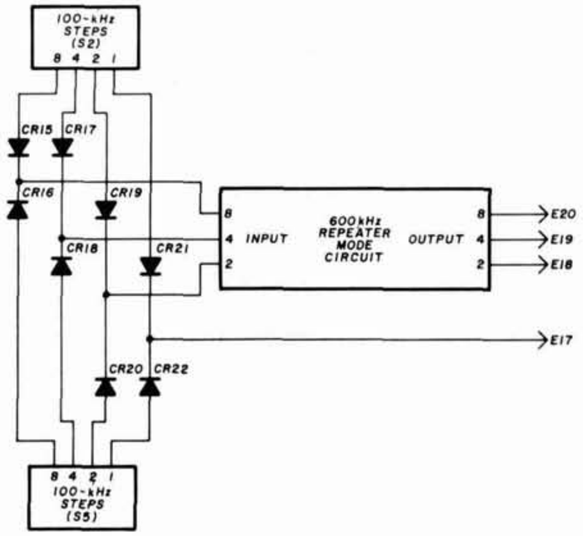
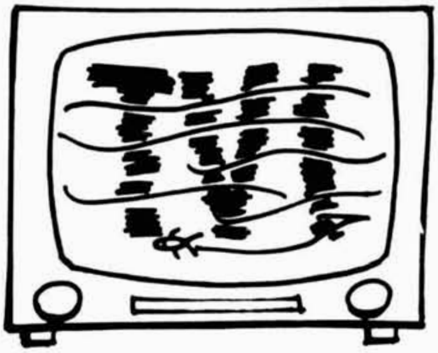


fig. 5. Diagram for connecting the 600-kHz repeater-mode circuit to the GLB 400B Channelizer 2-meter synthesizer (see text).

different repeater frequencies may be set up. But always remember that the repeater input frequency should be used for working *into* the repeater. Selection of the standard simplex frequencies will prevent the circuit from shifting the receiver, so simplex operation is provided, although the repeater mode is still selected by the center position of the receive switch (S8). Setting this switch to either of its extreme positions will disable the 600-kHz *up* or *down* circuit and return the synthesizer to its normal operation.

ham radio



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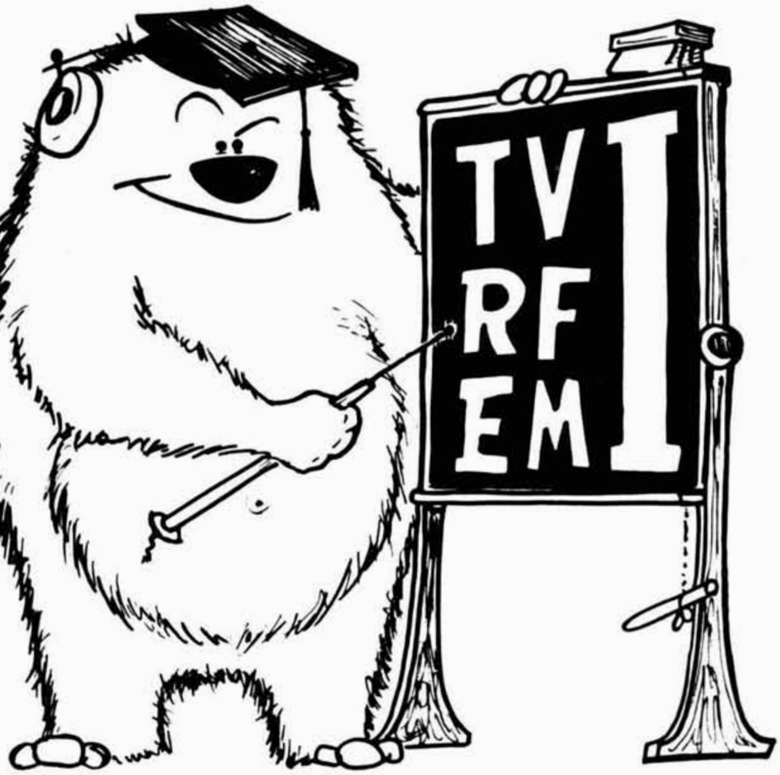

Whatever you call it, the common denominator is "I" for Interference.

The study of interference to consumer products such as TV sets, hi-fis, and the like from radio transmitters is a complex subject. For a primer, see p. 11, "QST Magazine" for March, 1976. We do know that radiation interference can be greatly reduced and perhaps eliminated by the use of a well-engineered, quality-built TVI filter. The low-pass type for the transmitter is at times not enough...a high-pass type for the TV set may also be required. But, here's the rub! If a filter is not properly designed and engineered, it may not work like a filter at all. At the R. L. Drake Company, we've been designing and building filters for over 30 years...since before the days of "Uncle Miltie." And, these are real filters...not toys.

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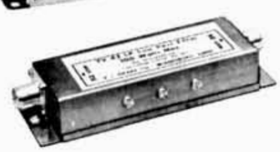

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simple diode tester

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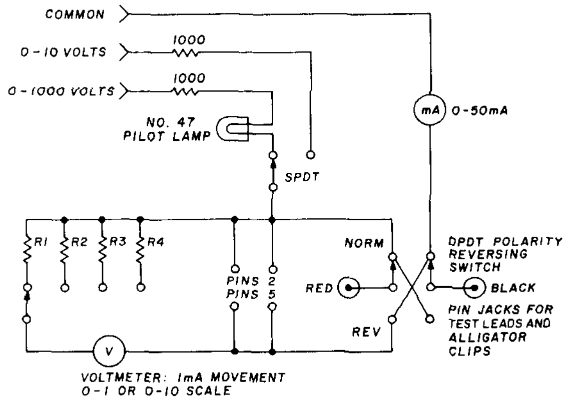
When you have a diode with no numbers on it and no color bands to identify it, what do you do with it? Here's a simple tester to help identify whether the diode is silicon or germanium. The diode current rating can be approximated by the physical size. Refer to the size and ratings from catalogs or other diodes you may have that are of known ratings. Small-signal diodes such as 1N914s and 1N34s will have a PIV rating somewhat above 25 volts. This tester will indicate that some small-signal diodes will have a lot of leakage current compared to the forward current, which is usually detrimental. It will also indicate zener voltage ratings.

applications

Other uses for this tester include checking diacs, SCRs, triacs, LEDs, VR tubes, neon tubes, and pull-in and drop-out voltage of small relays, showing that many relays marked 24 volts will work nicely at 12-13 volts. (Multileaf relays may not be advisable at this lower voltage, however). You can form new or old electrolytic capacitors. After an electrolytic capacitor has been formed for a few minutes, the operating voltage for that particular capacitor may be safely marked at about 20 percent less voltage than the maximum forming voltage. That is a voltage where the capacitor is drawing something less than about 5 mA.

This tester was first built and used in 1942 and has been indispensable all these years. An earlier article[1] described this tester, but it was primarily designed to test VR tubes. When 1000-volt PIV diodes became available, it was necessary to modify the tester.

Modifying the tester to accommodate 1000 volts, that is, getting rid of the vacuum-tube dual triode (grid-controlled rectifier in this case) was easy since I



R1 =	1 meg =	1000 volts full scale
R2 =	100k =	100 volts full scale
R3 =	10k =	10 volts full scale
R4 =	1k =	1 volt full scale

fig. 1. Metering and control section of the diode tester. Pins 2 and 5 are for a 7-pin miniature tube socket and an 8-pin octal socket for testing VR tubes. All resistors are 1 watt.

By Lloyd Jones, W6DOB, 17779 Vierra Canyon Road, Salinas, California 93901

happened to have a couple of small Variac controls. With a Variac to control the input to the transformer primary and a solid-state half-wave rectifier with a 2 μF capacitor, it was easy to produce 1000 volts.

description

If you buy and use any of the diodes (new or surplus), you should build one of these testers. The basic requirement for such a tester is a dc voltage supply that's variable from 0 to at least 500 volts, preferably to 1000 volts. This supply should be "soft"; that is, one with very poor voltage regulation. At 50 mA, the voltage as shown on the voltmeter may drop to 60 or 70 percent of the no-load voltage. (Most of the testing I do on this tester is at less than 5 or 10 mA). When I test unknown surplus diodes it's not uncommon to zap a few of the bad ones, so a no. 47 pilot lamp is connected in series with the 0-50 mA meter to protect the meter movement.

A second meter is used as a voltmeter. An ideal meter for this purpose is a 0-1 mA meter with series resistors adjusted to read 10, 100 and 1000 volts. In my tester another voltmeter with a pushbutton is used to read voltages less than one volt. Ideally, diode rectifiers should be added to the unused filament winding (6.3 V) when using the 1-volt meter to determine whether a diode is germanium (around 0.45 volt) or a silicon (around 0.7 volt).

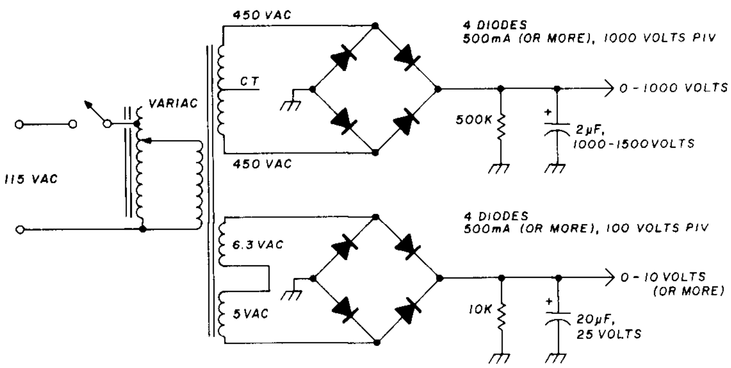


fig. 2. Diode-tester power supply. An autotransformer is a must for input voltage control; so-called "light dimmer" controls and motor-speed controls will not control the ac input voltage.

circuit

Consider the tester in two sections. The first is the system following the rectified voltage; the second is for controlling the voltage from zero to some higher value of voltage. **Fig. 1** shows the schematic for the most versatile tester. This system uses a transformer and bridge-rectifier power supply (**fig. 2**) to supply 0-100 and 0-1000 Vdc. (By using the 6.3- and 5-volt windings in series and another bridge rectifier, you'll have more than ample voltage for 0-1 and 0-10 volts. Most small power transformers have these secondary windings).

A dpdt switch is used for quickly reversing the connections to the item under test, which eliminates changing clip leads. An spdt switch selects 0-1000 volts from the high-voltage supply or 1-10 volts from the low-voltage supply. A miniature 7-pin tube socket and an octal socket are used for testing VR tubes.

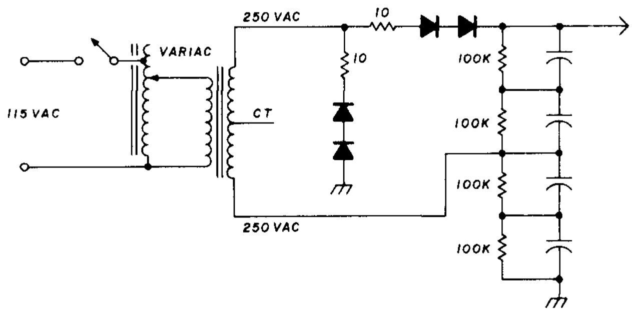


fig. 3. Alternative power supply using a smaller transformer in a voltage-doubler circuit. Diodes are 1000 PIV, 500 mA (or more); all electrolytic capacitors are 40 μF, 450 volt; resistors are 1 watt. The 2 μF capacitor must be oil filled.

The power supply is shown in **fig. 2**. If you don't have a 450-volt center-tapped transformer, you can use the full-wave voltage-doubler in **fig. 3**.

Here's an important warning: while checking the PIV of a diode, *be sure to keep the current low*. Ten microamperes is fine; 100 microamperes is the maximum that can be used (for one or two seconds). One-hundred microamperes is just discernible on the 50-mA meter by the slightest movement of the pointer. The zener rating of any diode can be read directly on the voltmeter. My collection of zeners includes devices as low as 3 volts and as high as 175 volts. Some are soft; most are hard or stiff, meaning they produce good regulation.

closing remarks

By this time it may have occured to you to keep all your old-fashioned parts. Some you can use; some you can give away to other experimenters. The days when you could walk into a radio parts house and buy amateur components are a thing of the past. However, you can find good bargains in surplus components by watching the ads in the amateur magazines. I bought a pound (half a kilogram) of diodes from M. Weinschenker (*ham radio*, May, 1973, page 60) for $10.00 and found that nearly 85 percent were good. About 100 were 1 amp, 1000 PIV; perhaps 100 were small zeners; another 100 or so were small-signal diodes including some noise diodes.

reference

1. Lloyd Jones, W6DOB, "Tester for Glow Tubes, Selenium Rectifiers, and Germanium Rectifiers," *CQ*, November, 1957, page 130.

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Q measurement and more

With a communications receiver, this simple noise generator allows you to determine the loaded Q of tuned circuits

This article describes a simple piece of test equipment that can often replace a signal generator. When used with a communications receiver it can outperform the usual Q meter by measuring the Q of a tuned circuit while in place in the equipment. The principle, borrowed from the antenna noise bridge, is to energize the tuned circuit with noise, giving constant signal strength over a wide frequency band. The frequency response is then observed using a communications receiver. It is of course necessary that the receiver bandwidth be appreciably narrower than that of the circuit under test, but this is generally true of most communications receivers. The receiver S-meter is used to find the −6 dB bandwidth of the circuit, and from this the Q is calculated.

the noise generator

The schematic is shown in **fig. 1**. Noise is generated by reverse breakdown of the base-emitter junction of Q1. Q1 output is then amplified by the remaining three transistors. The output, which is at low impedance, is S9+26 dB up to 7 MHz and S9 at 28 MHz, which allows very loose coupling to the circuit under test. Several transistors should be tried for Q1 and the noisiest one used. Note that, because the zener voltage is usually about 6 or 7 volts, the zener current and hence the noise output is very sensitive to battery voltage. A good battery is therefore necessary for stable output. Leads must be short to avoid resonance. The components are mounted, complete with a 9-volt transistor battery, in a metal enclosure measuring 3x4½x1 inch (77x108x25.5mm). A shield partition is installed across the enclosure (dashed line, **fig. 1**), and the electronic components are mounted on a terminal strip with ground connections soldered directly to the enclosure. This construction ensures good shielding, which is essential if the generator is to be used for receiver sensitivity measurements. Note the feedthrough capacitor in the power lead. The on/off switch is arranged to provide the alternatives of an external 12-Vdc supply through an "idiot diode" or 6.3-Vac operation. The 6.3 Vac modulates the noise output, making it easily distinguishable from other noise sources.

By **R. C. Marshall, G3SBA**, "The Dappled House," 30 Ox Lane, Harpenden, Hertfordshire, England

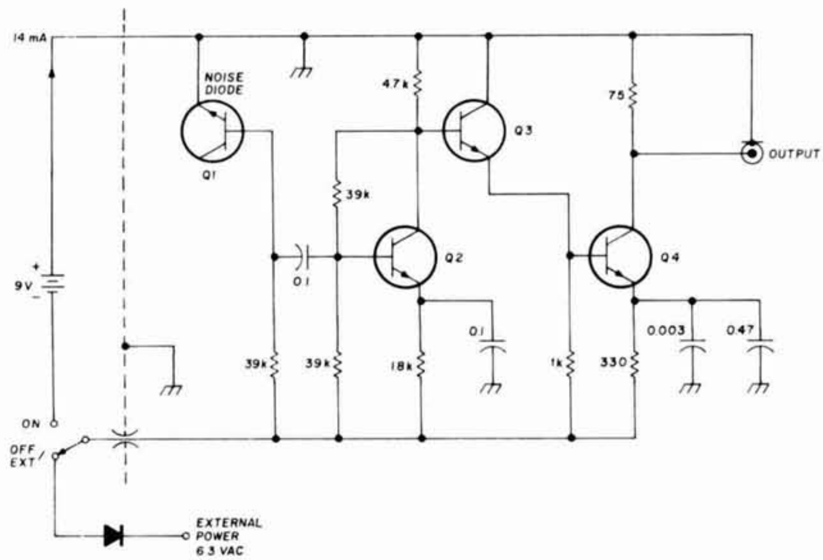


fig. 1. Noise generator schematic. Transistors are type 2N2368; resistors are 1/8 watt; capacitors are ceramic. Noise output is sensitive to battery voltage; therefore a good battery is necessary for stable output. An external ac power supply may also be used (see text).

Q measurement

Fig. 2 shows one test setup for Q measurement. Here, both generator and receiver are coupled by the smallest capacitors that give a usable signal at the receiver, which minimizes loading effects. Either or both couplings may

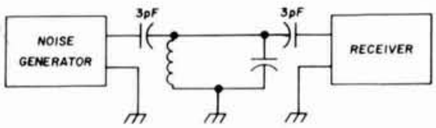


fig. 2. Example of a test arrangement for measuring Q. Minimum coupling between noise generator and receiver is required to minimize loading effects.

be inductive if convenient. The −6 dB point will be 1 or 2 units below maximum (there seem to be two rival standards; if in doubt, make a 6 dB attenuator and use it with the noise generator to check). Then, assuming sufficiently narrow receiver bandwidth, the formula to use is

$$Q = \frac{170\,(f_1)}{\%\ bandwidth\ (f_2 - f_3)} \quad (1)$$

where

f_1 = peak response (MHz)
f_2 = upper 6-dB point (MHz)
f_3 = lower 6-dB point (MHz)

For example, if the peak response is at 14.27 MHz and the −6 dB points are 14.03 MHz and 14.50 MHz as in **fig. 3**, then

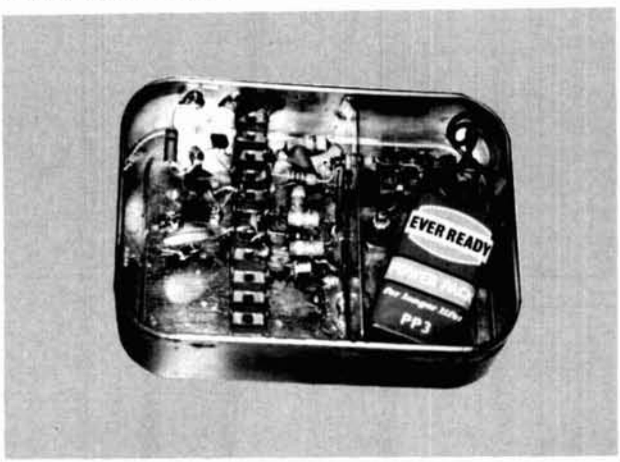
$$Q = \frac{170 \cdot 14.27}{100 \cdot 0.47} = 51.6$$

To measure loaded or in-circuit Q, it's possible to use the equipment's switching, coupling, and amplifying characteristics. For example, **fig. 4** shows the input to a hypothetical multiband preselector with a coupled-pair of tuned circuits. The noise generator can be connected to the hot end of the first coil with capacitor C1 removed. To check the first coil, the noise generator can be connected to the antenna socket and a test receiver capacitively coupled to the hot end.

response curves for simple filters

The shape of the frequency characteristic of the coupled pair in **fig. 4** can be investigated with the noise generator connected to the antenna socket and the test receiver at the output (with C1 replaced). You then have the choice of a) plotting response in S-units using the receiver meter, or b) adjusting an attenuator inserted between the noise generator and the circuit under test to obtain a constant meter reading. This is an example of a simple filter easily checked with the noise generator, provided the receiver bandwidth is a few times narrower than the feature being investigated. A CW receiver will meet almost any needs; an ssb receiver will meet most.

The author's completed noise bridge. On the left is the actual noise generator circuitry.



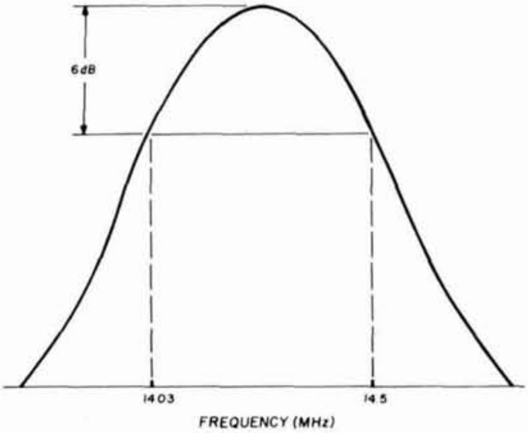


fig. 3. Typical response curve obtained during in-place measurements to determine Q of tuned circuits.

tuned-circuit alignment

The generator can be used to align any circuit whose wideband nature does not involve risks such as tuning an input circuit to the image frequency. Tuned circuits associated with crystal filters are particularly easy to align this way, as the need for accurate tuning of a stable generator is avoided — the crystal filter selects the frequency used.

checking sensitivity

The sensitivity of a receiver may be checked by connecting the noise generator to its input through a switched attenuator. The generator is powered by ac and the attenuation increased until the buzz in the receiver

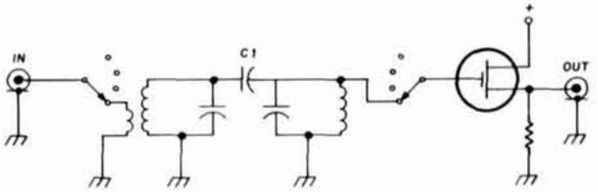


fig. 4. An hypothetical preselector with a coupled pair of tuned circuits. The frequency response of the tuned circuits is easily checked with the noise generator of fig. 1 and a communications receiver of narrower bandwidth than that of the circuit under test.

output is only just distinguishable from the noise. This is a useful way of comparing receivers or checking circuit improvements.

design improvement

The Q values of homemade coils may surprise you — I found values around 25, and the generator has taught me to follow the rules:

1. Use the largest diameter coil and the largest diameter wire possible.

2. Space the turns by one-half to one wire diameter.

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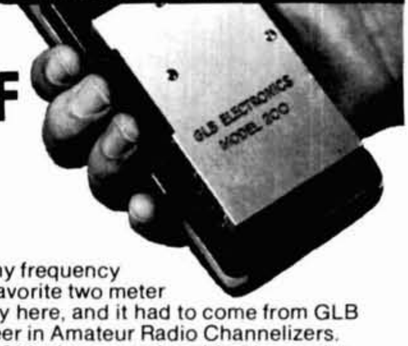

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More Details? CHECK–OFF Page 126

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This amazing new breakthrough in filter design is by Bob Crawford and Eckert Argo of Consulting Engineers. Atlas Radio is privileged to be first to offer this "programmable filter" in the radio communication field and for sometime to come will be the only one.

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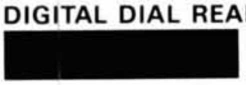

The Atlas 350-XL has space provided for quick installation of this plug-in accessory. Provides precise frequency readout to 1/10 of a kHz. All L.E.D. Dot Matrix 6 digit display.

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Auxiliary VFO is plugged into the space provided on the front panel of the 350-XL. You have a second tuneable VFO with same tuning ranges as primary VFO for tuning to a separate transmit or receive frequency. L.E.D.'s indicate which VFO, primary or secondary, will be used for receive and transmit.

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36-volt solar power source

A system of jumpers and switches to allow versatile metering, maintenance, and use of solar-charged batteries

In my normal solid-state experimental activities and QRPP operations, several days pass before the 12-volt, 5.5 ampere-hour, sun-charged battery needs to be recharged (see the November, 1974, *Circuits and Techniques* column). Thus two additional motorcycle batteries have been included along with a new control panel, **fig. 1**. Power capacity has been increased and both 24 and 36 volts have been made available. These higher voltages are helpful for work with fets and higher-voltage bipolar transistors.

Each battery can be trickle-charged or charged at the 300-mA rate (in bright sun) each third day. Two or three batteries can be parallel-charged if desired, or other arrangements can be combined depending on your specific needs. Based on a 20-hour discharge rate the current available from each battery is

$$I = \frac{5.5}{20} = 275\ mA$$

Available power rates based on the 20-hour discharge time, using series-connnected units, are

1 battery = 12 x 0.275 = 3.3 watts
2 batteries = 24 x 0.275 = 6.6 watts
3 batteries = 36 x 0.275 = 9.9 watts

In parallel combinations of two and three batteries, power values are

2 batteries = 12 x (2 x 0.275) = 6.6 watts
3 batteries = 12 x (3 x 0.275) = 9.9 watts

The figures above are for conservative operation and are based on 20 hours of demand at 275 mA per battery.

How many hours per week do you operate QRP? Even more significantly, during those operating hours your maximum power demand would be intermittent, which will extend your operating-hour capability. The 12-volt, 300 mA solar panel can easily keep your batteries charged for these operating conditions. In my case, the solar power supply supports a considerable amount of solid-state experimentation in addition to on-the-air operation.

Let's look at power capability based on an 8-hour discharge rating

$$I = \frac{5.5}{8} \approx 700\ mA$$

Batteries in series

1 battery = 12 x 0.7 = 8.4 watts
2 batteries = 24 x 0.7 = 16.8 watts
3 batteries = 36 x 0.7 = 25.2 watts

By **Edward M. Noll, W3FQJ**, P.O. Box 75, Chalfont, Pennsylvania 18914

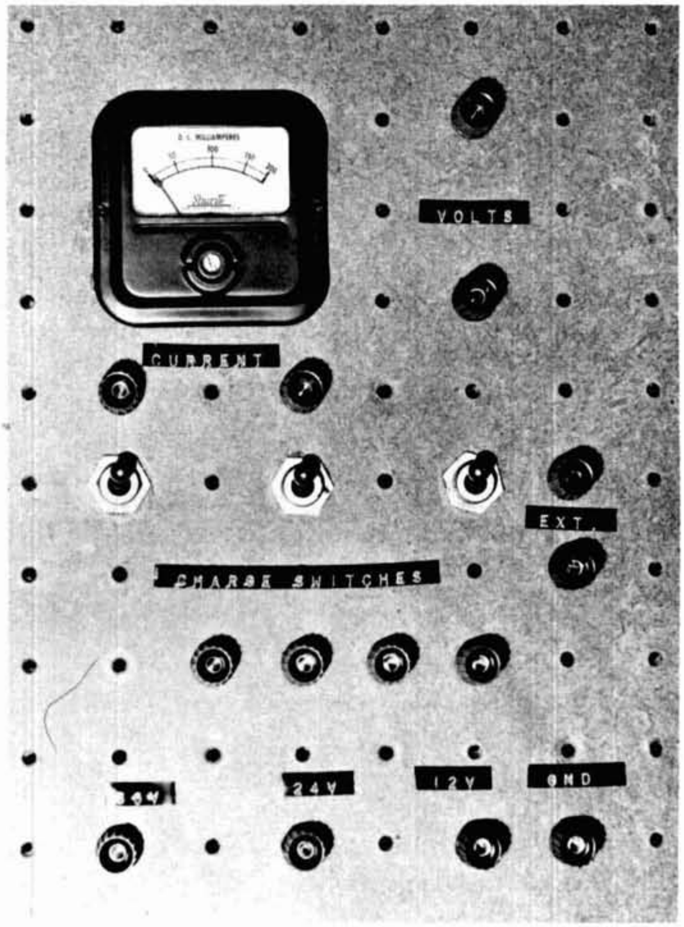


fig. 1. Solar control panel.

Batteries in parallel

2 batteries = 12 x (2 x 0.7) = 16.8 watts
3 batteries = 12 x (3 x 0.7) = 25.2 watts

The 8-hour figures indicate that you can draw considerable power from the 3-battery combination for extended periods of operation because of the very nature of the power demand during QRP activities. However, a much longer period is needed to restore the batteries to full charge, because the maximum charging rate is only 300 mA during maximum sunlight.

working with the sun

Assume 36 hours of weekly QRP operation at 5 watts. Based on a normal operating situation, a conservative figure for CW and ssb operating time at maximum demand would be one-third this value or 12 (36/3) hours. What would be the weekly watt-hour demand? Watt-hours are a measure of the *quantity* of electricity and are the product of watts and hours

$$\text{watt-hours} = Wh = 5 \times 12 = 60\ Wh$$

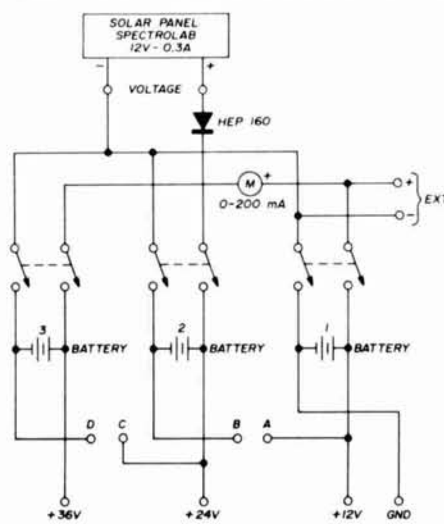
This amount of energy must be returned to the battery. In maximum sunlight the solar energy converter at W3FQJ supplies 3.6 watts (12 x 0.3). How many hours of a brightness level producing this amount of output would be required to replace the weekly watt-hour demand on the battery according to the preceding operating schedule? Assuming 100% efficiency

$$h = \frac{Wh}{W} = 16\ 2/3\ \text{hours}$$

This corresponds to approximately 2-1/3 hours of saturation-level brightness per day, averaged over a week's time. Indeed this amount allows very conservative operation of the solar power source. The one-third correction factor for normal operation is also conservative, compensating for the fact that the power demand on receive is substantially less than on transmit. Furthermore, even during transmit, no significant power demand is made during the spaces of code keying. For sideband transmission the peak demand is made only during the voice peaks; therefore the average power drawn is substantially lower. Consider also the fact that light energy can be converted to electrical watts at levels less than saturation brightness. Even during overcast and in the early morning and late afternoon hours, watt-hour replacement is being made. This extra charge time at lower levels more than compensates for the fact that you can't assume 100% efficiency in the battery-charging process. There is great emphasis today on the development of high-efficiency, lightweight and small-size batteries.

It is instructive to consider watt-hour capacity in terms of the solar panel itself. Again let's be conservative and assume the average brightness is such that saturation current is present something more than 3 hours per day. This average load figure more than compensates for days of dark overcast and rain. On this basis it is safe to assume approximately 25 hours per week of available saturation current, which corresponds to 90 watt-hours. If not maximum, at least significant power is being made available for 3 to 5 hours during the remainder of the day even during the winter months. Therefore the total weekly capability is at least 150 watt-hours. This is an average figure — some weeks more; other weeks less. The

fig. 2. Schematic of three-battery control panel.



actual figure also depends on geographical location. Consumption rates of this level, week after week, operate the system near limit at W3FQJ. This data indicates that 10 watts for 15 hours or 25 watts for 6 hours, averaged over the week, will not overburden the system. Using the one-third correction factor, this amounts to 30 operating hours at 10 watts or 18 operating hours at 25 watts.

The maximum power figures above are based on a weekly average. You must be careful not to demand too much power in any one day. For example, if you demand 25 watts for two hours in any one day (six hours of operation), your consumption would be 50 watt hours. *Recharge time at maximum sun would be nearly 14 hours (50/3.6).* Also in the same time you'll have used a bit more than 4 ampere-hours (25/12 x 2). This is a significant discharge of a 5.5 ampere-hour battery. *Another hour of such continuous operation without recharge would discharge your battery completely.* Continuous and average demand are factors in solar power systems. Each must be considered individually when working a system near its limit.

new control panel

The new control panel has been designed for maximum operating convenience here. You may develop plans that better meet your specific needs. However, the description will give you an idea of how the panel can be arranged for versatile charging and use. Three charge switches permit the batteries to be charged one at a time or two or three simultaneously. This is an aid in dividing the charge current as a function of individual battery use. A 0-200 dc milliammeter is connected in the charge path to the first battery only. It reads the current delivered from the solar panel when battery 1 only is under charge. If the charge switches are closed to the other batteries, this reading will decrease and will give some idea of how current divides among the three batteries. Remember, too, that when parallel-connected, batteries charge each other. Furthermore, a bad battery in the combination can place a heavy load on a good battery.

Batteries can be connected in series or parallel depending on the operating voltages to be established. Another pair of binding posts is used for external battery charging directly from the solar panel. An additional pair of binding posts permits a measurement of the solar-panel voltage at the point where the incoming wires connect to the control panel. The schematic is shown in fig. 2. Note that the protective-diode cathode and common connect to the poles of the dpst switches. The batteries, using associated binding posts, are connected across the individual terminals of the three switches. Therefore 1, 2, or 3 batteries can be charged at the same time. Battery 1 has its negative side connected to ground. 12 volts can be obtained by connecting the load between +12 volts and ground. Whenever 24 or 36 volts is used all three charging switches are turned off. To obtain 24 volts a jumper is connected between binding posts A and B, which makes +24 volts available at the output binding post labeled +24V. When output is to be obtained from the +36-volt binding post, jumpers must be connected between binding posts A and B and between C and D. *Never operate the charging circuit with any jumpers connected between A and B or C or D.* A battery short circuit will result if either the battery 2 or battery 3 charge switches are closed with either of these two jumpers in position.

Parallel operation of the three batteries can be obtained by joining the +12, +24, and +36 volt binding posts together. Additionally a ground is established by

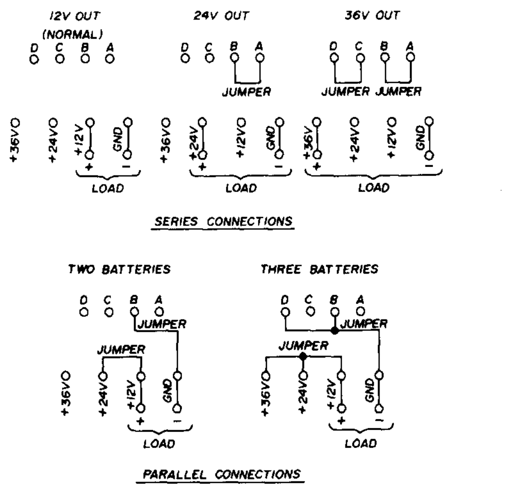


fig. 3. Use of jumpers in making series and parallel battery connections.

joining binding posts D and B with ground. The various binding post interconnections for various series and parallel groupings of the batteries is detailed in **fig. 3**. The 12-volt single-battery operation is inherent. The additional batteries in series or parallel require the use of appropriate jumpers. The charging of an external battery requires only that it be connected across the EXT binding posts. With all charge switches off, the meter will read charging current to the external battery.

expro I on forty meters

The Expro I fet transmitter in the August, 1975, column was adapted for 40-meter operation by winding a separate toroid coil. No other charges were required. The coil was wound on an Amidon T68-2 core and consists of 40 turns, number-24 enameled copper wire close-wound. It tuned up well on the antenna also described in the August column. The first contact I made on 40 meters was a special thrill. It was made with "Pop," W2ZTC, of Hancock, New York. Pop is an 88-year old gent with a hand-key CW rhythm better than my own. Thank you Pop for your patience with my rst 539 weak signal. You're the most! Your homebrew 100-watt rig sounded great. This is an example of amateur radio joining the generations.

ham radio

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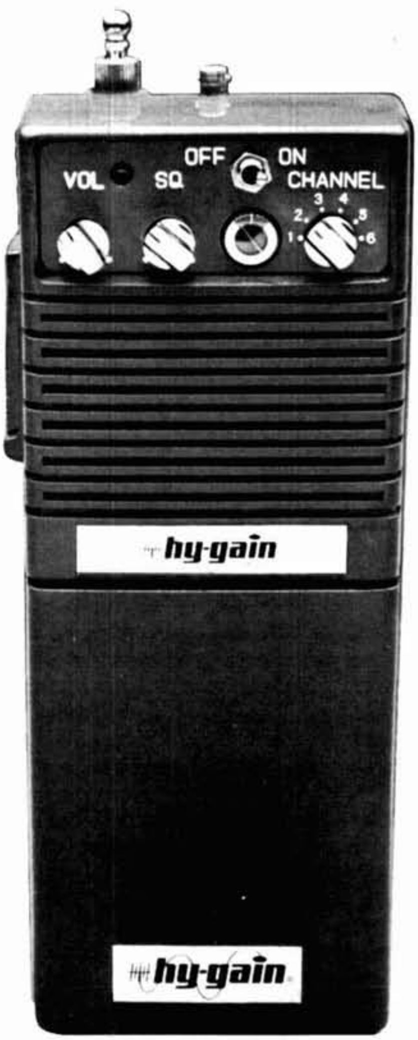

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The Hy-Gain 3806 is built to out-perform. Outlast. And out-class every other 2-meter hand-held.

It's built tough. Water, dirt and corrosion are sealed out by the specially gasketed case. The speaker /microphone grill is engineered to prevent direct entrance by water. Even changing the power pack in the field won't diminish case integrity. The power section is separately sealed. So you never expose the circuitry.

The high-impact ABS case is extra tough. And ribbed for a sure, non-slip grip. The controls are up front. And easy to operate. There's volume. Squelch. 6-position channel selector. Transmit LED indicator. A meter that indicates battery condition on transmit, signal strength on receive. And a separate power switch for positive on-off.

There's a telescoping antenna that collapses completely into the case. Or you can use our 269 flexible antenna for extra convenience. And there are jacks for use with external antenna. Earphone. And external 12 VDC.

The 3806 has the kind of guts that have made Hy-Gain products famous throughout the world. Its receiver section is superior to everything else for the money. It has sharply tuned, on-frequency selectivity in the RF amplifier circuit. Two MOS-FET RF amplifier stages. Plus MOS-FET's in the 1st and 2nd mixers. They make the 3806 virtually immune to out-of-band signals. Intermodulation distortion. And cross-modulation. So you get truly incredible dynamic range. For superb adjacent channel rejection, the 1st mixer is followed by a monolithic crystal filter. And the 2nd mixer by an 8-pole ceramic filter.

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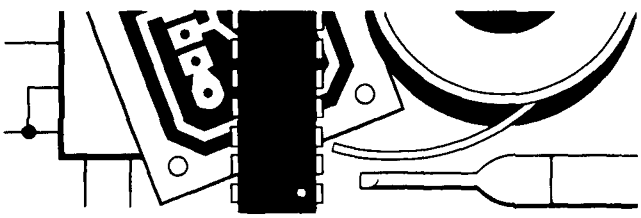
the weekender



a simple computing vswr indicator

The reasons for using a transmatch to match a random-length wire antenna to a typical 50-ohm transmitter output impedance are well known. However, practical experience shows that adjusting the transmatch for a good match can become a tedious affair. Since transmitter output changes with the load presented to it, you must constantly put the typical swr bridge on *forward,* adjust for a full-scale meter reading, then switch to *reflected* to read the swr. Otherwise, if you leave the bridge on *reflected* and tune for minimum meter indication, you usually find that, instead of being tuned for minimum swr, you've tuned for minimum transmitter output power instead.

The swr meter described here makes transmatch tuning incredibly simple, since it automatically uses the ratio of forward and reflected wave components to display the swr continuously regardless of transmitter output power. All you have to do is tune the transmatch to minimum meter deflection, thus avoiding the constant switch flicking and pot diddling usually required with swr meters. The circuit has some advantages over other types of computing swr meters[1,2] including:

1. A minimum of parts, which means a minimum of time and money to put it together.

2. Conventional power requirements. The unit may be powered from a 12-volt battery or from a ±9 or ±12-volt supply.

3. Accuracy over a 1000:1 range of transmitter power levels with no sensitivity adjustment needed. Actually a 100:1 or even a 20:1 range would be adequate for most situations.

4. Adaptation to existing swr bridges.

5. Only two adjustments needed for initial calibration.

operation

To understand how the circuit works, we should first think about how the typical swr meter operates. The usual swr indicator has a directional coupler inserted into the coax line. (The coupler could be of the Varimatch variety,[3] or it could be a directional wattmeter[4]). The coupler outputs a pair of dc voltages proportional to the *forward and reflected* voltages in the coax. When you adjust the swr meter sensitivity so that the forward dc voltage produces full-scale deflection, you have essentially calibrated the meter; applying the reflected dc signal to the meter allows you to read the swr directly. What this computing swr meter circuit does is

*A complete parts kit for this computing vswr indicator is being made available in conjunction with this article. For ordering information and prices, write to G.R. Whitehouse & Co., 10 Newbury Drive, Amherst, New Hampshire 03031.

By **Donald B. Lawson, WB9CYY,** 1317 Randall Court, Madison, Wisconsin 53715

adjust the meter sensitivity automatically as it applies the reflected signal to the meter.

Referring to the block diagram of **fig. 1** and its timing diagram, you can see that the directional coupler output voltages are applied to a pair of integrators. The integrator outputs are ramp waveforms for constant inputs; the higher the input voltages the steeper the ramps become. At any instant in time, the ratio of integrator outputs is

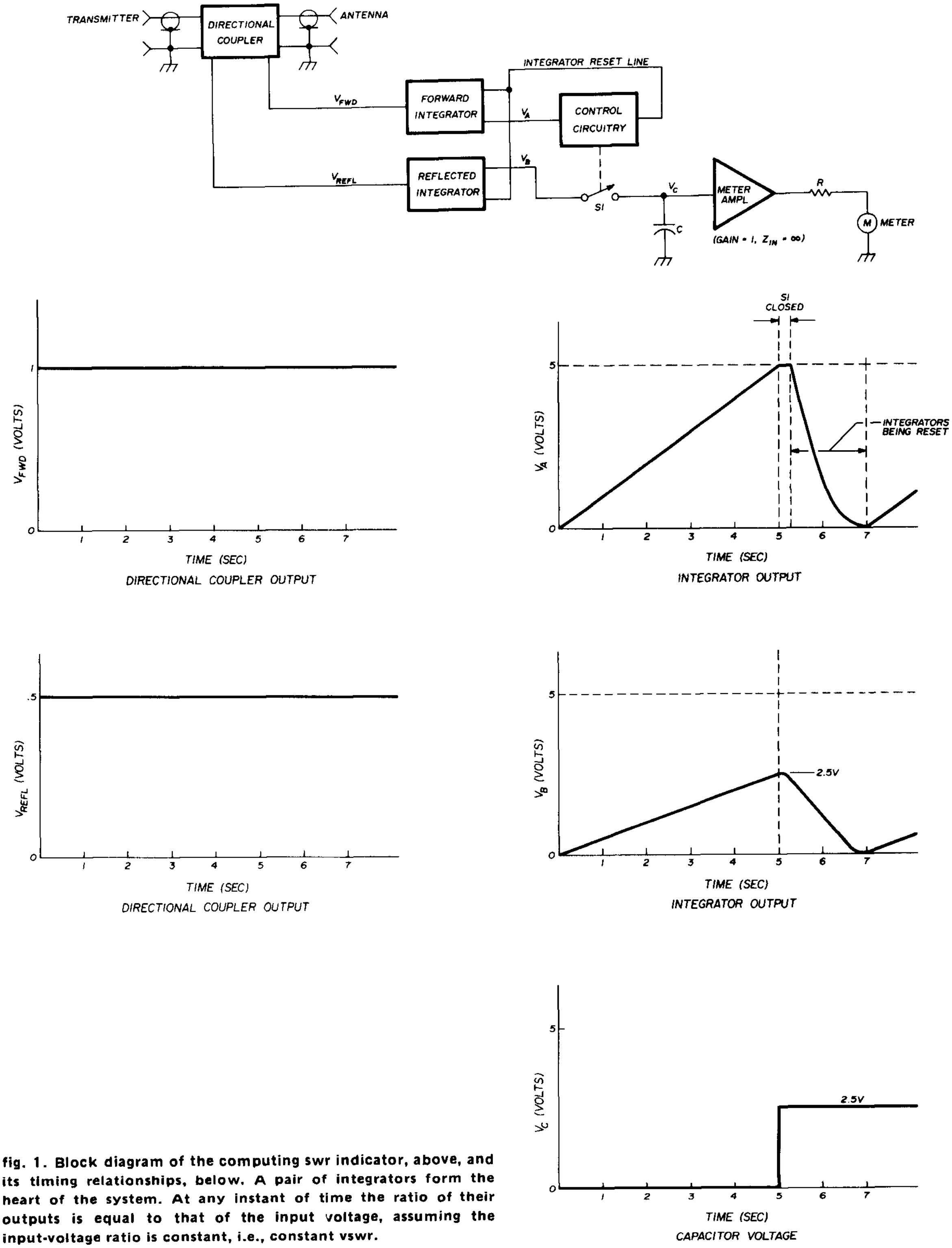


fig. 1. Block diagram of the computing swr indicator, above, and its timing relationships, below. A pair of integrators form the heart of the system. At any instant of time the ratio of their outputs is equal to that of the input voltage, assuming the input-voltage ratio is constant, i.e., constant vswr.

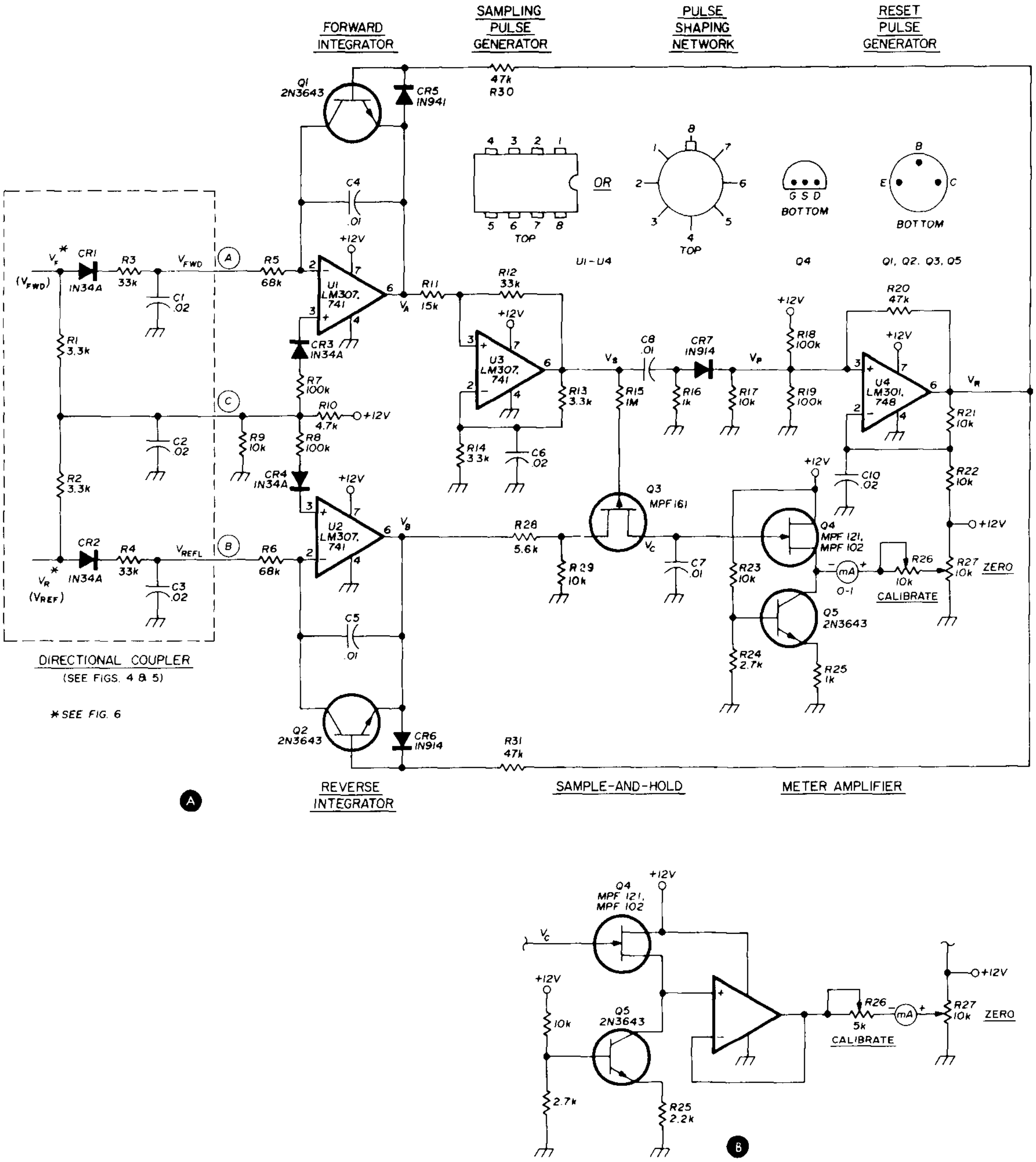


fig. 2. Computing swr indicator schematic, A, and an alternative meter-amplifier circuit, B. If a single 12-volt power supply is used, a special directional coupler is required (see fig. 4).

equal to the ratio of their input voltages (assuming the *ratio* of the input voltages remains constant; i.e., constant swr).

Now, let's say that *R* in **fig. 1A** is set so that 5 volts at V_C produces full-scale meter deflection. The integrators produce ramps V_A and V_B. When V_A reaches 5 volts the control circuit briefly closes S1 so that the capacitor is charged to V_B. V_B is 2.5 volts at this time. The meter is now at half-scale deflection, indicating an swr of 3:1. After opening S1, the control circuit resets the integrator outputs to zero and the process starts all over again. The capacitor will hold the 2.5 volts until S1 is again closed, because the meter-amplifier input draws essentially no current.

In the circuit of **fig. 2A** (and the corresponding timing diagram of **fig. 3**), you can see that the integrators operate around +8 volts, instead of zero volts, when you use the single +12 volt supply shown; this requires that a special directional coupler circuit be used (see **figs. 4 and 5**). If a conventional directional coupler is desired, you must use a dual-polarity power supply as discussed later. When V_A drops to 3.5 volts, the positive input of

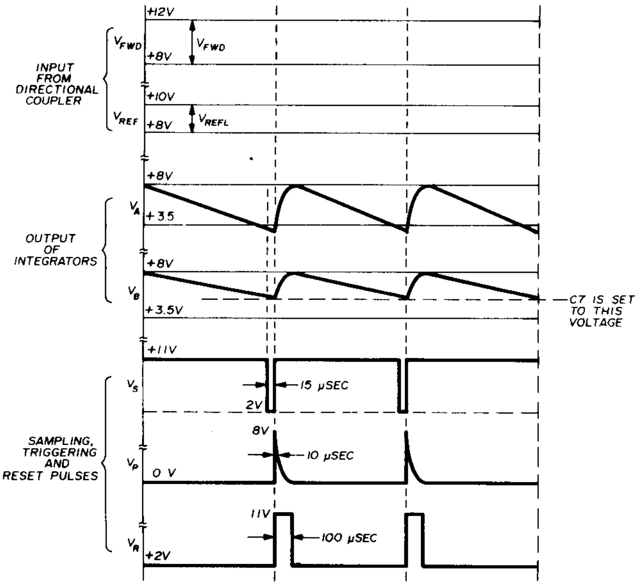


fig. 3. Timing diagram for the circuit of fig. 2A showing relationships between input signals, integrator outputs, and sampling, trigger, and reset pulses.

U3 is pulled below the voltage at the negative input, forcing the output low. It is held low until C6 discharges to where the negative input is closer to ground than the positive input, forcing the output high. When the output is low, Q3 is turned on, charging C7 to a new voltage.

The rising edge of U3 output is applied to U4, which generates a pulse in a similar manner, resetting the integrators to 8 volts by discharging C4 and C5 through Q1 and Q2. CR5 and CR6 prevent the transistor base-emitter junctions from accidentally breaking down and turning on the transistors when U4 output is low.

The meter amplifier, Q4 and Q5, can drive meters with sensitivities of 1 mA or better. If the meter you happen to have has lower sensitivity than this (or if you want *good* meter accuracy) then you should probably use the meter-amplifier circuit shown in **fig. 2B**. In the circuit of **fig. 2A**, Q5 acts as a constant 2-mA current source; more meter current means less current through Q4, which would mean a change in Q4 gate-source voltage, introducing some dc error. In **fig. 2B**, the change in Q4 current is negligible.

The meter is calibrated using the usual swr meter scale. You can calibrate a junk-box meter by:

$$swr = \frac{I_{fs} + 1}{I_{fs} - 1} \qquad (1)$$

where I_{fs} is the meter full-scale deflection current.

construction hints

U1 and U2 should be good-quality op-amps requiring very small input bias currents. LM307s are a good compromise between cost and results. Type 741s could be used if you have some on hand, although they are slightly inferior to the less-expensive LM307. U3 and U4 should be uncompensated, since they are used as fast pulse generators. Internal compensation makes op amps such as the LM307 and the 741 too slow. Don't use 709s, because their differential input voltage ratings will be exceeded in this application.

Diodes CR3 and CR4 provide better sensitivity at low transmitter power levels by compensating for the forward drop across CR1 and CR2. Diode pairs CR1-CR3 and CR2-CR4 should be matched for forward-voltage drop at low currents. (Do this by matching their forward resistances on the x10k and x100k scales of a vtvm). Diodes CR1 and CR2 should have low reverse leakage current (high back resistance). Using silicon instead of germanium diodes decreases circuit accuracy at low rf power levels (10 watts and less).

Q1 and Q2 should have low leakage current through the collector-base junction; most silicon transistors will work fine here. Check the I_{dss} of Q4 if you wish; if it's 3 mA or more, decreasing R25 to 680 ohms will reduce the meter-amplifier error mentioned earlier, since Q4 will then supply 3 mA. Don't worry about this if your meter sensitivity is better than 500 μA; however, be sure to increase R26 to a value that will protect the meter movement.

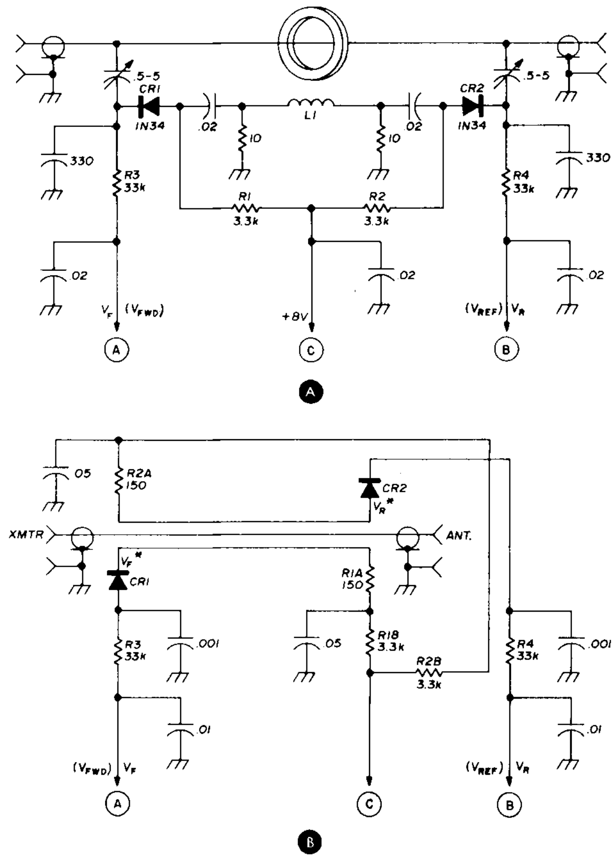


fig. 4. Circuits to be used in modifying existing swr bridges for use with the computing swr meter. A modified directional wattmeter is shown in A; a modified Monimatch in B. Inductor L1 consists of 30 turns of no. 22 AWG (0.6mm) wire on an Amidon T-50-2 form.

If you build this circuit into an existing swr meter, you can use **figs. 4** and **5** as guides when wiring the directional coupler to the circuit of **fig. 2A**. In general, expect better results if you use a Varimatch coupler rather than a directional wattmeter. Directional wattmeters don't seem to work well at power levels below 5 or 10 watts because of their low sensitivity. If you build your circuit from scratch, the directional coupler shown in **fig. 5** is easy to build and gives good results to at least 30 MHz.

If you have a dual-polarity power supply (±9 or ±12 volts), you'll probably want to use a conventional directional coupler circuit. If so, connect point C of **fig. 2A** to ground and connect all other ground to the negative supply line. Also, when using either single-polarity supplies of more than 15 volts, or dual-polarity supplies, you'll probably want to increase R23 and R26 (and possibly R27 as well). Except for these minor changes, the circuit will work as is on any voltage between 12-28 volts. At 12 volts the circuit draws approximately 20 mA, making a battery power supply practical. Since the meter calibration accuracy depends on the supply voltage, extreme accuracy will require the use of a regulated power supply. However, as long as the power-supply voltage doesn't vary by much more than ±10% or ±15%, the resulting accuracy will be more than adequate for practical use. Be sure that no strong rf fields can get into the op amps. Install the circuit in an aluminum box. Filter all leads entering and leaving the box.

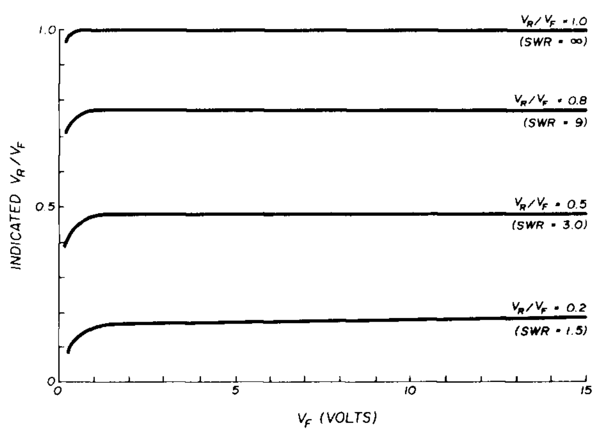


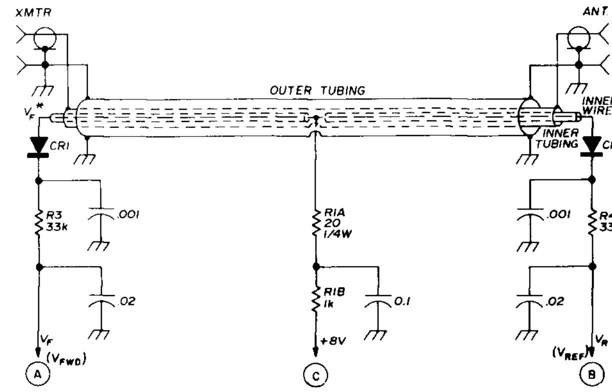
fig. 6. Actual vs indicated ratios of V_R/V_F as a function of V_F. V_F and V_R were dc voltages applied to points V_F* and V_R* of fig. 2A. CR1-CR4 were 1N914s; R5-R8 were 1 megohm. By using the components specified in fig. 2A the curves should extend in nearly straight lines to V_F = 0.1 volt or so.

calibration and results

The first step in calibration is to check that the directional coupler is working properly. Connect a dummy load to the antenna jack and check for zero volts between points V_{refl} and C of **fig. 4** or **5**. After removing the dummy load, you should get nearly equal voltages at V_{fwd} and V_{refl} (they don't have to be exactly equal). These steps need not be taken if you use a dual-polarity power supply and an old but reliable swr bridge directional coupler.

Set the *calibration* pot (R26) for maximum resistance and apply power to the circuit. With the dummy load connected and the transmitter key down, adjust R27 for zero meter deflection. Next, disconnect the load from the antenna jack, briefly close the key and adjust R26 for full-scale meter deflection. You may want to touch up R27, but this probably won't be necessary. Your computing swr meter is now calibrated and ready for use.

If the circuit doesn't work properly, first check that the *transmitter jack really is* the transmitter jack. Then, by using very low transmitter power (a half watt or less),



Inner conductor	inner part of RG-59/U coax with insulation, prepared as shown above
Inner tubing	1/4" (6.5mm) diameter copper tubing, 8" (20cm) long, with a small hole (1/8" or 3mm) filed at the midway point
Outer tubing	1/2" (13mm) copper tubing, 7" (18cm) long, with a small hole filed at the midway point

fig. 5. The Varimatch circuit modified for use with the computing swr meter of fig. 2A.

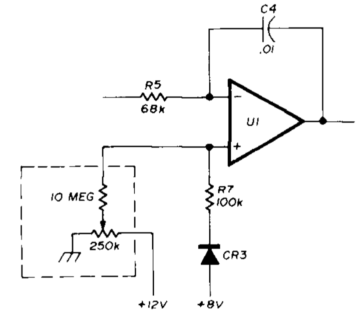


fig. 7. Optional circuit for adjusting U1 offset voltage if the swr meter indicates a random value during key-up conditions. So long as U1 output remains above 3.5 volts the meter needle will stay put with no transmitter output.

you should be able to see the integrators move with your vtvm. Pulses at U3 and U4 can be detected with the vtvm set to ac volts or with a vom set to *output*.

Typical performance using silicon diodes for CR1-CR4 is shown in **fig. 6**. The integrators are almost impossible to overload (an overload would correspond to trying to make the outputs move faster than 0.5 volt per microsecond), so the upper limit to what power the circuit will handle is set by the PIV of CR1 and CR2 and by the width of the pulse fed to Q3. The lower limit for good meter accuracy is set by how well diodes CR1-CR4 are matched, plus whether the diodes are germanium or silicon. The constant offset between indicated and actual V_R/V_F ratio is due to error in the meter amplifier.

Fayman[1] noted that his swr meter had a tendency to sit at random values of swr during key-up conditions, requiring special circuitry to correct the problem. The circuit of **fig. 2A** can have the same problem, but it can be overcome by adjusting U1 offset voltage (see dashed box, **fig. 7**) so that its output drifts slowly toward the positive end of the supply line with no transmitter output. (Check your circuit before adding the pot and resistor of **fig. 7**; your particular U1 may already be doing this). As long as U1 output remains above 3.5 volts, Q3 will remain turned off, and the meter needle will stand still (it won't go to zero when the key is up, but it won't go off to some random value either).

concluding remarks

This computing swr meter has been a big help in transmatch tune up. It also has suddenly made all kinds of antenna ideas appear appealing since the transmatch is now an easily used piece of equipment. Even so, many improvements could be made in this circuit. You could, for instance, try a circuit allowing the use of *both* a conventional directional coupler *and* a single-polarity 12-volt supply. This could be done by using CA3130 CMOS op amps for U1 and U2. Diodes CR1 and CR2 would have to be turned around, and CR3, CR4, R7 and R8 would have to be eliminated; also, an amplifier would have to be used between U1 and U3 to transform a signal exceeding +10 volts to a signal dropping below +3.5 volts.

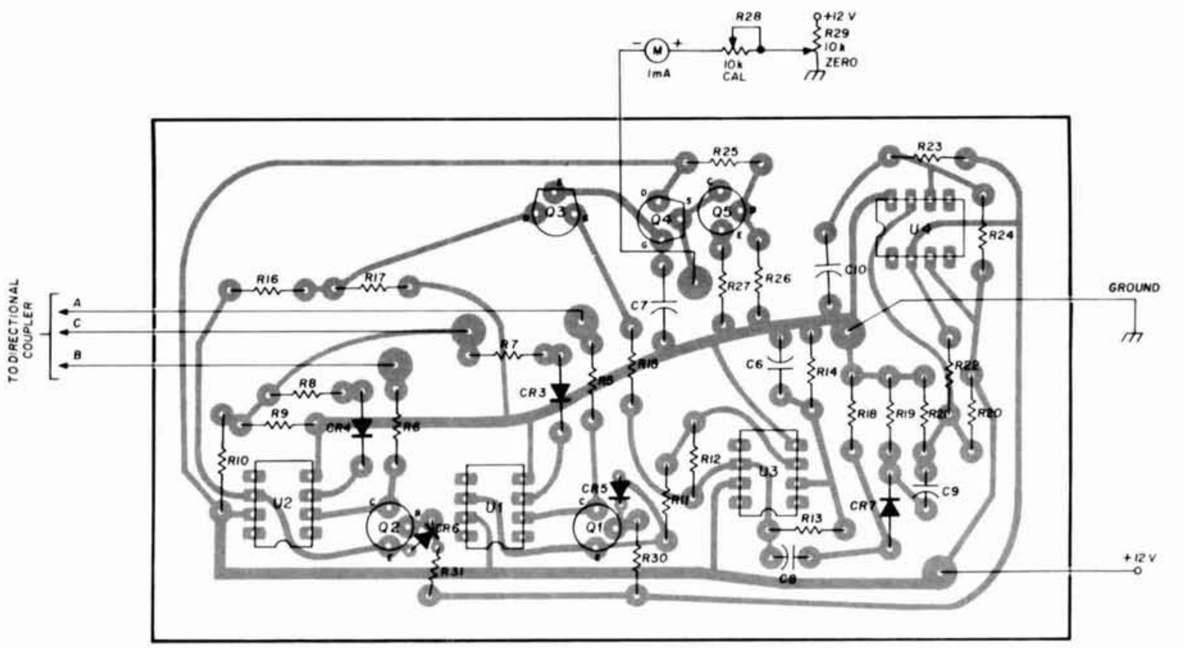


fig. 8. Printed-circuit component layout for the swr computer. A printed-circuit board for this project is available from G.R. Whitehouse (see footnote on page 58).

You could also try reducing the cost (at a sacrifice of accuracy) by using an LM3900 quad amplifier. The problem here is that you'd have an swr of 1:1 every time V_{refl} dropped below 0.7 volt or so – not so neat if V_{fwd} is only 0.8 volt zero to peak. However, for higher voltage levels, this idea might be OK. Another idea would be to add a peak-reading circuit to the directional coupler V_{fwd} line to indicate transmitter PEP in side-band applications.

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2. T. Mayhugh, W6OTG, "A Digital SWR Computer," *73*, November, 1974, page 80; December, 1974, page 86.
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4. D. DeMaw, W1CER, "In-line RF Power Metering," *QST*, December, 1969, page 11.

ham radio

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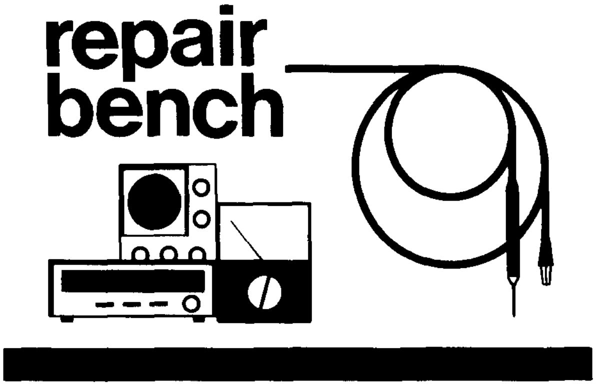

Bob Stein, W6NBI

using the swr indicator

Ever since the end of World War II, the surplus market has been a major source of test equipment, transmitters and receivers, and parts. For the serious experimenter, the first category has been of paramount importance, enabling him to obtain equipment which would otherwise be out of the question because of cost. Surplus equipment continues to be in strong supply from both industrial and military sources. In fact, there is more available now than ever before, for several reasons.

First of all, the state of the electronics art has changed so rapidly in the past few years that much of the test equipment which was standard in industry is no longer economical to use, although it is perfectly adequate for amateur use. A typical example of this is the slotted line used with the swr indicator, a combination that has largely been replaced by the reflection bridge or the network analyzer. A second reason for the availability of good commercial test equipment is the fact that the military services have been using off-the-shelf commercial equipment, which they continue to surplus.

This article is the first of a series which will explain the uses and benefits of certain classes of test equipment which heretofore have been relatively uncommon in the ham shack. I hope to show how modest investments in such equipment will enable you to improve your testing capabilities as well as expand your knowledge of test methods.

the swr indicator

Although there are and have been several types of swr indicators available, the one which is most common and which seems to be the easiest to obtain is the Hewlett-Packard model 415B Standing Wave Indicator. Others which appear on the surplus market from time to time are the Sperry Microwave SWR Indicator model 29A1 and the Narda model 441 VSWR Amplifier. Current instruments of the same type are the Hewlett-Packard model 415E SWR Meter and the GenRad (formerly General Radio) Standing-Wave Meter type 1234. Obviously there are differences among all of these, but basically they are similar.

Despite the similarity in names, the swr *indicator* to be discussed in this article is something completely different from the vswr *bridge* commonly found in most ham shacks. The bridge which you use in your transmission line is an rf *power* instrument which measures incident and reflected power or voltage (with varying degrees of accuracy). The vswr is then calculated from these readings, or is read directly from the meter provided that a reference level for the incident wave has been established.

The swr indicator, on the other hand, is an instrument which is exactly what its name says it is – an indicator. It is capable of indicating vswr only when used in conjunction with an rf detector and other equipment, such as a slotted line or a directional coupler. However, it can do this with no more power applied to the device under test than is produced by a signal generator. Thus, vswr readings can be obtained for virtually any type of equipment – converters, attenuators, filters, transmitters, coax relays and switches, antennas, transmission-line sections, and so on.

But that's only the beginning. The swr indicator can also be used with a detector to measure the attenuation and insertion loss of fixed and variable attenuators, insertion loss and response of filters, cross-talk in coaxial relays and switches, and antenna gain (when compared to a standard gain antenna on an antenna range). It can also serve as an extremely sensitive null indicator in ac bridge circuits. So you can see that we are talking about a very versatile instrument.

inside the swr indicator

Despite its versatility, the swr indicator is a relatively simple instrument; it is basically nothing more than a tuned electronic voltmeter which responds to a fixed frequency of 1000 Hz. (There are special cases where a frequency other than 1000 Hz is used, but these are rare, and the instrument model number generally will have been modified by the addition of an option or special number. Check the back of the instrument housing for a sticker which shows this modified model number.) The gain is extremely high, resulting in a sensitivity of typically 0.1 microvolt for full-scale meter deflection on the most sensitive range.

The swr indicator incorporates range attenuators, a gain control, and provisions for selecting and matching the type of detector used. The meter scales are marked in swr and dB. Note that the presence of a gain control indicates that the instrument is not a calibrated voltmeter, but is one which is designed to measure the ratio of two voltages. This capability is all that is required, since swr and dB are, by definition, both ratios.

outside the swr indicator

As mentioned earlier in this article, a detector must be used with the swr indicator for all rf measurements,

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and obviously an rf signal source at the desired frequency is required. The signal source must be amplitude modulated with a 1000-Hz sine or square wave. An output of *0.2 milliwatt (100 millivolts across 50 ohms)* is generally sufficient. Regardless of the actual output power, the signal source must supply a constant output and should have minimum harmonic distortion. The modulating voltage must also be stable to prevent measurement errors.

The detector must be a square-law device, that is, one whose *output voltage* is proportional to rf *input power*. Coaxial slotted lines usually have a detector built into them, but an external detector must be used for other applications of the swr indicator. Such a detector may be either a coaxially mounted bolometer* or semiconductor diode, operated at low signal levels.

Although the Hewlett-Packard 415B can supply either 4.3 or 8.7 milliamperes bolometer bias current, bolometer detectors are relatively rare so we will consider all operation using a diode detector. There are many types, made by many manufacturers, all of which will be more than satisfactory for use with the swr indicator. However, be sure that the detector which you use presents a termination which corresponds to the system impedance; both 50- and 75-ohm detectors are available. For the purpose of this article, all impedances are assumed to be 50 ohms.

The Hewlett-Packard model 415B Standing Wave Indicator. Although this instrument has been superseded by the model 415E, it will still provide years of useful service. (Photo courtesy of Hewlett-Packard Company)

A coaxial detector is also a simple and inexpensive device to construct; methods of construction are shown in previous articles by W6VSV[2] and W1JAA.[3] Virtually *all commercial detectors incorporate a resistive termination* at the rf input connector, but those described in W6VSV's article do not. Therefore a 50-ohm feedthrough termination should be used at the input of such a detector. (Alternatively, a 50-ohm pad and coaxial short can be used, as shown by W6VSV.)

Some diode detectors incorporate a matched load resistor either at the *output* connector or in a separate coaxial load. These too are relatively rare, but bear mentioning. Their advantage is greater square-law range, although this is achieved at a cost of some sensitivity loss.

There are two precautions which must be observed when using a diode detector. The first of these entails staying within the square-law region of the diode. For amateur measurements, power levels up to a few microwatts may be applied to the detector input without causing serious measurement errors. In general, if the applied rf power is kept below the level which results in a full-scale reading on the 30-dB range of the swr indicator with the gain controls at maximum, the detector will be working within its square-law range.

Secondly, if a detector with a matched load is used, the input selector switch on the swr indicator must be set to the high-impedance (200 kilohm) *crystal* position in order not to shunt the detector load with a low impedance. As previously stated, however, detectors with matched loads are relatively uncommon. With an unloaded detector, the input selector is set to the *crystal* position which results in the highest sensitivity.

The attenuation of loss pads, cables, filters, etc., may be measured using the test set-up shown in **fig. 1.** Loss pads, preferably 10 dB or more, are used at the input and output of the device under test (DUT) to ensure a uniform 50-ohm system. If the detector presents a known 50-ohm impedance at the test frequency (as most commercial units do), the pad between the DUT and the detector may be omitted.

Connect the equipment as shown, except substitute a feedthrough coaxial fitting for the DUT. Adjust the signal-generator output and the range switch and gain controls of the swr indicator for a reference level of 0 dB on the lowest range (most counter clockwise range-switch setting) which will allow for a reduction of signal level equal to the expected attenuation of the DUT. This ensures operation of the detector in its square-law region. For example, if a 20-dB attenuator is to be checked, setting the swr indicator reference level to 0 dB on the 40-dB range setting will allow you to measure up to 30 dB of loss – two 10-dB ranges of the switch plus the 10-dB meter range.

*There are two types of bolometers: *barretters*, which are normal resistance elements with a positive temperature coefficient, and *thermistors*, which are manufactured from metallic oxide materials which exhibit a negative temperature coefficient. In its simplest form the barretter may be a short length of very fine wire, such as an instrument fuse, or a metallized film resistor.[1]

The Hewlett-Packard models 420A and 423A Crystal Detectors are typical of the many detectors which can be used with the swr indicator. Both detectors are usable from 10 MHz to 12.4 GHz. The response of the 420A, on the top, is ±3.5 dB with a maximum vswr of 3.0. The 423A is flat within ±0.5 dB and has a maximum vswr of 1.5 (1.2 below 4.5 GHz). (Photo courtesy of Hewlett-Packard Company)

Insert the DUT into the test set-up, in place of the coax feedthrough, and note the swr indicator meter reading. *Do not touch the gain controls.* If the meter is still on scale, the attenuation of the DUT is equal to the meter reading on the dB scale. If the meter reads below the 10-dB mark, switch to the next lower (counterclockwise) range-switch setting which moves the meter on-scale. The attenuation of the DUT in dB then will be equal to the difference between the reference and final switch settings plus the meter reading.

Continuing with the example cited above, assume that when the 20-dB pad is inserted in the test set-up, the range switch has to be changed from the 40- to the 60-dB position, and the meter pointer rests at the 1-dB mark. The attenuation of the loss pad is thus actually 21 dB – two 10-dB switch positions plus 1 dB on the meter.

The Hewlett-Packard 415B has a *meter scale* switch which makes reading the meter more accurate under certain conditions. Since the dB scale is logarithmic, the meter scale between 5 and 10 dB is greatly compressed. If the meter reading is in this region, you can set the *meter scale* switch to the *−5 dB* position and turn the range switch to its next lower (counterclockwise) setting. The meter pointer will then fall between 0 and 5 dB, providing a more accurately read indication, but don't forget to subtract 5 dB from your final readings.

If a reading of less than 2 dB is involved, such as would hopefully be expected when measuring insertion loss, it can be read more accurately on the *expanded dB* scale of the meter. This requires setting the *meter scale* switch to *expand* and establishing the reference level with the *meter scale* switch in that position.

measuring filter response

The attenuation vs frequency response of a filter may be measured in a manner similar to that just described. However, certain additional precautions are involved. First and foremost, your signal source output must be kept constant over the frequency range of interest. Secondly, if you are interested in the response below −35 dB, the loss pad at the input to the filter must be adjustable or be changed, since 35 dB is about the limit of a typical diode detector's square-law range.

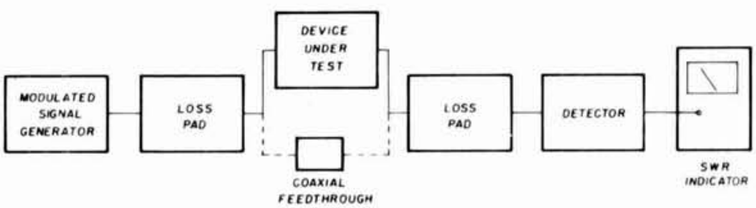
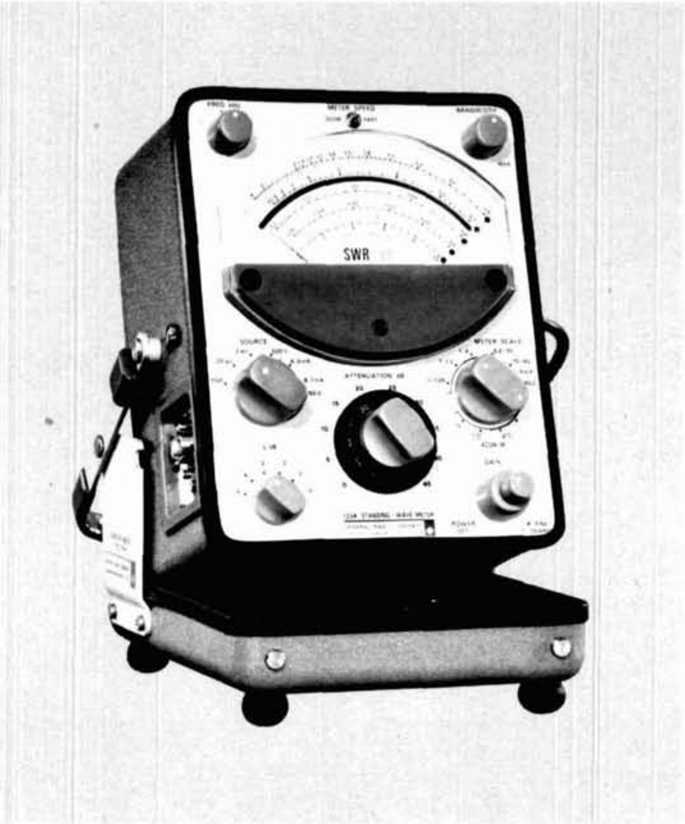


fig. 1. Equipment set-up for measuring attenuation, filter response, and gain. The coaxial feedthrough connector is used to establish a reference level on the swr indicator, and is replaced by the device under test (DUT) for the actual measurement. The signal generator may be replaced by any stable small-signal source which is modulated by 1000 Hz signal.



The type 1234 Standing-Wave Meter is the current swr indicator in the GenRad (formerly General Radio) product line. (Photo courtesy GenRad)

As an example, let's assume that you want to check the response of a 145-MHz bandpass filter. Connect it as shown in **fig. 1**, using a frequency counter at the output of the signal generator if the frequency calibration of the generator is in doubt. Instead of a fixed loss pad between the signal generator and the filter, use a step attenuator of known accuracy, set to provide 40 dB of attentuation. Tune the signal generator for maximum indication on the swr indicator, using the 30-dB range with the gain controls at or near maximum. Establish a 0-dB reference level by means of the signal generator output attenuator and the swr indicator fine-gain control.

As the generator frequency is varied, the attenuation of the filter can be read directly from the dB scale of the meter in conjunction with the range switch. As you get further away from the center (reference) frequency, you will run out of swr indicator sensitivity. At this point, note the meter reading, reduce the sensitivity of the swr indicator by 20 dB, and lower the attenuation of the step attenuator by 20 dB, thus still keeping a 20-dB pad in the system for impedance matching. If your step attenuator is accurate, the meter indication should be the same as before; if it is not, it indicates an error in the step-attenuator calibration which must be accounted for in subsequent readings. Now continue to check the filter response, adding 20 dB (or the amount by which the step attenuator was changed) to the swr meter readings.

If you don't have a step attenuator, you can accomplish the same thing by using two fixed loss pads between the signal generator and the filter. When you reach the point of maximum swr indicator sensitivity, simply remove one of the pads and continue as described above. In this case, you must add to the swr indicator readings the attenuation of the pad which was removed.

An immediate reaction to these procedures may well be that the accuracy of the measurements at low levels depends on the calibration of the adjustable or additional fixed attenuator. This is true, but all you have to do is to *measure* the attenuator, using the same swr indicator and detector, if you are not sure of the calibration. What could be simpler than a self-checking system?

measuring gain

It should be obvious that if attenuation, or signal loss, can be measured with an swr indicator, signal gain can also be determined. This is accomplished by exactly the same procedure described for attenuation measurement, except that the reference level through the coax feedthrough should be established on the most sensitive (60-dB) range of the swr indicator.

For example, let's assume that you want to know the gain of your two-meter converter, and expect it to be between 25 and 30 dB. If you set the 0-dB reference level on the 60-dB range of the swr indicator, you will have to reduce the sensitivity when the converter is connected in place of the feedthrough connector. The amount by which sensitivity is reduced is equal to the change in the range-switch setting *minus* the meter reading, and represents the gain of the converter.

Conversely, gain can be measured by establishing a reference level using the device under test. Then substituting a coaxial feedthrough for the DUT will result in a loss equal to the gain of the active device.

measuring cross-talk or isolation

A coaxial antenna change-over relay or switch should

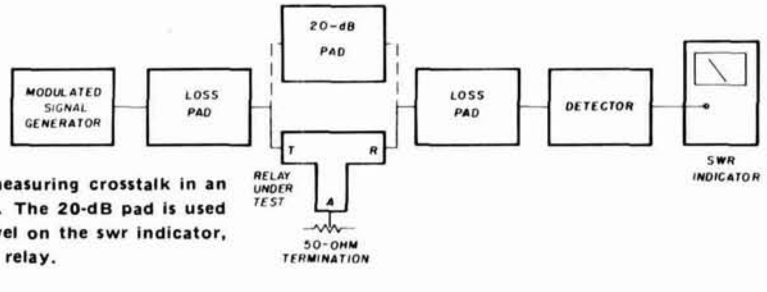


fig. 2. Arrangement for measuring crosstalk in an antenna change-over relay. The 20-dB pad is used to establish a reference level on the swr indicator, and is then replaced by the relay.

table 1. Reflection coefficient and VSWR vs return loss

return loss (dB)	reflection coefficient	vswr	return loss (dB)	reflection coefficient	vswr
1	.8913	17.3910	31	.0282	1.0580
2	.7943	8.7242	32	.0251	1.0515
3	.7079	5.8480	33	.0224	1.0458
4	.6310	4.4194	34	.0200	1.0407
5	.5623	3.5698	35	.0178	1.0362
6	.5012	3.0095	36	.0158	1.0322
7	.4467	2.6146	37	.0141	1.0287
8	.3981	2.3229	38	.0126	1.0255
9	.3548	2.0999	39	.0112	1.0227
10	.3162	1.9250	40	.0100	1.0202
11	.2818	1.7849	41	.0089	1.0180
12	.2512	1.6709	42	.0079	1.0160
13	.2239	1.5769	43	.0071	1.0143
14	.1995	1.4985	44	.0063	1.0127
15	.1778	1.4326	45	.0056	1.0113
16	.1585	1.3767	46	.0050	1.0101
17	.1413	1.3290	47	.0045	1.0090
18	.1259	1.2880	48	.0040	1.0080
19	.1122	1.2528	49	.0035	1.0071
20	.1000	1.2222	50	.0032	1.0063
21	.0891	1.1957	51	.0028	1.0057
22	.0794	1.1726	52	.0025	1.0050
23	.0708	1.1524	53	.0022	1.0045
24	.0631	1.1347	54	.0020	1.0040
25	.0562	1.1192	55	.0018	1.0036
26	.0501	1.1055	56	.0016	1.0032
27	.0447	1.0935	57	.0014	1.0028
28	.0398	1.0829	58	.0013	1.0025
29	.0355	1.0736	59	.0011	1.0022
30	.0316	1.0653	60	.0010	1.0020

provide at least 50 dB isolation between the transmit and receive connectors, but many do not, especially at uhf. Inadequate isolation can easily result in the destruction of transistors in the receiver when used in proximity to a high-power transmitter.

You can play it safe and measure the cross-talk, or isolation, of your change-over device by means of (you guessed it) the swr indicator. Since you hope to find the cross-talk down by 50-dB, which is well beyond the square-law region of the detector, a substitution method of measurement is employed.

Fig. 2 shows the test set-up for such measurements. Initially, a 20-dB pad is inserted as shown, and a 0-dB reference level established on the swr indicator. Since we hope to find the cross-talk between the transmit and receive ports down by well over 20 dB, the reference level should be set on the 40-dB range. Then remove the 20-dB pad and connect the relay as shown. The isolation will be equal to the change indicated by the swr indicator plus 20 dB.

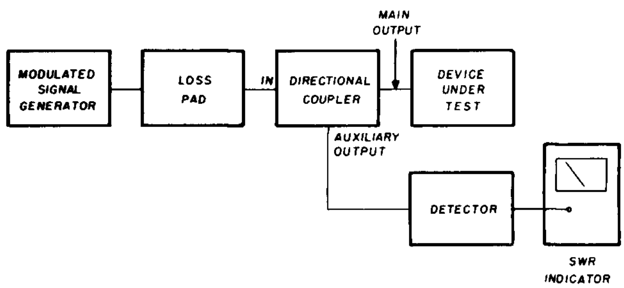
measuring vswr with a directional coupler

This one is for the vhf and uhf enthusiast, since directional couplers are usually used at frequencies of 200 MHz and higher. And although amateurs who are fortunate enough to have a directional coupler normally use it only for power measurements, it can be utilized to measure vswr by return loss.

The equipment set-up for this measurement is shown in **fig. 3**, and the procedure is as follows:

1. Establish a reference level of 0 dB on the least sensitive range (but not less than 30 dB) commensurate with the available signal-source power.
2. Reverse the input and output connections to the directional coupler, keeping the detector on the auxiliary-output port.
3. Determine the return loss (α) in dB from the reference level, as measured by the swr indicator.

fig. 3. Equipment configuration for measuring reflection coefficient and vswr by the return-loss method. Measurements are essentially independent of the coupling coefficient, but accuracy is severely limited by the directivity of the coupler, as explained in the text.



4. Determine the vswr from **table 1**, which shows the tabulated results of the following equations, where ρ is the reflection coefficient.

$$p = 10^{\frac{-\alpha}{20}}$$

and

$$VSWR = \frac{1 + \rho}{1 - \rho}$$

Theoretically, measuring vswr by the return-loss method is accurate and quite simple to perform. In practice, however, the directional coupler can introduce large errors if its directivity is not substantially greater than the measured return loss. A good rule of thumb is to use a coupler whose directivity is at least 15 dB greater than the return loss. Since commonly available directional couplers generally have a specified directivity of only 20 or 30 dB, this would appear to limit accurate measurements to return losses of 5 to 15 dB, with the lower of these two values corresponding to a vswr of 3.57 (see **table 1**). However, even though the difference between the measured return loss and the coupler directivity is less than 15 dB, the technique is still usable for adjusting the equipment under test for minimum vswr.

In addition to coupler directivity, there are other factors which affect measurement accuracy, but these are of lesser importance. A complete discussion of measurement errors using directional couplers is beyond the scope of this article, but appears in reference 4.

I hope that this article has demonstrated the versatility of the swr indicator in the ham shack. Although the various commercial models mentioned earlier are generally available in limited quantities, there is no sure way of knowing that the supply will continue to exist. Even if you cannot find an instrument on the surplus market, it is a relatively easy unit to build, and will be just as accurate as the commercial versions. An equivalent, though slightly less complicated, instrument is completely described in reference 2.

Despite the length of this article, the primary *raison d'ëtre* of the swr indicator, that of use with the slotted line, has not been covered. This will be the subject of a future article.

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6. *Operating and Service Manual, 415E SWR Meter*, Hewlett-Packard Company, Palo Alto, California 94304.

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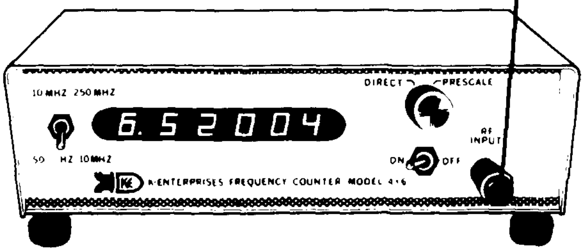

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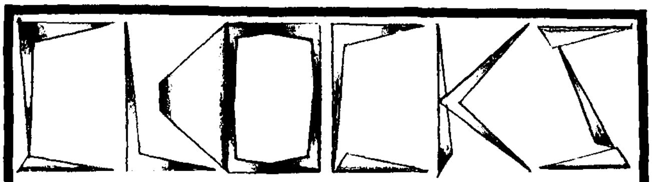

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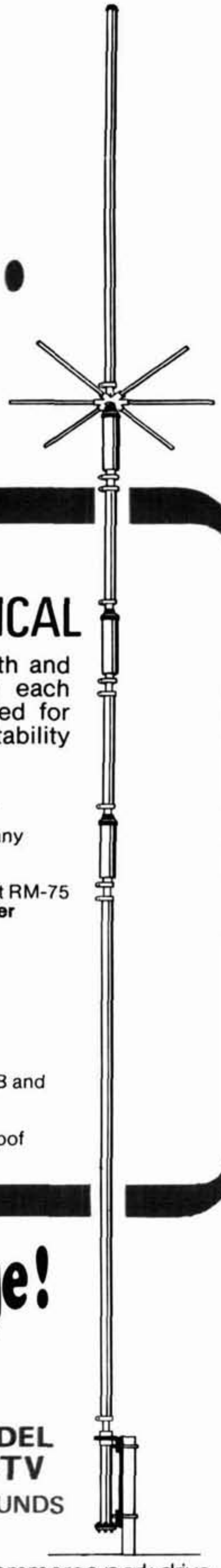

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MICROPROCESSORS

microcomputer interfacing: the vectored interrupt

This month we continue our discussion of computer interrupts, with emphasis upon the vector-interrupt hardware and software associated with the 8080A microprocessor chip. The three signals that are used in vector-interrupt circuits include INT (input pin 14 on the 8080A chip), INTE (output pin 16), and $\overline{\text{INTA}}$ which is not available on the 8080A chip but derived with external logic.

A positive clock pulse, from an interrupting device, supplies a logic 1 to the INT (*interrupt request*) input. This pulse generates an interrupt request which the CPU recognizes either at the end of the current instruction being executed or while the CPU is in the halt state. The

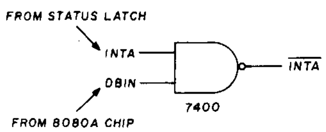

fig. 1. The $\overline{\text{INTA}}$ control signal is generated from the DBIN and INTA control signals, only one of which is available on the 8080A chip.

INTE, *interrupt enable*, output pin indicates the logic state of the interrupt-enable flip-flop within the 8080A chip. This internal flip-flop can be set (enabled) or cleared (disabled) with the aid of the 8080A microcomputer instructions:

363	DI	Disable interrupt flip-flop
373	EI	Enable interrupt flip-flop

When cleared, the interrupt-enable flip-flop inhibits interrupts from being accepted by the CPU. The flip-flop is automatically cleared when an interrupt is accepted, and also by the RESET input signal applied at pin 12 of the 8080A chip.

The $\overline{\text{INTA}}$ or *interrupt acknowledge* control signal is generated by applying the INTA and DBIN control signals to a two-input NAND gate (**fig. 1**). A logic 1 at DBIN, *data bus in*, (pin 17 on the 8080A chip) indicates to external devices that the data bus is in the input mode. INTA is a positive clock pulse that is generated as a status output with the aid of a latch connected to the 8080A microprocessor chip.[1,2] We shall talk about the

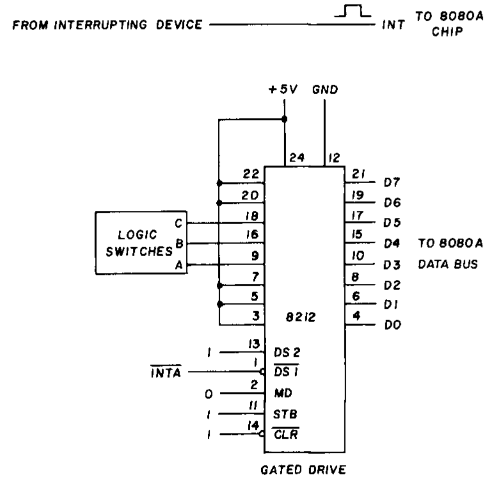

fig. 2. Interface circuit for the jamming of a single-byte instruction into the instruction register of an 8080A microprocessor chip.

status latch in a subsequent column. The interesting aspect of the $\overline{\text{INTA}}$ control signal is that it permits you to "jam" an interrupt-vector instruction byte directly into the instruction register in the 8080A chip. This can only be done during an interrupt, but nevertheless it is a unique and highly interesting operation that is possible with the 8080A microprocessor.

A simple circuit that demonstrates how a single-byte instruction can be jammed into the instruction register is shown in **fig. 2.** Assuming that the interrupt-enable flip-flop has been previously enabled by the instruction, 373,

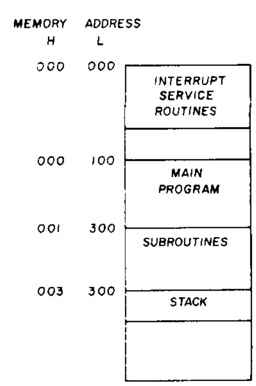

fig. 3. Possible memory map for 8080A microcomputers.

By David G. Larsen, WB4HYJ, Peter R. Rony, and Jonathan Titus

Mr. Larsen, Department of Chemistry, and Dr. Rony, Department of Chemical Engineering, are with the Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Mr. Jonathan Titus is President of Tychon, Inc., Blacksburg, Virginia.

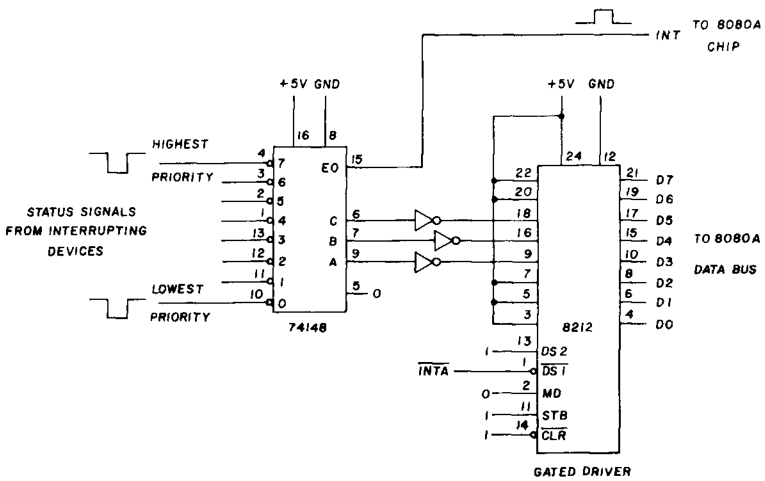

fig. 4. Priority interrupt encoding scheme for an 8080A microcomputer.

the interrupting device must supply a logic 1 input at INT in order to generate an interrupt request. The microcomputer finishes the current instruction and than generates the interrupt acknowledge signal, $\overline{\text{INTA}}$, which jams the desired vector instruction byte on the data bus and into the instruction register. Although any instruction byte can be jammed into the instruction register during an interrupt, usually the following eight instructions produce a useful result:

307	RST 0	Call the subroutine that starts at HI = 000 and LO = 000
317	RST 1	Call the subroutine that starts at HI = 000 and LO = 010
327	RST 2	Call the subroutine that starts at HI = 000 and LO = 020
337	RST 3	Call the subroutine that starts at HI = 000 and LO = 030
347	RST 4	Call the subroutine that starts at HI = 000 and LO = 040
357	RST 5	Call the subroutine that starts at HI = 000 and LO = 050
367	RST 6	Call the subroutine that starts at HI = 000 and LO = 060
377	RST 7	Call the subroutine that starts at HI = 000 and LO = 070

Thus, the first sixty-four memory locations are reserved for *interrupt service routines* or *pointers*, extremely short programs, often consisting of only a single jump instruction. They tell the microcomputer what to do or where to go for a specified interrupt condition. Such routines precede the main program and associated subroutines in memory (**fig. 3**). If interrupts or restart instructions are not used, this portion of memory does not have any special significance.

Fig. 4 is probably the simplest priority-encoder interrupt circuit that can be used with an 8080A microcomputer. The Intel 8212 chip is used as an 8-bit three-state buffer that inputs the instruction byte into the instruction register. The 74148 8-line to 3-line priority-encoder chip has the following truth table:

inputs								outputs			
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**C**	**B**	**A**	**EO**
X	X	X	X	X	X	X	0	0	0	0	1
X	X	X	X	X	X	0	1	0	0	1	1
X	X	X	X	X	0	1	1	0	1	0	1
X	X	X	X	0	1	1	1	0	1	1	1
X	X	X	0	1	1	1	1	1	0	0	1
X	X	0	1	1	1	1	1	1	0	1	1
X	0	1	1	1	1	1	1	1	1	0	1
0	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	0

The letter X means that the logic state is irrelevant.

The purpose of the circuit of **fig. 4** is to input the restart instruction, 3Y7, into the microcomputer. Five of the eight inputs to the 8212 chip are tied to a logic 1 state. The remaining three bits supply the encoded-vector address of the restart subroutine. By virtue of its truth table, the 74148 priority encoder chip provides eight priority levels. The inputs to this chip should be latched. The chip provides the three-bit binary output that corresponds to the highest valued priority input which is at logic 0 state. The inverters supply the three-bit Y component of the restart instruction. If there is a logic 0 at any of the inputs to the 74148 chip, a logic 1 output will be generated at the EO output (pin 15). This output serves as the input to the interrupt request pin, INT, on the 8080A chip. Upon receiving an interrupt request, the microcomputer responds with an interrupt acknowledge output, $\overline{\text{INTA}}$, that strobes the selected highest priority restart instruction into the instruction register.

references

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2. David Larsen, Peter Rony and Jonathan Titus, *Bugbook III, Microcomputer Interfacing Experiments Using the Mark 80*[R] *Microcomputer, an 8080 System*, (E & L Instruments, Inc., Derby, Connecticut, 1975, $14.95 from Ham Radio Books, Greenville, New Hampshire 03048).

ham radio

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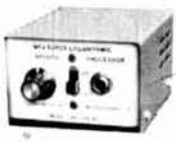

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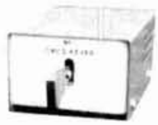

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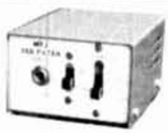

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the ham notebook

WWV on the Heath SB-102

The SB-102 (and others of the Heath series) may be used to copy WWV on 5, 10, or 15 MHz by using the plug-in heterodyne crystal modification.[1] The bandswitch position and frequency of the heterodyne crystal depend upon the WWV frequency to be monitored. For instance, I use a junk-box crystal with a marked frequency of 8.001 MHz in conjunction with a homebrewed remote vfo operating above 5.6 MHz. This permits me to copy 15 MHz WWV while on the 14 MHz bandswitch position with the crystal tripling. Some crystals I tried would not oscillate properly on their third or fourth overtone in the SB-102 circuit (most did) and if a specific frequency is desired, a proper crystal should be purchased. However, the crystal available in your junk box should at least be given a trial.

Some combinations of crystal/LMO/-WWV frequencies in the 3.5 MHz bandswitch position are shown in **table 1.**

table 1. crystal frequency chart for copying WWV on the Heath SB-102.

band	WWV frequency	injection frequency (upper/lower limits) (MHz)
3.5	5.0	13.3936 to 13.8964
7.0	10.0	18.3936 to 18.8964
14.0	15.0	23.3936 to 23.8964
21.0	20.0	28.3964 to 28.8964

1. Injection frequency = LMO + WWV + 3.3964 (for compatible usb/CW)
2. Injection frequency = LMO + WWV + 3.3936 (for lsb)

This, in conjunction with the formulae, should be sufficient to calculate the needed/desired heterodyne crystal frequency. Remember, the LMO is at its lowest frequency (5.0 MHz) at the upper band edge and vice-versa; it always tunes backwards. As shown in **table 1**, for WWV at 5 MHz any crystal between 13.3936 and 13.8964 MHz will permit copy at some point between 3.5 and 4.0 MHz. Since the LMO actually tunes a little above and below the 5.0-5.5 MHz range, some margin is provided in case of error or crystal tolerance.

HC-6/U or HC-17/U crystals should be used. FT-243 types won't work. Also, the frequency of the heterodyne crystal should be reasonably close to that of the heterodyne crystal normally in use on the band in question. Check the SB-102 manual for other crystal information.

Paul K. Pagel, K1KXA

TVI cure for the Kenwood TS-520

A couple of local amateurs were having TVI problems on channel 5 (New York) on two separate cable television systems. On other channels, with an outside antenna, there was also some TVI, but not as bad. I was asked to take a look at the problem and to recommend a solution. From the first, it looked like harmonic interference and not fundamental overload. Initially, I thought that rf from the Kenwood was getting into the ac line via the chassis and ac line cord, but after some filtering, additional bypassing and shielding on the chassis, I concluded that the problem was not there, since these measures did not help appreciably.

Next, I checked neutralization of the 2001A final amplifier tubes, but found them rock-solid from 80 through 10 meters.

Finally, I looked inside the final rf amplifier compartment and discovered the problem. I discovered that the final plate tuning capacitor had only one supporting plate and that the stator and rotor plates are unsupported at the front end. The rotor is grounded to the chassis by a three-legged spring clip that helps to hold the rotor in line. The rotor shaft is attached to a fiber shaft by a flexible coupling, and the fiber shaft exits the final amplifier compartment through a metal sleeve or collar.

Harmonic rf energy is radiated through the sleeve, flows over the outside of the compartment, and thence to the ac line. I also noticed that the fiber shaft is attached to a metal shaft by a small pin, and that the metal shaft makes a dandy little antenna to radiate the unwanted harmonic.

To cure the problem in your TS-520, proceed in the following manner:

1. Remove the three screws that hold the plate tuning capacitor to the wall of the final amplifier compartment.

2. Make a cover of thin sheet aluminum large enough to cover the three screw holes so it can be fastened to the compartment wall.

3. Clean the area of contact so that it makes a good rf-tight joint and drill a hole in the aluminum plate just large enough to pass the shaft of the variable capacitor. File a small notch in the aluminum at the edge of the drilled hole to pass a grounding wire (this wire will be soldered to the above-mentioned sleeve).

4. Scrape the sleeve where the wire will be soldered to it, for a solid joint, and solder one end of a short length of wire to it.

5. Disconnect the flexible coupling from the shaft of the variable capacitor.

6. Immediately behind the front panel of the TS-520 where the variable tuning capacitor shaft passes through, locate a locking spring clip; loosen the bolt and pull the shaft out an inch or so, so that you can slip the aluminum plate over the shaft and the wire soldered to the sleeve.

7. Replace the screws in the capacitor mounting plate and place a solder lug at the upper right-hand screw (looking from the front of the rig back at the plate). Tighten the screws and solder the free end of the wire to the lug.

You will also notice a white wire passing through a rather large hole in one wall of the compartment. Try to fashion the aluminum cover plate in such a way as to cover this hole, leaving room only for the wire.

The "fix" described here will remove interference from the picture carrier, but will not solve the sound carrier interference. To get rid of the latter, proceed as follows:

1. Buy, beg or steal a sheet of perforated aluminum of the kind that has small holes and is available at most hardware stores. Do not get the slotted *variety!*

2. Cut a piece of this screening material large enough to cover the slots in the rf final amplifier compartment. A piece about 4½x5 inches (11.4x12.7cm) should do the trick. The slots are to permit the blower to pull cooling air through the compartment, and the screen cover you install will not appreciably alter this flow of cooling air. At the screw holes, brush the compartment, walls and the aluminum screening to make a good rf-tight contact.

3. Mount the "shield" made in this manner to the side of the rf amplifier compartment with sheet metal screws or other hardware.

4. On top of the rf amplifier compartment, fit a small piece of screening material just large enough to cover the two holes, and attach it by means of the screw that is close by.

5. The bottom of the TS-520 cabinet has a series of various-sized holes used to pass alignment tools for tuning the different circuits. These also pass rf and should be covered for a complete shielding job.

6. Remove the four feet and the center screw from the cabinet and cut a piece of aluminum screen large enough to cover all of the "tuning" holes and fasten it in place on the inside cabinet floor with the center screw and the four feet.

After completing these operations, the only way rf can escape the transmitter is through the center conductor of the coaxial cable — just where you want *it!*

I verified the TVI cure by running the transmitter and an SB-220 at full rated output next to an old TV set that had a barely discernible picture and poor sound. Oh yes, by the way, I used an open-wire feed line to my antenna. No interference on any channel! Needless to say, my amateur buddies, the cable company and the subscribers are very happy; because when you get into the cable you get into the city!

Stacky Stackhouse, W3FUN

simple tune-up for Drake gear

I have found a very simple method of tuning my Drake T4XB, R4B transmitter-receiver combination that certainly will work with other models of the T4 and R4, and may even work with other equipment. The advantage of my tuning method is that it takes less time, it is easier on the final amplifier tubes and little or no carrier appears on the operating frequency during 95% of the procedure. Here's how it is done:

1. Set the receiver to the desired operating frequency.

2. Set the transmitter for CW mode operation, place the transceive switch in the "spot" position and tune the transmitter vfo until the spot signal is heard in the receiver. The transmitter "gain" control may have to be advanced *slightly, perhaps even one-quarter turn,* to obtain enough signal to be useful.

3. Now, using the receiver's S meter, tune both the transmitter and receiver preselectors for maximum S meter reading.

4. While watching the S meter, vary both the transmitter "plate" and "load" tuning controls for maximum signal, and repeat this step until no further signal increase is possible.

5. Turn the transceive switch to "separate" (with either receiver or transmitter controlling the frequency, as desired) and finish the tune-up according to the instruction book.

J. L. Kofron, W7DIM

etch tank

If you etch printed circuit boards regularly, the professionally styled etch tank shown in **fig. 1** works very well. It features an aerator that allows you to bubble air from a fish tank pump through the holes in aerator. This speeds up the etching process.

The basic material for the tank is 1/8 inch (13mm) plexiglass. Needless to say, the joints must be water tight.

Gary L. Tater, W3HUC

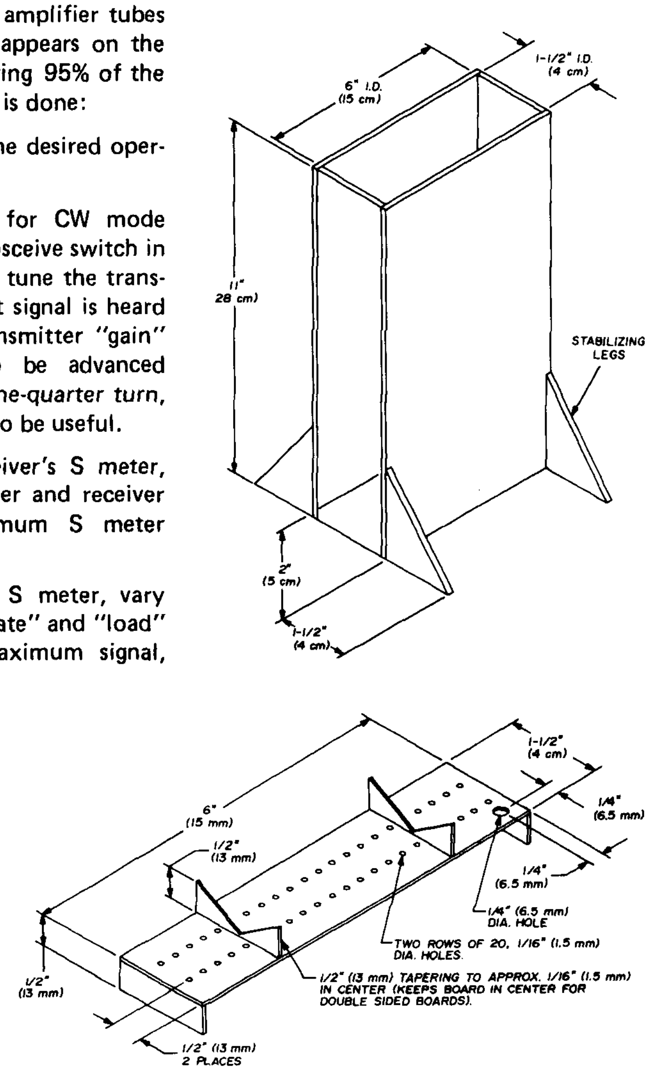

fig. 1. Professionally styled etch tank for printed-circuit boards uses aeration to speed up the etching process. Aerator sits on bottom of the tank; air is *furnished by a fish tank* type air pump. All material is 1/8" (13mm) plexiglass or lucite. All joints must be water tight.

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More Details? CHECK–OFF Page 126

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POWER REQUIREMENTS: 12-14 volts D.C. negative ground only. 12 amps maximum. Reverse polarity protection.
WEIGHT: 5.4 lbs.

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SENSITIVITY: Less than 0.5 microvolt for 15 db. signal-plus-noise/noise ratio.
SELECTIVITY: 2.1 KHz @ -6 db., 3.8 KHz @ -60 db.
IMAGE REJECTION: Better than 60 db.
AUDIO OUTPUT: 2 Watts at less than 5% distortion into 4 ohm load.

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POWER INPUT: 100 watts P.E.P. or C.W., nominal.
POWER OUTPUT: 50 Watts P.E.P. or C.W., minimum.
OUTPUT IMPEDANCE: 52 ohms, nominal.
UNWANTED SIDEBAND: –40 db or better.
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More Details? CHECK–OFF Page 126

NEW products

side swiper morse keyer

The Swedish firm, Kungsimport, has introduced its new Side Swiper, a keying lever designed by SM6CKU, for use by amateurs or commercial operators throughout the world. The Side Swiper may be used by itself to produce dots and dashes in an easy and natural manner or it may be used as a keying lever for an electronic keyer.

Easy and fun to handle, the Side Swiper requires only a few hours familiarization and provides a distinctive personal fist or the characteristic swing of an old-time operator. CW produced by the Side Swiper is easily recognizable and lacks the monotonous, mechanical-sounding CW of the electronic keyer or bug.

The Side Swiper is personally and individually hand crafted with a wood base and metal armature and contacts, and is priced at $13.00, airmail shipment included. Your name or callsign may be engraved on the wooden base for an extra dollar. For additional information write Kungsimport, Post Office Box 257, S43401 Kungsbacka, Sweden, or use *check-off* on page 126.

Amphenol dummy load coaxial connector

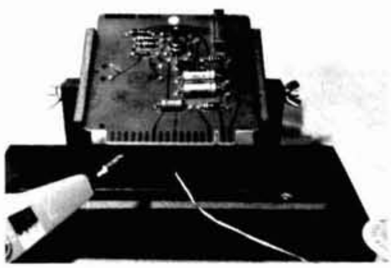
A new combined illuminated power output indicator and dummy load that provides a visual indication of low-power transmitter performance was recently introduced by Bunker Ramo RF Division.

The new device, designated Amphenol® Model 83-888, consists of a light-terminated coaxial load mounted in a modified uhf connector (PL 259-type) body. It can be used to tune your low-power transmitter for maximum output — the brighter the light, the greater the output.

Amplitude modulation can also be checked quickly, because the brilliance of the light increases and varies when someone talks into the microphone when the transmitter is functioning properly. The 83-888 can also be used to check ssb carrier balance: there will be no glow if the carrier is correctly nulled, but the light will glow with modulation.

The new power output indicator mates with standard uhf receptacles (5/8 - 24 thread). Its nominal impedance is 52 ohms, the frequency range is 0-30 MHz, power rating is 4 watts, maximum, and VSWR is 1.1:1 at 27 MHz. For additional information, contact Bunker Ramo RF Division, 33 East Franklin Street, Danbury, Connecticut 06810 or use *check-off* on page 126.

printed-circuit board holding fixture



The W.N. Wellman Company, has introduced a versatile holding fixture to facilitate PC board parts-mounting and soldering. The fixture is adjustable to accomodate most PC board sizes and may be positioned to provide convenient and easy assess to either surface of the board. The base of the holding fixture is provided with resilient feet to hold it firmly on a flat work table or bench.

The price is $7.95 postpaid within the continental U.S. Missouri residents please add $.25 tax. For additional information, write the W.N. Wellman Company, 451 Saline Road, Post Office Box 722, Fenton, Missouri 63026 or use *check-off* on page 126.

Larsen adds TLM trunk lid mount mobile antennas

An all-new mobile antenna mounting option has been added to the wide variety of mobile mounts available from Larsen Electronics. The TLM stands for Trunk Lid Mount, and it is available in seven different variations so that every antenna and mounting condition can be met.

This new Larsen trunk lid antenna mount follows the configuration of the popular Larsen magnetic mount, and results in a low-silhouette installation. It is finished in highly-polished chrome and is provided with a special molded gasket to protect the car finish. The mount clamps to the vehicle with stainless-steel, hollow-head screws that provide a positive ground and will not rust or "freeze" in place. The mount comes factory- assembled with 17 feet of RG58A/U coaxial cable and plug. The TLM is available with hardware to accomodate all standard antenna mounts including Motorola, ASP, GE, RCA and — of course — Larsen. It may be purchased complete with antenna, or without either antenna or mounting hardware.

For additional information, write Jim Larsen, Larsen Electronics, Box 1686, Vancouver, Washington 98663; telephone (206) 573-2722 or use *check-off* on page 126.

dual dc power supplies

Mid-Continent Communications Company recently introduced a new power supply package featuring two independent power supplies, having isolated outputs, contained within a single enclosure. The Mcc/103 power supply helps eliminate bench clutter when designing with ± 15 Vdc and is conveniently dimensioned to facilitate stacking with identical units or with other items of equipment. The wood-grained aluminum enclosure measures 2.25 inches high, 10 inches wide and 5.7 inches deep (5.7x25.4x14.5cm). A back-lighted and flush-mounted panel meter permits accurate monitoring of current and voltage for either supply with the desired functions selected by a meter mode switch.

Variable voltage and current limit controls allow easy setting of the voltage to typical values between zero and 25 volts, and the current to typical values between 10 and 250 milliamps. Since the two supplies are completely independent, it is possible to connect them in series or parallel to provide, typically, 50 volts at 250 milliamps or 25 volts at 500 milliamps. A unique feature of the Mcc103 is the provision of two LEDs (light-emitting diodes), one for each section, to indicate when the output current exceeds a preset limit point. This feature can help prevent confusion and false indications during circuit design and testing.

The Mcc103 employs two voltage regulator boards designed for excellent regulation and temperature stability. All components, including the rectifier and filter, are mounted on the printed-circuit board and the boards themselves can be lifted from the enclosure without unsoldering any wiring, permitting easy removal for maintenance and repair. Internally mounted *Thermatab* transistors are used, eliminating shock or shorting hazards. The current-limit system and the internally mounted ac fuse provide total short circuit protection for both the power supply and the load.

Power requirements are 105 to 125 Vac at 25 watts, and the line regulation is ± 0.2 percent maximum. Load regulation is ± 0.05 volt, maximum, while ripple and noise are 1 millivolt rms, maximum. The Mcc103 is priced at $99.95 plus $2.50 postage and handling. Missouri residents please add 3 percent sales tax. For additional information, write to Mid-Continent Communications Company, Box 4407, Kansas City, Missouri 64127, or use *check-off* on page 126.

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LPM-885
SWR Watt Meter
A sensitive, in-line type power meter which measures SWR of x'mission lines and power output from 1.8 to 54MHz. Facilitates adjustment of x'mitter and antenna systems for better results. May be left in circuit for continuous power output monitoring in the 1-1000W range. SWR Power Detector circuit assembly separates for remote measurements. Forward-to Reverse power ratio is used for accurate SWR readings. **$99.95**

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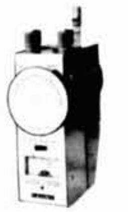
Antenna Coupler
Obtain cleaner signal reception and transmit at maximum power output with this dependable Antenna Coupler. Helps provide optimum antenna matching and virtually removes annoying TVI problems. The instrument features a built-in SWR and in-line power meter. Frequency range is: Amateur Band - 3.5, 7, 14, 21, 28MHz; input impedance - 50Ω; Load Impedance - 50Ω, 75Ω co-ax cable. **$159.95**



LIM-870A Antenna
Impedance Meter
Take your time. Adjust your antenna slowly for perfect matching. This self-contained, battery operated Impedance Meter lets you make adjustments on your roof or at the antenna by combining with the LDM-815 Dip Meter. The combination also measures linear amplifier and receiver input impedance. Compact, lightweight with 1.8 to 150MHz freq. range; 0.1KΩ direct-reading impedance range. **$99.95**

LDM-815 Tran-
sistorized Dip Meter
Checks receiver, x'mitter and antenna in 1.5 to 250MHz range. Determines LC network resonance freq'y. Helps align receivers and find parasitic oscill'tns. A handy instrument that combines with the LIM-870A for proper antenna matching. **$99.95**

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RCA Low Drain Series: Model CMFT-50: 25-54 MHz, 50 w output, partly transistorized rcvr. Transistorized power supply. w/accessories.
RCA Low Drain Series: Model CMFL-50: 25-54 MHz, 50 w output. Transistor Power Supply. w/accessories.
RCA Low Drain Series: Model CMCT-30: 148-162 MHz, 30 w output, partly transistorized rcvr. Transistor power supply. w/accessories.
Motorola Model U41 GGT 1100: 30-50 MHz, 30 w output. Transistor power supplies. Less accessories.
Motorola Model U43 GGT 3100: 152-162 MHz, 30 w output. Transistor power supply. With Private Line. Less accessories.
Motorola Model T51GGV: 30-50 MHz, 50 w output. Less accessories.
Motorola Model T-43 GGV: 152-162 MHz, 30 w output, Less accessories.
Motorola Model U41HHT 1100: 30-50 MHz, 30 w output, Less accessories.
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General Electric Progress Line Receiver and AC Power Supply. Presently tuned to 47 MHz. Only 1 left.
Motorola Outdoor Cabinet. Stands about 5 ft. high with doors on front & rear. Only 1 left.
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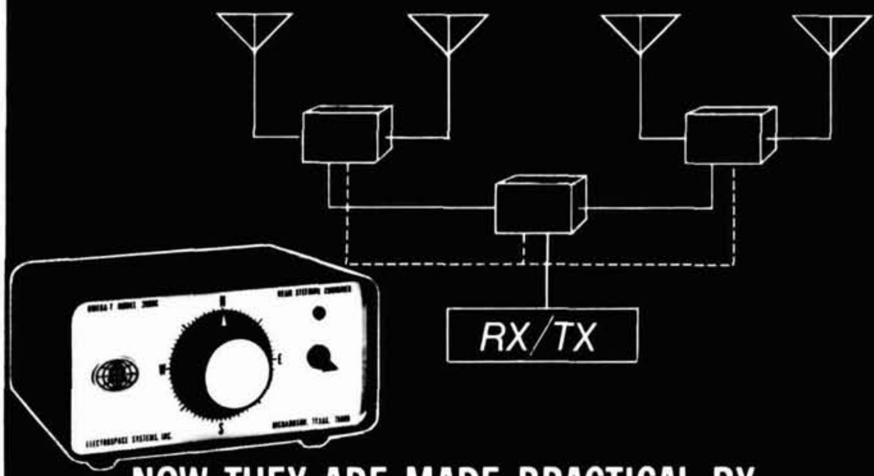

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H-P offers digital multimeter with touch-hold reading probe

The Model 3435A, 3-1/2 digit multimeter from Hewlett-Packard has a unique "touch-hold" probe available as an accessory. It lets the user "freeze" the reading on the display – a convenience when probing closely-packed circuit boards. Accurate enough for both bench and field use, the new digital multimeter is autoranging on ac and dc volts and resistance. Ac and dc current ranges are selected manually. Lighted front panel annunciators display the function and its units.

The digital multimeter covers a dc measurement range from 200 mV full scale to 1200 V full scale with a mid-range accuracy of ±(0.1% of reading + 1 digit). Ac measurement range is 200 mV full scale to 1200 volts rms full scale with a mid-range accuracy of ±(0.3% of reading + 3 digits) over a 30 Hz to 100 kHz bandwidth. Ac and dc current measurement range is from 200 microamps to two amps. Dc current accuracy for the 200 μA to 20 mA range is ±(0.3% of reading + 2 digits). Ac current measurements are made over a frequency band of 30 Hz to 10 kHz with a mid-band accuracy of ±(1.7% of reading + 4 digits). Resistance range is 10 milliohms to 20 megohms with a mid-range accuracy of ±(0.2% of reading + 2 digits). Open circuit voltage on the ohms terminal when set to its lowest range does not exceed 5 volts, preventing damage to most solid-state devices.

Input protection is provided to 1.2 kV on any dc range, 1700 V (dc + peak ac) on any ac range, and 250 V rms on any resistance range. A front panel fuse protects the instrument from overload when measuring current.

A choice of two power supplies is offered: internal ac power supply and rechargeable lead acid batteries. The standard 3435A Digital Multimeter comes with an internal ac power supply and rechargeable lead acid batteries. Option 001 is a lightweight portable case, ac line power only. Option 002 is the ac line power only with a rack and stack case.

U.S. price of the standard Hewlett-Packard Model 3435A digital multimeter with rechargeable lead acid batteries is $400. Option 001, ac only in custom plastic case is $335; 002, ac

More Details? CHECK—OFF Page 126

only, in a rack and stack case is $365. Delivery is from stock. "Touch-Hold" reading probe U.S. price is $40, RF Probe is $87. High Voltage Probe is $75.

For additional information, write Inquiries Manager, Hewlett-Packard Company, 1501 Page Mill Road, Palo Alto, California 94304; telephone (415) 493-1501, or use *check-off* on page 126.

six new calculators, video game and digital watches from National Semiconductor

National Semiconductor, Consumer Products Division, recently announced 6 new calculator products, including 3 advanced slide rules bearing the National Semiconductor brand name, an ideal family-type model, a teaching version of the QuizKid, a complete line of men's and ladies' LED digital watches and a video game series bearing the name Adversary.

The model 852 calculator offers scientific notation or floating decimal point system with reformating capability from one system to the other. The 852 features algebraic logic, two level parentheses, trig and log functions, degree/radian conversion. It offers an 8-digit Mantissa in floating point system and 5-digit Mantissa plus 2-digit exponent in scientific notation, plus many other features. Suggested retail, $29.95.

The model 4650 calculator offers algebraic logic, two level parentheses, full accumulating memory addressable in all 4 arithmetic functions, log and trig functions, degree/radian conversion, rectangular/polar coordinates, 8 Mantissa digits, 2-digit exponent display, plus many other features. Suggested retail, $59.95.

The model 4660 calculator that displays 10-digit Mantissa in floating point system and 10-digit Mantissa plus 2-digit exponent in scientific notation, with algebraic logic, two level parentheses, three separate, addressable, accumulating memories, trig and log functions, decimal degrees and degrees, minutes and seconds conversions, polar and rectangular coordinate conversion and many other features. Suggested retail, $79.95.

The QuizKid II allows the child to see a timed series of 10 problems which appear automatically in the display. The

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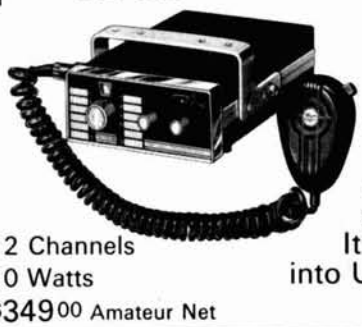

440 is fresh . . . it's new . . . and with our HR 440 you can use UHF without using-up your budget. So, pioneer some new ground! Put a compact HR 440 under your dash or at your desk. It's the best way to usher yourself into UHF.

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child is required to key in the answer to the problem shown in the display. Over 1200 problems are automatically generated by the calculator, permits selection of the type of arithmetic function (i.e., addition, subtraction, etc.) which is displayed automatically in random sequence, and offers a slow/fast speed control key to adjust time allowed for child to enter answer. Suggested retail, $24.95. Also available is an optional game adapter which connects two Quiz-Kid II's for a contest.

The QuizKid III – retains all the abilities of QuizKid II plus games for over 6,500 additional problems. Contains amateur and pro keys for adjusting complexity of problems, and a complex key for problems to be automatically displayed with one of the factors missing but with the answer given. This model is being test marketed.

The video game – Adversary – features a choice of 3 games: tennis, played by two players on a green court; ice hockey, played by one or two players on blue ice; and handball, played by two players on a brown court. All games are in full color, have realistic sound effects when the ball or puck strikes a surface, and offers a choice of 3 individually selectable paddle sizes. Serves are controlled by players, not by random, and scoring is automatically displayed in large easy-to-read numbers after each point is scored. Individual controls enable players to sit in their favorite chairs to compete. The game offers 7 modes of operation: 3 modes of 2 players, 3 modes of a player against himself and one mode with a player against the machine. A special feature allows "time out" during play without changing the score. Suggested retail, $99.95.

The model 830 Datachecker is an ideal calculator for shopping, taxes, family finances, and features an 8-digit LED display and floating decimal, and is designed to operate like the shopper thinks: add and subtract items, subtotal items, efficiently check grocery bills, balance checkbook. (Battery not included). Suggested retail, $14.95.

For further information contact Georgene Berglund, Public Relations, National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051; telephone (408) 732-5000, or use *check-off* on page 126.

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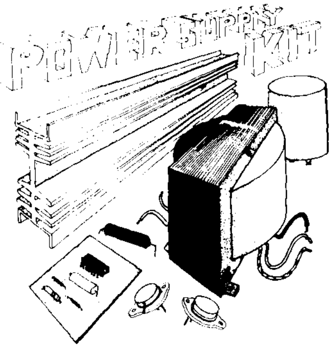

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- Wire

*15A INT.

Not only is the PS—12 able to supply a continuous 10 AMPS* of low ripple, regulated DC Voltage, but it is also variable from 3 to 30 volts! Use it as a building block for a fantastic bench supply. The chassis work is up to you — go fancy with meters and lights; or plain with a metal plate. Either way we get you out with a quality kit at a super low price and we guarantee your satisfaction.

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BULLET SUPER STAR PS-01A

Our first power supply kit was introduced almost two years ago and is still the most popular. A compact, well regulated triple output power supply. Gives +5VDC @ 1.5A and +15 @ 150 MA and −15 @ 150MA. The PS-01A uses the superior 78L series of three terminal regulators. Complete with P.C.Board, all components, heatsinks and quality tranformer. **$14.95**

PS-01B: Same as above but with ±12 output instead of ±15.

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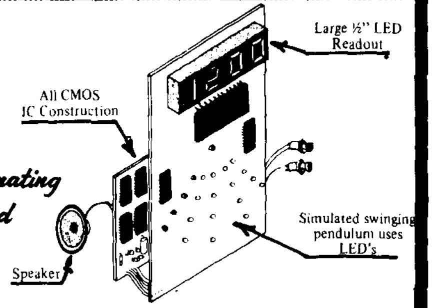

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Cushcraft builds new research and production facility

Construction is underway on the first phase of Cush Craft Corporation's new 50,000 square foot antenna research and production facility.

All manufacturing operations, executive offices and research were moved to the new facility at Grenier Industrial Park in Manchester, New Hampshire at the end of November 1976.

Bob Cushman, Cush Craft treasurer, reports this all new plant is designed especially for antenna manufacturing. It will allow increased production of current amateur, citizen's band and commercial antennas, plus the introduction of several new antenna types.

The new production lines and equipment have been planned for several years and, when fully operational, will be a model for the industry, allowing Cush Craft to maintain its traditionally high value standards.

automotive ignition noise filter

Marine Technology recently announced its new EMI-15A filter designed to control ignition system generated noise in mobile two-way radios.

The introduction in 1975 of high-voltage, solid-state ignition systems in all American automobiles focused attention on the need for better suppression of ignition interference. Fully fifty per cent of engine noise problems in an automobile come from the ignition system.

The EMI-15A is a three-element low-pass LC filter designed to control igni-

More Details? CHECK–OFF Page 126

tion system-generated noise. It prevents coupling of ignition impulses into the vehicle primary wiring system and supplements suppressor-type spark plugs and wiring. Installation is made at the battery connection to the coil or electronic ignition system.

Suggested retail price is $6.95, and the units are available from stock. For additional information contact Morgan Cox, Marine Technology, 2780 Temple Avenue, Long Beach, California 90806; telephone (213) 427-6443, or use *check-off* on page 126.

mobile radio case

If you worry about leaving your mobile radio in your car unattended, and if is is not convenient to carry your radio when you leave your car, Platt Luggage may have the solution to your problem. Platt has introduced a new line of rugged, lightweight, molded cases for mobile radio equipment and accessories. Molded from high-density polyethylene with a double wall construction, the cases incorporate shock-absorbent polyfoam interiors that can be custom-cut to fit nearly any size and shape of mobile equipment.

A Platt case makes it convenient to carry your radio if you want to take it with you and it protects the radio if you want to leave it in the trunk of your car. The case is ruggedly handsome and is dent, shatter and scuff proof. Two sizes are available to fit nearly any requirement: CB-1 measures 12x8.5x4.25 inches (30.5x21.6x10.8cm) and CB-2 measures 13.5x10x4 inches (34.3x25.4x10.2cm). Finished in black, they make attractive companions for your equipment and are guaranteed for five years. The CB-1 sells for only $14.95 and the CB-2 is priced at

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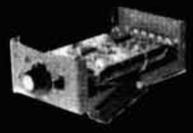

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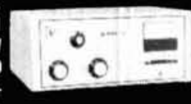

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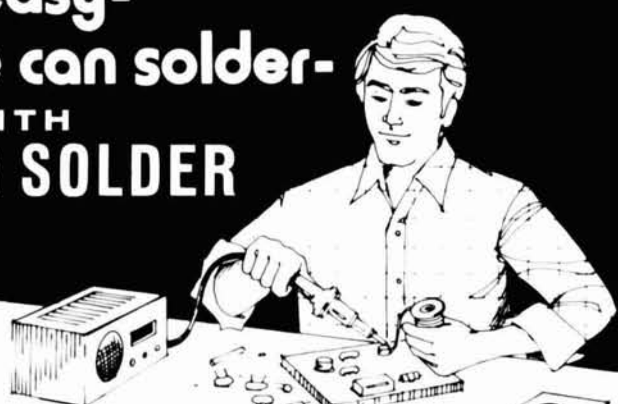

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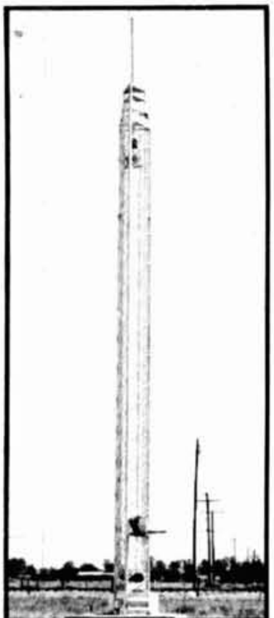
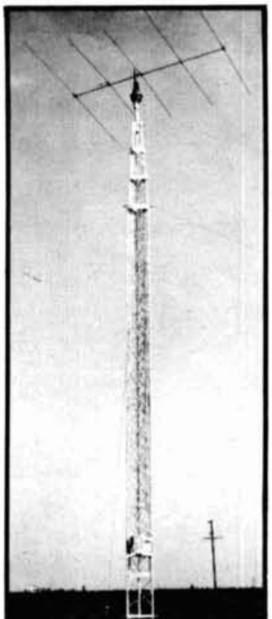
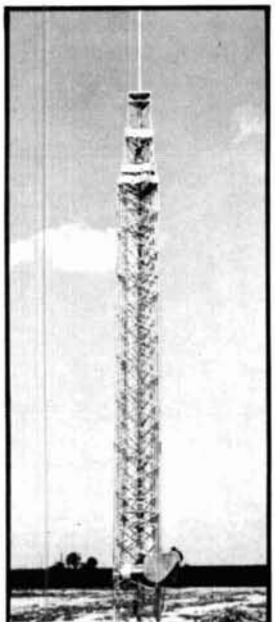


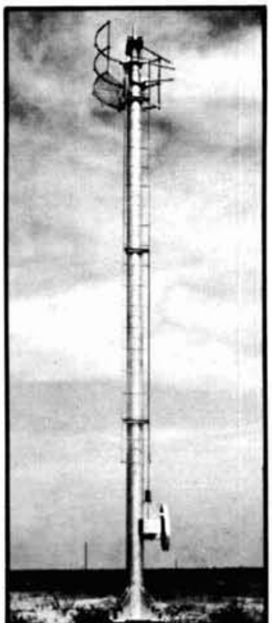
W-51



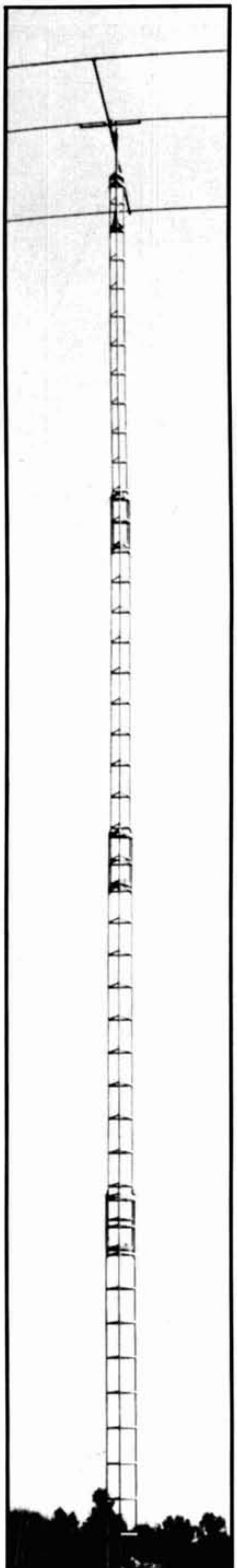
MW-65



LM-470D



TM-370



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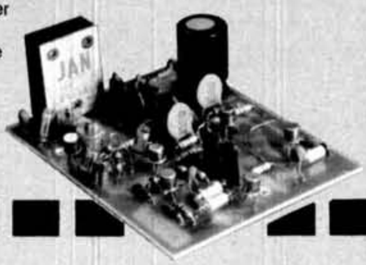

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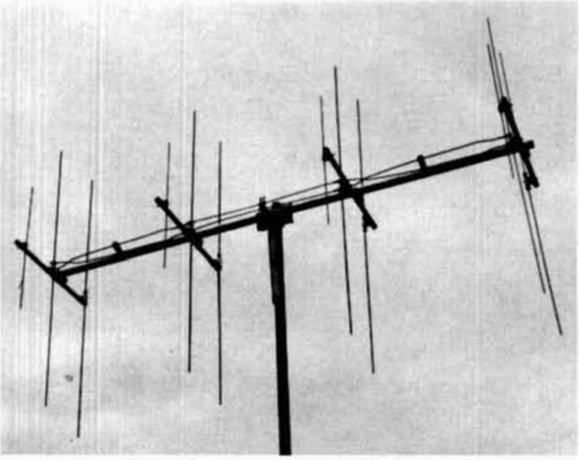
VHF DX



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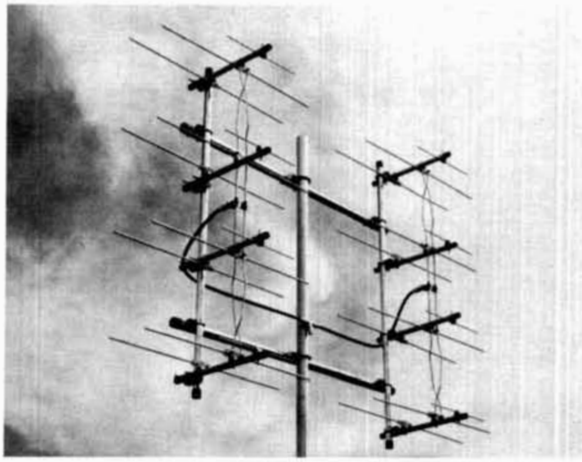

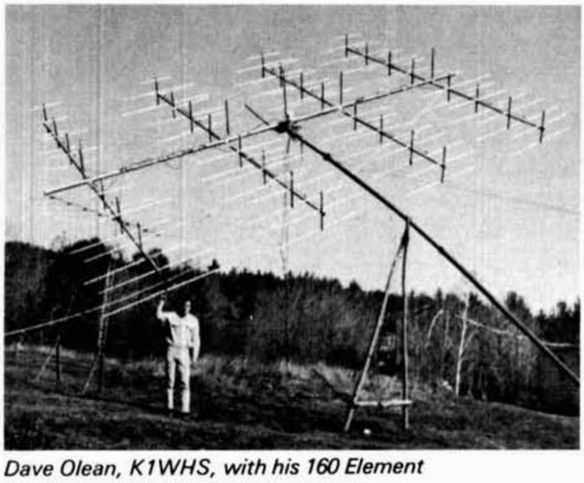

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CD4069	.30
CD4071	.35
CD4082	.45
75108A	.35
75110	.35
75491	.50
75492	.50

– TTL –

7400	.15	7451	.25	74156	1.15	74S00	.55
7401	.15	7453	.25	74157	.95	74S02	.55
7402	.20	7454	.25	74161	1.25	74S03	.50
7403	.25	7460	.25	74163	1.25	74S10	.25
7404	.15	7470	.45	74164	.95	74S11	.45
7405	.25	7472	.45	74165	1.50	74S20	.50
7406	.45	7473	.35	74166	1.75	74S40	.30
7407	.55	7474	.40	74175	.95	74S51	.45
7408	.25	7475	.45	74176	1.25	74S64	.55
7409	.15	7476	.20	74180	.85	74S74	.50
7410	.15	7480	.65	74181	3.25	74S112	1.50
7411	.25	7483	1.00	74182	.95	74S133	.45
7412	.30	7485	1.05	74190	1.75	74S151A	1.00
7413	.65	7486	.40	74192	1.65	74S158	.65
7414	1.10	7489	2.75	74193	.85	74S194	1.50
7416	.25	7490	.40	74195	.95		
7417	.50	7491	1.15	74196	1.50	74LS00	.45
7420	.15	7492	.95	74197	1.25	74LS01	.45
7426	.40	7493	.60	74198	2.35	74LS02	.45
7427	.45	7494	1.25	74367	.85	74LS04	.55
7430	.20	7495	.85			74LS08	.45
7432	.45	7496	.95	74H00	.25	74LS09	.45
7437	.45	74100	1.85	74H04	.25	74LS10	.45
7438	.20	74107	.45	74H22	.40	74LS11	.45
7440	.25	74121	.40	74H52	.15	74LS20	.50
7441	1.15	74122	.55	74H53J	.25	74LS32	.55
7442	.65	74123	.55	74H72	.55	74LS40	.55
7443	.95	74125	.45	74H101	.75	74LS42	1.75
7444	.95	74132	1.35	74H103	.75	74LS74	.95
7445	.95	74141	1.30	74H106	.95	74LS90	1.30
7446	1.20	74150	1.00			74LS93	1.65
7447	1.20	74151	.95	74L00	.35	74LS107	1.50
7448	1.20	74153	.95	74L02	.35	74LS164	1.90
7450	.25	74154	.75	74L03	.45		
				74L10	.35		
				74L30	.45		

MEMORY, CLOCKS

74S188(8223)	3.00
8080	26.50
MM1702A	10.50
MM5314	3.95
MM5316	4.95
2102-1	1.95
2102L1	2.25
TMS6011	9.95
TR 1602A	6.95

LINEARS, REGULATORS, etc.

MCT2	.95	LM311	1.35	LM340T-15	1.65	LM723	.45
8038	3.95	LM320K5	1.65	LM340K-12	2.15	LM725	1.95
LM201AH	.75	LM320K12	1.65	LM340K-15	2.15	LM739	1.50
LM301AH	.55	LM320T12	1.65	LM340K-24	2.15	LM741	.25
LM308AH	1.00	LM320T15	1.65	LM373	1.95	LM747	1.10
LM309H	.65	LM339	1.65	LM380	1.55	LM1307	1.25
LM309K	.90	7805	1.00	LM709	.30	LM1458	.95
LM310	1.15	LM340T-12	1.65	LM711	.45	LM3900	.65
						LM75451	.65
						NE555	.50
						NE556	1.10
						NE565	1.15
						NE566	1.95
						NE567	1.35
						SN72720	.35
						SN72820	.35

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MONARCH
TB5EM/4KWP

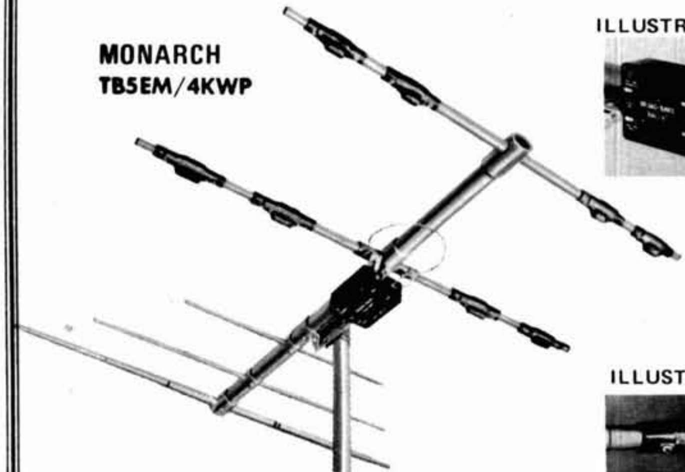
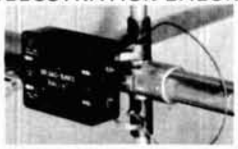


ILLUSTRATION BALUN



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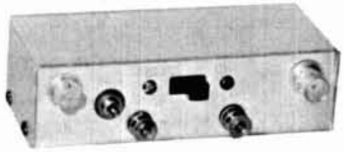
PRE-AMP



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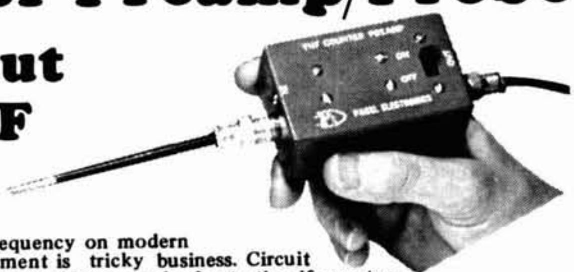
Counter Preamp/Probe
Sniffs out weak RF



Measuring oscillator frequency on modern communications equipment is tricky business. Circuit density and accessibility problems can be frustrating if you try using clip leads, loops, or coils. You might short out something or pull the oscillator off frequency with close coupling and be unable to get a reading because there just isn't enough signal to drive the counter. Also the counter input cable itself may load the oscillator even though the counter is high impedance. The COUNTER PREAMP is designed to solve these problems. It has 20 dB of gain which increases the sensitivity of your counter ten times. The low capacity insulated probe can pick up the signal just by holding it near the oscillator crystal, coil, or any active component. Sometimes it is possible to read the oscillator thru a plastic case. The preamp has BNC connectors on both ends and can be used as an in-line preamp for scopes, detectors, RF meters, etc., as well as counters. Input is high Z and output is low Z to drive 50 ohm cable. Another serious problem when alligning receivers is that many signal generators shift frequency when the attenuator is moved from high output to drive the counter to low output to make adjustments or check receiver sensitivity. The preamp will give 20 dB of isolation and eliminate the error. Customers have commented that having used the preamp they are now unable to get along without it. Many have made repeat purchases. The preamps are battery powered with three pencells at 25 ma. Output level is 200 to 300 millivolts RMS. One year warranty, money back guarantee. Shipped with probe, less batteries, postpaid cont. USA. Foreign add $5.00. Call 213/342-2714 for COD or save money by sending check to Pagel Electronics.

VHF Preamp, 100 KHz to 200 MHz $35.00
UHF Preamp, 1 MHz to 500 MHz $49.00

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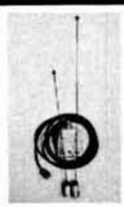

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More Details? CHECK—OFF Page 126

The proof of the pudding is in the eating.

The proof of Triton IV is in owner satisfaction.

Here's some of the proof . . .

K4EME — This is my second TRITON IV. They are excellent xceivers! **WA8ICK** — Luv it. Dynamite! **W9NXU** — I am very thrilled with this unit, it is great. I think you have scooped the field. **WA0AYA** — I like CW and full break-in. (Beautiful) **K3TFU** — I love the unit. **WA3VEZ** — Rig is just great. Combined with your service makes a super transceiver. **WN0SED** — Beautiful radio to use. Magnificent CW filter! Just a pure joy. **W8IIT** — I have had my TRITON IV for two months and am delighted with it. **YN1MBV** — It is a very nice rig. **W3GTX** — New features very welcome. **W0BYC** — Bought one of the first TRITON II, like it so well I updated it with a TRITON IV. **W2TBK** — It is absolutely fantastic. **WB0OPI** — I am pleased with the rig. **WA3GJA** — Very-very-very nice. Good audio quality. **W5ZBC** — The most outstanding rig I have ever used. **K8CJQ** — Excellent rig, Good filters. **W7BKK** — Very happy . . . getting excellent quality reports. **W2CET** — Power-signal reports good. **WB2UEH** — I like the compactness and appearance. **VE3IBK** — An excellent rig with superior receiving quality. **K4IVM** — I think it is tops. **WA4LOG** — I've become so used to dip, peak and adjust, this TRITON is a beautiful new experience. **KL7IHW** — Easy to set up—works great. **K4JXD** — Seems to be very FB rig. **WA7KHE** — Fantastic performance. Thanks for a fine rig. **WB4BPG** — No problems—fine rig. **VEIBZ** — Good work. **W9HQT** — Receiver better than expected, CW break-in is super. **W0AP** — Tremendous transceiver. I appreciate your engineering. **WA2ZRO** — Wonderful. **K0SFV** — Real nice rig. You thought of almost every feature and built it in. **KQ9DQ** — Beautiful. **WB0JIQ** — Beautiful radio; however, your ads do not do justice to the radio. **WN5SOH** — Very sophisticated—Easiest tuning rig ever. Very glad I bought it. **K3OJV** — Very impressed. **W4LZP** — Very good results. Put out 100 watts as good as 300 watt rigs. **WA4DQY** — I think the TRITON IV is great. **W6QXN** — Appreciate full CW break-in. **W0INH** — Enjoy light weight. **VE3CYK** — I am extremely pleased with the clarity of receiver and after putting rig on the air, received unsolicited compliments on the audio quality of the transmitter. **K4PHY** — Was 3rd in USA, first in fourth district in WWCQ contest. **W8RYU** — Own Argonaut. Both fine rigs. **W4CDA** — Compact, light weight, good engineering. **WB2WZG** — TRITON IV is the most versitile CW/SSB radio I have ever used. **WB2FMV** — Outstanding. Highly pleased with performance. **WA8ACZ** — A real nice rig. I have owned about every other make. **W5EGK** — Works nicely. **WB4ECO** — I tried this rig, a pleasure to operate. **WA4YRK** — Excellent reports on audio. **WB8NKB** — Wonderful. **W9QPQ** — An excellent rig. Love it. **W8SOP** — Makes running SSB nets a real breeze. Also good on CW nets. **WL7IRT** — Fantastic rig. **W4MDB** — Has rekindled my interest and enthusiasm in Amateur Radio to an extent I hadn't thought possible. It far out distances any competitive product at **any** price. **W6EYR** — Very nice. Been a ham for 45 years and now solid state perfection. **W2RPH** — Excellent rig. **WN0TDK** — TRITON IV is a fabulous piece of equipment. **W5VIW** — Very nice rig **WB2LQF** — Wow! **W9JCV** — Tnx for giving us a FB piece of equipment made in the USA. **W8GHO** — Very pleased. **K4KXB** — Seems to have everything desired. **W4SZ** — A pleasure to operate. **W2FKF** — Greatest rig I ever had. So far in a month 34 QSO's without one miss. Been a ham since 1922. **W4GVC** — Nothing but complements. **WB9EZE** — Well pleased with performance and simplicity of operation. **K4ETI** — Rig is great. **W8CNV** — Man—! what a rig. I've had this call since 1929. Never saw anything like it and I've seen them all! **WB2MZU** — Seems like everything the S - - - - - O - - was supposed to be at one third the price. **WN0VHE** — I think it is a very good rig. **WB9FTD** — Break-in CW is very impressive. **K0CBA** — I believe it is one of the finest HF transceivers on the market. I can't tell you how pleased I am with the noise blanker. I can get on the air from my home station again for the first time in a few years. Other rigs with noise blankers just didn't hack it. **WA7YHW** — I am very pleased with this equipment. It is certainly of high quality. **W7IIA** — Excellent equipment. **WB0RWA** — Couldn't be more pleased with it. It certainly has performed beautifully and is all I expected and more. **WB4QJT** — Like it very much — keep up the good work. **WN1YVX** — Really impressed with looks and performance. **W0NC** — Very FB rig. Performs up to specifications, an excellent design. **K8PBZ** — Already have TRITON II and IV. **W7KD** — This little "T-4" is smooth as silk . . . I've received some very flattering reports about transmitter voice quality and the CW operation is the greatest. **WN8TTO** — I found that the TRITON IV was the best rig on the market for around $800. I love it! **W2JBK** — It is absolutely fantastic. **W8FEI** — Am amazed at receiver performance. I thought I had a top notch receiver with the H - - - - - - - -! **W1FYM** — Your guarantee is refreshingly proper. **W8MOK** — Sure makes a guy look twice at his old tube type gear. **W1TFS** — Finest CW ever, CW selectivity very good. **WB6IVR** — Very satisfied with TRITON IV. Just what I was looking for to use on my yacht. Thanks. **WA8ONP** — Also have a TRITON II. I am pleased that Al Kahn and the **good guys** at TEN-TEC thought of the CW operator! **W2EMX** — Excellent Amateur gear meets and exceeds advertised claims. **W0AMJ** — It looks like there is nothing left to be desired. It is beautiful. **W6SE** — The receive function is outstanding. It is superb in transmit. **W1BV** — In love with this fantastic gem. It's so easy and a pleasure to operate. **W6ASH** — Very happy with performance. Particularly impressed with full break-in and light weight. **WA0IMS** — By far the best rig I have ever operated. I am glad I decided on the TRITON IV and not one of the other transceivers on the market. **WA8HQO** — Thank you gentlemen.

Add your name to the growing list. See your TEN-TEC dealer or write for full details.

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BARREL KIT #143 75-PC TRANSISTORS $1.98 100% material, TO-92, factory discontinued lines, pnp's mixed with npns. 2N4400-1-2-3-4. 1H3290

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BARREL KIT #136 PANEL SWITCHES 30 for $1.98 Did you hear of OAK? Another eqpt maker barrelled all types of rotaries, electric, slides, etc. 1H3268

BARREL KIT #134 CALCULATOR CHIPS 15 for $1.98 National type. Can be MM5736, 38, etc. Untested. Cat. No. 1H3258

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BARREL KIT #131 TANTALUM ELECTROS 30 for $1.98 Mixed, marked prime, top grade asst. values, voltages. Cat. No. 1H3255

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BARREL KIT #128 MINI DIP ICS 75 for $1.98 Large mfgr dumped 100's of lbs into barrels. Includes 741s, LM-380-8, 703, 567, 555, 558—but who knows? Wt 1 lb. 1H3245

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BARREL KIT #101 RESISTOR SPECIAL 200 for $1.98 Includes: 1/8, 1/4, 1/2, 1, 2-watters, carbon. 8 oz. 100% good. 1H3054

BARREL KIT #99 PHOTO ELECTRIC CELLS 10 for $1.98 Asst. GE types, CDS types. Mixed by factory. Big job for us to separate. 100% good. Cat. No. 1H3052

BARREL KIT #93 HALF WATTERS 200 for $1.98 Resistor factory tried to fool us by mixing 100% color-coded resistors in barrel. But value is there. 4 oz. 1H3046 Untested

BARREL KIT #92 3 AMP EPOXY RECTIFIERS 100 for $1.98 Untested. Cosmetic rejects, electrically fine business! You check 'em, it's not for us. Asst. voltages. 1H3204

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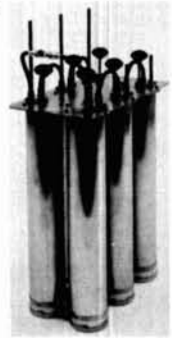

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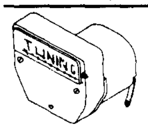

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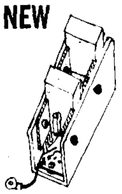

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DON'T READ THIS AD unless you want a good deal and good service on your next ham radio or hi-fi purchase. Thousands of satisfied customers nation-wide have made us the largest volume communications and hi-fi dealer in the country. We are factory-authorized dealers for Kenwood, Drake, Collins, ICOM, Regency, and over 100 other brands of amateur radio and hi-fi gear. We have something for you! Call or write us today and become one of the many happy and satisfied customers of Hoosier Electronics, Inc., P. O. Box 2001, Terre Haute, Indiana 47802. (812) 238-1456.

RUBBER STAMP, name/call/QTH $2.50 ppd. (CA residents add tax). LWM Press, Box 22161, San Diego, CA 92122.

SB-401 WITH CRYSTAL PACK $245, SB-313 (80-15M + foreign BC) with all crystal filters $245, Mosley SWV-7 $40. Add shipping. WB5NSS, 104 Galahad, Victoria, TX 77901. 512-578-4495.

TELETYPEWRITER PARTS, gears, manuals, supplies, tape, toroids. SASE list. Typetronics, Box 8873, Ft. Lauderdale, Fl. 33310. Buy parts, late machines.

SELL — Touch tone pad, solid state, subminiature size, great for HT's, $25. Regency HR2A, excellent condition, unmodified, $125. Knight VOM KG-640, mint, $20. Heath SWR bridge, AM-2, $10. Heath 2M, ⅝ wave mobil antenna, never used, $12. Drake low pass filter, TV-100, 100 watts, $5. Slinky dipole, $20. Motorola RF transistors, new, sealed, 2N5643, 2N5642, $5 each. Prices include shipping. Send SASE for more information. WA9WDB/P5 John Teles, 10511 Tenneco, Houston, Texas 77099.

PORTA-PAK the accessory that makes your mobile really portable. $67.50 and $88.00. Dealer inquiries invited. P. O. Box 67, Somers, Wisc. 53171.

SPECIAL OFFER

— all in stock for delivery —

SAVE $$$$ SPECIAL ON ICOM IC-230. Call now for price too low to be published.

Icom, IC22S, IC230, IC22A, IC215, IC502, IC202, Collins KWM2a, 75S3C, 32S3C, 30L1, Yaesu FT101, Kenwood TS820, TS520, TS700A, Atlas 210X DD1, 220cs, 206, Drake T4XC, R4C, L4B, MN200, MN2000 SSR1 SPR4 FS4 TR22C TR33, TR4C, Tempo 2020, Tempo One, CL146A, VHF One, Standard 146A, Horizon Two, VHF Engineering Synthesizer II, EBC144AJR, all Hygain, Newtronics, Antenna Specialists, Savoy, Larsen, Mosley antennas. Also Turner, Astatic, Shure, Spectronics DD1, Sc250 Bird 43, Loads, elements, Swan, National Radio NCL2000, NCX1000, HRO-500, KLM Multi 2700A, Multi II, Multi 7 all linears in stock. Ten-Tec KR50A, KR20A, Triton II, Venus SS2, SS2K, C1. DX Engineering, CDE, Brimstone, Cush-Craft, TEN TO FIFTEEN, TO TWENTY PER CENT OFF on everything in the house. Top trades given on your used equipment, Barry Electronics World Wide amateur Radio Since 1920.

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TEST EQUIPMENT

All equipment listed is operational and unconditionally guaranteed. Money back if not satisfied—equipment being returned must be shipped prepaid. Include check or money order with order. Prices include UPS or motor freight charges.

BECKMAN 7570A Counter Freq conv 10-1000mHz	275
BOONTON 190A Q-mtr 30-200mHz	425
BOONTON 202E AM-FM sig gen 54-216mHz	395
DEI TDU-2 30mHz video display	55
GR546C Audio microvolter	85
HP100ER Freq stand .05 parts/mil Outputs 10,100Hz 1,100,1000MHz	155
HP160B(USM105) 15MHz scope with reg horiz, dual trace vert plugs	375
HP166B(Mil) Delay sweep for above	130
HP170A(USM140) 30MHz scope with reg horiz, dual trace vert plugs	475
HP185A Sampling scope 1 gHz 186B xstr rise time plug	585
HP202B LF Osc .5Hz-50kHz 10v. out	75
HP205AG Lab Audio Gen .02-20kHz,	195
HP212A Pulse Gen .06-5kHzPRR	65
HP430CR Microwave Pwr Mtr	45
HP540B Transfer Osc to 12.4gHz for use with HP524 type counters	145
HP571B-561B Digital clock/rcdr	325
HP616 Sig gen 1.8-4gHz FM-CW	365
HP686 Sweep Gen 8.2-12.4gHz Sweep range 4.4mHz-4.4gHz	495
HP803A VHF Ant bridge 50-500mHz	135
SINGER SSB4 Sideband spec anal 0-40mHz, res. to 10Hz	635
TEK 181 Time-mark scope calib.	55
TEK 190 Sig gen(const ampl) 50mHz	125
TEK536 11MHz X-Y scope, accepts two letter-series plug-ins	295
TEK 565 Dual beam 10mHz scope less plug-ins	625
TS 505 Std VTVM (rf to 500mHz)	65

For complete list of all test equipment send stamped, self-addressed envelope

GRAY Electronics
P.O.Box 941, Monroe, Mich. 48161
Specializing in used test equipment.

More Details? CHECK—OFF Page 126

6 Digit LED Clock Kit - 12/24 hr.

$9.95 ea. QTY. 12 OR MORE — $10.95 ea. QTY. 6-11 — $11.95 ea. QTY. 1-5

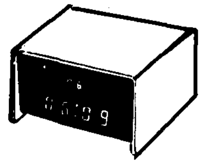
KIT INCLUDES
- INSTRUCTIONS
- QUALITY COMPONENTS
- 50 or 60 Hz OPERATION
- 12 or 24 HR OPERATION

6-LED Readouts (FND-359 Red, com. cathode)
1-MM5314 Clock Chip (24 pin)
13-Transistors
3-Switches
6-Capacitors
5-Diodes
9-Resistors
24-Molex pins for IC socket

LARGE .4" DIGITS!
ORDER KIT #850-4
AN INCREDIBLE VALUE!

"Kit #850-4 will furnish a complete set of clock components as listed. The only additional items required are a 7-12 VAC transformer, a circuit board and a cabinet, if desired."

Printed Circuit Board for kit # 850-4 (etched & drilled fiberglass) $2.95
Mini-Brite Red LED's (for colon in clock display) pkg. of 5 .... 1.00
Molded Plug Transformer 115/10 VAC (with cord) 2.50
NOTE: Entire Clock may be assembled on one PC Board or Board may be cut to remote display.
Kit # 850-4 will fit Plexiglas Cabinet II.



PLEXIGLAS CABINETS

Great for Clocks or any LED Digital project. Clear-Red Chassis serves as Bezel to increase contrast of digital displays.

CABINET I 3"H, 6¼"W, 5½"D
CABINET II 2½"H, 5"W, 4"D

Black, White or Clear Cover

ANY SIZE/COLOR **$6.50 ea. 2/$12.**

RED OR GREY PLEXIGLAS FOR DIGITAL BEZELS
3"x6"x1/8" **95¢ ea. 4/$3**

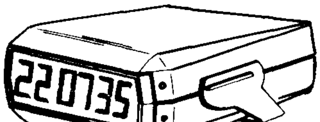
MOBILE LED CLOCK

12 OR 24-HOUR OPERATION

12 VOLT AC or DC POWERED FOR FIXED OR MOBILE OPERATION.

SIX LARGE .4" DIGITS!

KIT OR ASSEMBLED — **MODEL 2001**



ACCURATE TIME WITH ADJUSTABLE XTAL TIME BASE

Approx. Size: 1¾"H x 4"W x 4½"D

BATTERY BACK-UP FOR POWER FAILURE OR TRANSPORTING FROM HOUSE TO CAR, ETC.

- 6 JUMBO .4" RED LED'S BEHIND RED FILTER LENS WITH CHROME RIM.
- SET TIME FROM FRONT VIA HIDDEN SWITCHES • 12/24-Hr. TIME FORMAT
- STYLISH CHARCOAL GRAY CASE OF MOLDED HIGH TEMP. PLASTIC
- BRIDGE POWER INPUT CIRCUITRY — TWO WIRE NO POLARITY HOOK-UP
- OPTIONAL CONNECTION TO BLANK DISPLAY (Use When Key Off in Car, Etc.)
- TOP QUALITY PC BOARDS & COMPONENTS - EXCELLENT INSTRUCTIONS
- MOUNTING BRACKET INCLUDED

KIT #2001 COMPLETE KIT (Less 9V. Battery) **29.95 EA.** — 3 OR MORE **$27.95 EA.** — 115 VAC Power Pack #AC-1 **$2.50 EA.**

ASSEMBLED UNITS ORDER #2001 WT — WIRED & TESTED (LESS 9V. BATTERY) **$39.95 EA.** — 3 OR MORE **$37.95 EA.** — Assembled Units May Be Mixed With Kits for Qty. Price
WIRED FOR 12 HR OP IF NOT SPECIFIED OTHERWISE

JUMBO RED LED's 12/$1.00 50/$3.95

6 Digit-LED Clock-Calendar-Alarm Kit

This is a complete, top of the line, Kit for the person that wants the best. Some of the many features and options are: 12/24 time, 28-30-31 day calendar, alternates time (8 sec) and date (2 sec) or can display time only and date on demand, 24 hr alarm - 10 minute snooze, alarm set indicator, 50/60 HZ. line operation or use with Xtal time base (#TB-1), built in OSC for battery back-up / AC failure, Aux. timer, CHOICE OF DIGITS.

Kit #7001B	6 - .4" Digits	$39.95
Kit #7001C	4 - .6" Digits & 2-." [Seconds]	$42.95
Kit #7001X	6 - .6" Digits	$45.95

Kits are complete (less cabinet) including PC boards, power supply, IC socket, 9 switches, 16 transistors and all parts required for above features and options **[All #7001 Kits Will Fit Cabinet I Above]**

60 HZ. XTAL TIME BASE KIT

Will enable Digital Clock or Clock-Cal. Kits to operate from 12VDC. Uses MM5369 and 3.58MHZ. XTAL. Req. 5-15VDC/2.5 MA. 1"x2" PC Board. Easy 3 wire hookup Accuracy: +- 2 PPM

#TB-1 [adjustable]
Complete kit $4.95 ea
Wired & Cal. $9.95 ea

PRINTED CIRCUIT BOARDS for CT-7001 Kits sold separately with assembly info. PC Boards are drilled Fiberglass, solder plated and screened with component layout. Specify for # 7001B or # 7001C (Set of 2) $7.95

JUMBO DIGIT CLOCK KIT

A complete Kit (less Cabinet) featuring: six .5" digits, MM5314 IC, 12/24 Hr. time, 50/60 HZ., Plug-Transformer, Line Cord, Switches, and all Parts.
[Ideal Fit in Cabinet II]
Kit #5314-5 .... **$19.95 ea. 2/$38.**

JUMBO DIGIT CONVERSION KIT

Convert small digit LED clock to large .5" displays. Kit includes 6-.5" LED's, Multiplex PC Board & easy hook-up info.

Kit #JD-1CC For common Cathode
Kit #JD-1CA For common Anode
$9.95 ea. 2/$19.

SCHOTTKY TTL

74S00	$ .35
74S01	.40
74S04	.55
74S05	.60
74S09	.65
74S10	.40
74S15	.55
74S20	.50
74S22	.45
74S40	.45
74S50	.45
74S51	.55
74S60	.85
74S64	.55
74S73	1.25
74S74	.85
74S75	1.75
74S78	1.50
74S86	.95
74S107	.95
74S112	.95
74S113	1.40
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74S157	1.80
74S158	2.50
74S174	2.50
74S175	2.50
74S181	2.95
74S182	1.95
74S251	2.75

DTL

930	$ .09
932	.09
937	.09

LED DRIVERS

7447	$ .95
7448	.95
75491	.65
75492	.65

VOLTAGE REGULATORS

LM 309 H	TO-5	$ .95
LM 309 K	TO-3	1.25
7805	TAB	.95
7812	TAB	1.25
7815	TO-3	1.25
7815	TAB	1.25
78L 15	TO-5	.75
7824	TO-3	1.25
723	DIP	.75
723	TO-5	.75

DIGITAL CLOCK IC's

MM 5312	$ 4.95
MM 5314	3.95
MM 5375 AB	3.95
CT-7001	7.95
CT-7002	13.95
50380	3.95
MM 5369	2.50

XTAL

3.579545 MHZ. $ 1.95

PRESCALE

11C90DC	$15.95
95H90	9.95

DIODES

IN 4002	1A, 100 PIV	12/$1.00
IN 4005	1A, 600 PIV	11/$1.00
IN 4007	1A, 1000 PIV	10/$1.00
RECTIFIER	2.5A, 1000 PIV	4/$1.00
IN 914	SIL. SIGNAL	20/$1.00
IN 4148	SIL. SIGNAL	20/$1.00
DYAC	28V.	4/$1.00

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12 VAC at 150 MA	$ 2.50
12 VAC at 500 MA	3.50

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555 TIMER	2/$1.00
556 DUAL TIMER	.95
565 PLL	.95
566 FUNCTION GEN.	1.75
567 TONE DECODER	1.75

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PINS	1-24	25	100
8	$ .25	$ .22	$ .20
14	.25	.22	.20
16	.28	.25	.23
18	.31	.28	.26
24	.50	.45	.40
28	.60	.55	.50
40	.75	.70	.65

MEMORY

21L02 IK RAM $1.95

EXAR

XR 2556	$ 1.75
XR 2567	$ 1.95

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2N2222A	TO-18	5/$1.00
2N3415	TO-92	5/$1.00
2N3704	TO-92	5/$1.00
2N4249	TO-92	5/$1.00
2N4400	TO-92	5/$1.00
2N4437	TO-92	5/$1.00
2N5089	TO-92	5/$1.00
2N5457 N	J-FET	.95

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ROCKER SPDT	6/$1.
MINI-SLIDE SPDT	5/$1.
REG. SLIDE DPDT	6/$1.
PUSH BUTTON N.O.	3/$1.
MINI TOGGLE SPDT	$1.30
MINI TOGGLE DPDT	1.50

TRANSISTOR SOCKET TO-5/18 GOLD PINS
5/$1.00

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8" TIE-WRAP	100/$1.95
4" TIE-WRAP	100/$1.75

MOLEX PINS

REEL OF 1000	$ 8.50
STRIP OF 100	1.25

MISC. PRIME IC's

FAIRCHILD 9316 (74161)	$ .95
75234 DUAL CORE SENSE AMP	1.50
MM 502H TO-5 SHIFT REG	.95

OP AMPS
3/$1.00

301 TO-5
709 DIP
709 TO 5
741 DIP
741 M-DIP
741 TO-5
747 DIP
748 DIP

DISCRETE LED's
JUMBO RED
12/$1.00
50/$3.95
100/$7.50

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25K 6/$1.00
4.7K 6/$1.00

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BUY 100 OR MORE IC's [Any Mix] TAKE 10% DISCOUNT.

Fairchild Super Digit FND-359

.4" Char. Ht. 7 segment LED RED Com. Cath. Direct pin replacement for popular FND-70.

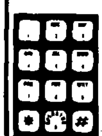
95¢ ea, 10/$8.50 100/$79.00

SET OF 6 FND-359 WITH MULTIPLEX PC BOARD $6.95

25 AMP BRIDGE

$1.95 ea. 3/$5.00
100 PIV

TELEPHONE FORMAT KEYBOARD BY Chomerics

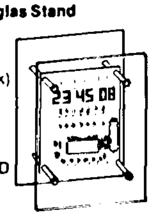


2-1/4"x3" 5/32" thick
$4.95 6/$28.

SEE THE WORKS Clock Kit
Clear Plexiglas Stand

- 6 Big .4" digits
- 12 or 24 hr. time
- 3 set switches (back)
- Plug transformer
- all parts included

Plexiglas is Pre-cut & drilled
Size: 6"H, 4⅓"W, 3"D



A SUPER LOOKING CLOCK!

Kit #850-4 CP **$23.50 ea. 2/$45.**

7-SEG LED

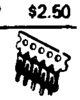
COMMON CATHODE

	COLOR	HT.	DEC.PT.	PR.EA.
FND-359	RED	.4"	RHDP	$ .95
FND-503	RED	.5"	RHDP	$1.35
DL-750	RED	.6"	LHDP	$2.95
XAN-654	GREEN	.6"	NDP	$2.95
XAN-664	RED	.6"	NDP	$2.95

COMMON ANODE

DL-747	RED	.6"	LHDP	$2.95
XAN-72	RED	.3"	LHDP	$1.25
XAN-81	YELLOW	.3"	RHDP	$1.75
XAN-351	GREEN	.3"	RHDP	$1.50
XAN-361	RED	.3"	RHDP	$1.50
XAN-362	RED	.3"	LHDP	$1.50
XAN-662	RED	.6"	NDP	$2.50
XAN-692	RED	.6"	NDP	$2.50

Form Inexpensive Sockets MOLEX PINS
100 for $1.25
Reel of 1000 - $8.50



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WANTED: Complete Manual, schematics for Federal Telephone & Radio FT-125 - B25A2 2M 6V gear #473063, has transmitter 282B25A #474902, receiver 148AA #4703385. Also #26 tubes, manual schematics for Motorola K 7288 2M xcvr, has PA7265B receiver, PA 7279A pls, #6300, PA 7291C #16413 transmitter. Will buy or copy. Company records destroyed in natural disaster. Source for parts, test cables appreciated. Robert Clark, 714 W. 11th, Waynesboro, VA 22980.

QRP TRANSMATCH for HW7, Ten-Tec, and others. Send stamp for details to Peter Meacham Associates, 19 Loretta Road, Waltham, Mass. 02154.

SST-T-1 gets you on 160-10. See ad this issue. SST Electronics, Box 1, Lawndale, Calif. 90260.

SYNTHESIZER, see Ham Radio, July 76, pg. 20-23, figures 21-24. Kit for $115. Assembled and tested, $140. Power supply to run from 117V additional $15. CTD, P. O. Box 708, Cambridge, MA 02139.

MOTOROLA: HT200 repeater complete with control circuits. Mounted in commercially milled block of alum. Size 5″ x 7″ x 1½″. Mil-standard construction throughout, $250.00. More info contact: Ray Waldemar, WA7ZYR, 2025 W. Indian School Rd., Phoenix, Arizona 85015, Apt. 628.

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NEED. #12 enameled or old cotton covered copper wire. 25 or 30 lb. spool. W4NNT, 6913-29th Ave., Tampa, FL 33619.

MANUALS for most ham gear, 1939/70. List $1.00. Send SASE (or 25¢) for one specific model quote. Hobby Industry, WØJJK, Box H864, Council Bluffs, Iowa 51501.

HT SCR-146A xtals, mike, standcharger, belt-clip case. Commercial grade fiberglass colinear ASP-680A. Factory tuned for 2M. List $105.00, 1 year old, $50.00. WB9SZQ, T. Menzel, 1971 W. Mill, Milwaukee, WI 53209.

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FOR SALE: Lampkin 107c Generator. 1 year old, mint condition. Original cost $3,000. Make an offer. Pete Hons, Portage, Pa. 15946. 814-736-3883.

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1 KW. LINEAR (continuous duty amplifier) custom manufactured compact with heavy duty power supply used once, excellent like new - $195 (ship UPS 50 lb.) OUNG, 210 Richardson Ave., San Francisco, CA 94123.

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$4.95 ea.

New Calculators made by one of the **largest calculator manufacturers** (their name has been removed so that we can offer these at this low, low price).

Check These Quality Features

- **Full 8 digit capacity**
- **All 4 functions plus constant (K) switch**
- **Floating or 2, 3, 4 decimal pt. set switch**
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- **Indicator for low battery condition**
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- **Size approx. 6″ x 3½″ x 1¾″. White case with black trim.**

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AA size nicads (used - excellent condition) 59¢ ea.

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.7-9pF Glass Piston Trimmer, JFD, VC-1 $2.25 ea 10 for $1.75 ea
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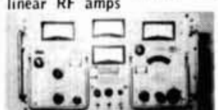


Great Repeater Receiver. 215-265 MHz Plug in front-end & video unit with BW 1.5 KC — 1 MC built-in deviation meter. Defense Electronics Model TMR-5A. Only 1 in stock. SPECIAL $215.00

RVCR 2 to 30 MHz depending on the plug-in front end. Provision for XTAL control. Makes a fine single-channel H.F. RCVR. $125.00

100 kHz solid state standard frequency oscillator. Complete in oven. Size: 4¼″ x 2″ x 1½″. James Knight's part #JKTO-23. Octal plug-in. Hermetically sealed. $25.00

WE ARE BUYERS as well as sellers. What have you? We don't have a catalog, by the time we'd publish it the merchandise would be gone.

DISC-CAP, 19075 BRAEMORE RD.
NORTHRIDGE, CA. 91326 213-360-3387

More Details? CHECK—OFF Page 126

7400N TTL

SN7400N	.16	SN7459A	.25		
SN7401N	.16	SN7460N	.22	SN74154N	1.00
SN7402N	.21	SN7470N	.45	SN74155N	.99
SN7403N	.16	SN7472N	.39	SN74156N	.99
SN7404N	.18	SN7473N	.37	SN74157N	.99
SN7405N	.24	SN7474N	.32	SN74160N	1.25
SN7406N	.20	SN7475N	.50	SN74161N	.99
SN7407N	.29	SN7476N	.32	SN74163N	.99
SN7408N	.25	SN7479N	5.00	SN74164N	1.10
SN7409N	.25	SN7480N	.50	SN74165N	1.10
SN7410N	.18	SN7482N	.98	SN74166N	1.25
SN7411N	.30	SN7483N	.70	SN74167N	5.50
SN7412N	.33	SN7485N	.89	SN74170N	2.10
SN7413N	.45	SN7486N	.39	SN74172N	8.95
SN7414N	.70	SN7488N	3.50	SN74173N	1.50
SN7416N	.35	SN7489N	2.49	SN74174N	1.25
SN7417N	.35	SN7490N	.45	SN74175N	.99
SN7420N	.21	SN7491N	.75	SN74176N	.90
SN7421N	.33	SN7492N	.49	SN74177N	.90
SN7422N	.49	SN7493N	.49	SN74180N	.99
SN7423N	.37	SN7494N	.79	SN74181N	2.49
SN7425N	.29	SN7495N	.79	SN74182N	.95
SN7426N	.29	SN7496N	.89	SN74184N	1.95
SN7427N	.37	SN7497N	4.00	SN74185N	2.20
SN7429N	.42	SN74100N	1.00	SN74186N	15.00
SN7430N	.26	SN74107N	.39	SN74187N	6.00
SN7432N	.31	SN74121N	.39	SN74188N	3.95
SN7437N	.27	SN74122N	.39	SN74190N	1.19
SN7438N	.27	SN74123N	.50	SN74191N	1.25
SN7439N	.25	SN74125N	.60	SN74192N	.89
SN7440N	.15	SN74126N	.60	SN74193N	.89
SN7441N	.89	SN74132N	1.09	SN74194N	1.25
SN7442N	.59	SN74136N	.95	SN74195N	.75
SN7443N	.75	SN74141N	1.15	SN74196N	1.25
SN7444N	.75	SN74142N	4.00	SN74197N	.75
SN7445N	.75	SN74143N	4.50	SN74198N	1.75
SN7446N	.81	SN74144N	4.50	SN74199N	1.75
SN7447N	.69	SN74145N	1.15	SN74200N	5.59
SN7448N	.79	SN74147N	2.35	SN74279N	.90
SN7450N	.26	SN74148N	2.00	SN74251N	1.79
SN7451N	.27	SN74150N	1.00	SN74284N	6.00
SN7453N	.27	SN74151N	.79	SN74285N	6.00
SN7454N	.20	SN74153N	.89	SN74367N	.75

MANY OTHERS AVAILABLE ON REQUEST
20% Discount for 100 Combined 7400's

CMOS

CD4000	.25			74C04N	.75
CD4001	.25			74C10N	.65
CD4002	.25	CD4035	1.85	74C20N	.65
CD4006	2.50	CD4040	2.45	74C30N	.65
CD4007	.25	CD4042	1.90	74C42N	2.15
CD4009	.59	CD4044	1.50	74C73N	1.50
CD4010	.59	CD4046	2.51	74C74	1.15
CD4011	.25	CD4047	2.75	74C90N	3.00
CD4012	.25	CD4049	.79	74C95N	2.00
CD4013	.47	CD4050	.79	74C107N	1.25
CD4016	.56	CD4051	2.95	74C151	2.90
CD4017	1.35	CD4053	2.95	74C154	4.00
CD4019	.55	CD4060	3.25	74C157	2.15
CD4020	1.49	CD4066	1.75	74C160	3.25
CD4022	1.25	CD4069	.45	74C161	3.25
CD4023	.25	CD4071	.45	74C163	3.00
CD4024	1.50	CD4081	.45	74C164	3.25
CD4025	.25	CD4511	2.50	74C173	2.60
CD4027	.69	CD4518	2.50	74C193	2.75
CD4028	1.65	CD4566	3.00	74C195	2.75
CD4029	2.90	74C00N	.39	MC4044	4.50
CD4030	.65	74C02N	.55	MC14016	.56

LINEAR

LM300H	.80			LM1310N	2.95
LM301H	.35			LM1351N	1.65
LM301CN	.35			LM1414N	1.75
LM302H	.75			LM1458C	.65
LM304H	1.00	LM370N	1.15	LM1496N	.95
LM305H	.95	LM373N	3.25	LM1556V	1.85
LM307CN	.35	LM377N	4.00	LM2111N	1.95
LM308H	1.00	LM380N	1.39	LM2901N	2.95
LM308CN	1.00	LM380CN	1.05	LM3065N	.69
LM309H	1.10	LM381N	1.79	LM3900N	.55
LM309K	.99	LM382N	1.79	LM3905N	.60
LM310CN	1.15	NE501K	8.00	LM3909	1.25
LM311H	.90	NE510A	6.00	LM5556N	1.85
LM311N	.90	NE531H	3.00	MC5558V	1.00
LM318CN	1.50	NE536T	6.00	LM7525N	.90
LM319N	1.30	NE540L	6.00	LM7535N	1.25
LM320K-5	1.35	NE550N	.79	8038B	4.95
LM320K-5.2	1.35	NE555V	.39	LM75450	.49
LM320K-12	1.35	NE560B	5.00	75451CN	.39
LM320K-15	1.35	NE561B	5.00	75452CN	.39
LM320T-5	1.75	NE562B	5.00	75453CN	.39
LM320T-5.2	1.75	NE565H	1.25	75454CN	.39
LM320T-8	1.75	NE565N	1.75	75491CN	.79
LM320T-12	1.75	NE566CN	1.25	75492CN	.89
LM320T-15	1.75	NE567H	1.95	75494CN	.89
LM320T-18	1.75	NE567V	1.50	**RCA LINEAR**	
LM320T-24	1.75	LM703CN	.45	CA3013	2.15
LM323K-5	9.95	LM709H	.29	CA3032	2.56
LM324N	1.80	LM709N	.29	CA3035	2.48
LM339N	1.70	LM710N	.79	CA3039	1.35
LM340K-5	1.95	LM711N	.39	CA3046	1.30
LM340K-6	1.95	LM723H	.55	CA3059	3.25
LM340K-8	1.95	LM723H	.55	CA3060	3.25
LM340K-12	1.95	LM733N	1.00	CA3080	.85
LM340K-15	1.95	LM739N	1.00	CA3081	2.00
LM340K-18	1.95	LM741CH	.35	CA3082	2.00
LM340K-24	1.95	LM741CN	.35	CA3083	1.60
LM340T-5	1.75	LM74114N	.39	CA3086	.85
LM340T-6	1.75	LM747H	.79	CA3089	3.75
LM340T-8	1.75	LM747N	.79	CA3091	10.20
LM340T-12	1.75	LM748H	.39	CA3123	2.15
LM340T-15	1.75	LM748N	.39	CA3130	1.39
LM340T-18	1.75	LM1303N	.90	CA3140	1.25
LM340T-24	1.75	LM1304N	1.19	CA3600	1.75
LM350N	1.00	LM1305N	1.40	RC4194	5.95
LM351CN	.65	LM1307N	.85	RC4195	3.25

74LS00 TTL

74LS00	.39			74LS139	1.95
74LS02	.39			74LS151	1.55
74LS03	.39	74LS74	.65	74LS153	1.89
74LS04	.45	74LS75	.79	74LS157	1.55
74LS05	.45	74LS76	.65	74LS162	2.25
74LS08	.39	74LS83	2.19	74LS163	2.25
74LS10	.39	74LS85	2.49	74LS164	2.25
74LS13	.79	74LS86	.65	74LS175	1.95
74LS14	2.19	74LS90	1.25	74LS181	3.69
74LS20	.39	74LS92	1.25	74LS190	2.85
74LS26	.49	74LS93	1.25	74LS191	2.85
74LS27	.45	74LS95	2.19	74LS192	2.85
74LS28	.49	74LS96	1.89	74LS193	2.85
74LS30	.39	74LS107	.65	74LS194	2.25
74LS32	.45	74LS109	.65	74LS195	2.25
74LS40	.49	74LS112	.65	74LS257	1.89
74LS51	.39	74LS132	1.55	74LS260	.55
74LS55	.39	74LS136	.65	74LS279	.79
74LS73	.65	74LS138	1.89	74LS670	5.95

CLOCK CHIPS

MM5309	6 Digit, BCD Outputs, Reset PIN	$9.95
MM5311	6 Digit, BCD Outputs, 12 or 24 Hour	4.95
MM5312	4 Digit, BCD Outputs, 1 PPS Output	4.95
MM5314	6 Digit, 12 or 24 Hour, 50 or 60 Hz	4.95
MM6316	4 Digit, Alarm, 1 PPS Output	6.95
MM5318	Video Clock Chip, For Use With MM5841	9.95
CT7001	6 Digit, Calendar, Alarm, 12 or 24 Hour	5.95

DATA HANDBOOKS

7400	Pin-out & Description of 5400/7400 ICS	$2.95
CMOS	Pin-out & Description of 4000 Series ICS	$2.95
Linear	Pin-out & Functional Description	$2.95

ALL THREE HANDBOOKS $6.95

FAIRCHILD TECHNOLOGY KITS FAIRCHILD

- Complete Specifications on back of each kit
- Packaged for WALL DISPLAY APPEARANCE
- Dealer's Inquires Invited — Price List Available

DIGITS

FTK0001	0.5" High Common Cathode Digit	$1.00
FTK0002	0.5" High Common Anode Digit	1.00
FTK0003	.357" High Common Cathode Digit	.75
FTK0004	0.8" High Common Cathode Digit	2.00
FTK0005	0.8" High Common Anode Digit	2.00

0.8" HIGH DISPLAY ARRAYS

FTK0010	12 Hour, 3½ Digit Clock Display	7.00
FTK0011	24 Hour, 4 Digit Clock Display	8.00

LED LAMPS

FTK0020	10 Red LED Lamps	1.00
FTK0021	5 Mixed Colored LED Lamps	1.00
FTK0022	10 LED Mounting Clips	1.00
FTK0023	5 Three Piece LED Mounting Adapters	1.00

PHOTO TRANSISTORS

FTK0030	5 Flat Lens Photo Transistors	1.00
FTK0031	5 Round Lens Photo Transistors	1.00
FTK0032	3 Flat Lens Photo Darlingtons	1.00
FTK0033	3 Round Lens Photo Darlingtons	1.00

PHOTO ARRAYS

FTK0040	9-Element Tape Reader Array	16.00
FTK0041	12-Element Card Reader Array	24.00
FTK0042	Reflective Opto Coupler	4.00

COUPLERS

FTK0050	3 General Purpose Opto Couplers	1.00
FTK0051	Darlington Opto Coupler	1.00

MOS CLOCK CIRCUITS

FTK0400	Digital Clock/Calendar Circuit (FCM7001)	7.00
FTK0401	Digital Clock/Calendar with BCD Outputs (FCM7002)	7.00
FTK0402	Direct Drive Digital Clock Circuit with AC Output (FCM3817A)	5.00
FTK0403	Direct Drive Digital Clock Circuit with DC Output (FCM3817D)	5.00
FTK0405	Direct Drive Digital Clock/Calendar Circuit (FCM7015)	6.00

KITS

FTK0106	Automobile Clock Kit	40.00

DISCRETE LEDS

.125" dia.			.90" dia.		
XC209	Red	10/$1	XC111	Red	10/$1
XC209	Green	4/$1	XC111	Green	4/$1
XC209	Orange	4/$1	XC111	Yellow	4/$1
			XC111	Orange	4/$1

.200" dia.			.185" dia.			.200" dia.			.085" dia.
XC22	Red	10/$1	XC526	Red	10/$1	XC556	Red	10/$1	MV50
XC22	Green	4/$1	XC526	Green	4/$1	XC556	Green	7/$1	.085" dia. Micro
XC22	Yellow	4/$1	XC526	Yellow	4/$1	XC556	Yellow	7/$1	red LED
XC22	Orange	4/$1	XC526	Orange	4/$1	XC556	Orange	7/$1	6/$1
SSL-22	RT	4/$1	XC526	Clear	4/$1	XC556	Clear	7/$1	

DISPLAY LEDS

DL707 DL338

TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	Common Anode	270	2.95	MAN 3620	Common Anode-orange	300	1.75
MAN 2	5 x 7 Dot Matrix	300	4.95	MAN 3640	Common Cathode-orange	300	1.75
MAN 3	Common Cathode	125	.39	MAN 4710	Common Anode-Red	400	1.95
MAN 4	Common Cathode	187	1.95	DL701	Common Anode-red ±	300	.99
MAN 7	Common Anode	300	1.25	DL704	Common Cathode	300	.99
MAN 7G	Common Anode-green	300	1.95	DL707	Common Anode	300	.99
MAN 7Y	Common Anode-yellow	300	1.95	DL 728	Common Cathode	500	1.95
MAN 52	Common Anode-green	300	1.75	DL 747	Common Anode	600	2.25
MAN 64	Common Anode-red	400	1.75	DL 750	Common Cathode	600	2.49
MAN 72	Common Anode	300	1.25	DL 338	Common Cathode	110	.50
MAN 74	Common Cathode	300	1.50	FND70	Common Cathode	250	.75
MAN 82	Common Anode-yellow	300	1.75	FND503	Common Cathode	500	1.00
MAN 84	Common Cathode-yellow	300	1.75	FND507	Common Anode	500	1.00

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.17	.16	.15	24 pin	$.38	.37	.36
14 pin	.20	.19	.18	28 pin	.45	.44	.43
16 pin	.22	.21	.20	36 pin	.60	.59	.58
18 pin	.29	.28	.27	40 pin	.63	.62	.61
22 pin	.37	.36	.35				

SOLDERTAIL STANDARD (TIN)

14 pin	$.27	.25	.24	28 pin	$.99	.90	.81
16 pin	.30	.27	.25	36 pin	1.39	1.26	1.15
18 pin	.35	.32	.30	40 pin	1.59	1.45	1.30
24 pin	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)

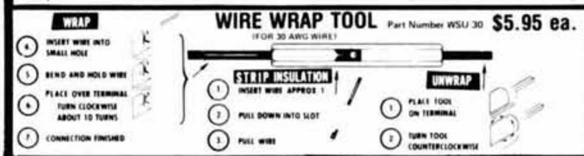
8 pin	$.30	.27	.24	24 pin	$.70	.63	.57
14 pin	.35	.32	.29	28 pin	1.10	1.00	.90
16 pin	.38	.35	.32	36 pin	1.75	1.40	1.26
18 pin	.52	.47	.43	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	$.45	.41	.37	24 pin	$1.05	.95	.85
14 pin	.39	.38	.37	28 pin	1.40	1.25	1.10
16 pin	.43	.42	.41	36 pin	1.59	1.45	1.30
18 pin	.75	.68	.62	40 pin	1.75	1.55	1.40

WIRE WRAP TOOL Part Number WSU 30 $5.95 ea.

(FOR 30 AWG WIRE)



WIRE WRAP WIRE

30 AWG — 25 ft. min. - $2.10   50 ft. - $2.75   100 ft. - $3.50   1000 ft. - $24.00

SPECIFY COLOR — White - Yellow - Red - Green - Blue - Black

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

		10 OHM	12 OHM	15 OHM	18 OHM	22 OHM	
ASST. 1	5 ea.	27 OHM	33 OHM	39 OHM	47 OHM	56 OHM	1/4 WATT 5% - 50 PCS.
		68 OHM	82 OHM	100 OHM	120 OHM	150 OHM	
ASST. 2	5 ea.	180 OHM	220 OHM	270 OHM	330 OHM	390 OHM	1/4 WATT 5% - 50 PCS.
		470 OHM	560 OHM	680 OHM	820 OHM	1K	
ASST. 3	5 ea.	1.2K	1.5K	1.8K	2.2K	2.7K	1/4 WATT 5% - 50 PCS.
		3.3K	3.9K	4.7K	5.6K	6.8K	
ASST. 4	5 ea.	8.2K	10K	12K	15K	18K	1/4 WATT 5% - 50 PCS.
		22K	27K	33K	39K	47K	
ASST. 5	5 ea.	56K	68K	82K	100K	120K	1/4 WATT 5% - 50 PCS.
		150K	180K	220K	270K	330K	
ASST. 6	5 ea.	390K	470K	560K	680K	820K	1/4 WATT 5% - 50 PCS.
		1M	1.2M	1.5M	1.8M	2.2M	
ASST. 7	5 ea.	2.7M	3.3M	3.9M	4.7M	5.6M	1/4 WATT 5% - 50 PCS.

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) $10.95 ea.

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets - 25¢ — Send 24¢ Stamp for 1977 Catalog
Dealer Discount Available — Request Pricing

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James ELECTRONICS

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PHONE ORDERS WELCOME — (415) 592-8097
All Advertised Prices Good Thru January

MINIATURE TOGGLE

DPDT				AMT	1	2-9	10-29	30-99
	ON	OFF	ON	221	2.95	2.55	1.87	1.70
	ON	NONE	ON	223	2.95	2.15	1.58	1.43
	ON	OFF	ON	121	2.35	1.95	1.43	1.30
	ON	NONE	ON	123	2.05	1.65	1.21	1.10

PUSH BUTTON

SPDT — SERIES PB, PB1
Maintained Action Switch Push To Make Contact And Push Again To Reserve Action
Momentary Action Switch Normally Open or Normally Closed (For N.C. circuit use terminals 2 & 1, for N.O. 2 & 3, for N.C. and N.O. 1, 2 & 3)

PB-123 $1.75
PB-126 $1.75

5 AMP RATINGS

THUMBWHEEL SWITCHES

THUMBWHEEL SWITCH ONLY

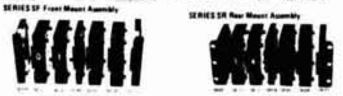
Part No.	Description	Price
SF 12	Single Pole 10 Position	$2.50
SR 12	Decimal	3.00
SF 21	10 Position BCD only	2.50
SR 21		3.00

Ordering: Order desired switch or switches and add necessary accessories for your particular application.

SF — Front Mount   SR — Rear Mount

SERIES SF Front Mount Assembly

SERIES SR Rear Mount Assembly



ACCESSORIES

Part No.	Description	Price
SF EP	End Plate (Pair)	.50
SF DP	Divider Plate (each)	.40
SF BB	Blank Body (each)	.40
SF HB	Half Body (each)	.40

ACCESSORIES

Part No.	Description	Price
SR EP	End Plates (pair)	$.50
SR DP	Divider Plate (each)	.40
SR BB	Blank Body (each)	.40
SR HB	Half Body (each)	.40

DIP SWITCH

These switches feature seven SPST slide switches in a molded dip. They are ideally suited for microprocessor applications.

$1.95

CLIPLITE !! 4/$1.00

NEW LED MOUNTING SYSTEM

- CLIPLITE mounts from the front of the Panel in a .250 hole on 3/8" centers. Panel thickness from 1/16" to 1/8".
- CLIPLITE equalizes and increases the brightness of commonly used wide beam LEDS.
- CLIPLITE is to be used with XC556 LEDS.
- Specify colors—red, green, amber, or yellow when ordering.

ZENERS — DIODES — RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400mm	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N751A	5.1	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6.8	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	8/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4305	75	25m	20/1.00
1N5232	5.6	500m	.28	1N4734	5.6	1w	.28
1N5234	6.2	500m	.28	1N4735	6.2	1w	.28
1N5235	6.8	500m	.28	1N4736	6.8	1w	.28
1N5236	7.5	500m	.28	1N4738	8.2	1w	.28
1N456	25	40m	6/1.00	1N4742	12	1w	.28
1N458	150	7m	6/1.00	1N4744	15	1w	.28
1N485A	180	10m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.50
1N4003	200 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR	$1.95
C38M	35A @ 200V	SCR	1.95
2N2328	1.6A @ 200V	SCR	.50
MDA 980-1	25A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	25A@ 200V	FW BRIDGE REC.	1.95

TRANSISTORS

MPS A05	5/$1.00			PN4249	4/$1.00
MPS A06	5/$1.00			PN4250	4/$1.00
2N2219A	3/$1.00	PN3567	3/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	PN3568	4/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	PN3569	4/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3704	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3705	5/$1.00	2N4409	5/$1.00
PN2415	5/$1.00	2N3706	5/$1.00	2N5086	4/$1.00
2N2484	4/$1.00	2N3707	5/$1.00	2N5087	4/$1.00
2N2906A	4/$1.00	2N3711	5/$1.00	2N5088	4/$1.00
2N2907A	5/$1.00	2N3724	$.65	2N5089	4/$1.00
2N2925	5/$1.00	2N3725	$1.00	2N5129	5/$1.00
2N3053	2/$1.00	2N3903	5/$1.00	2N5138	5/$1.00
2N3055	$.89	2N3904	4/$1.00	2N5139	5/$1.00
MJE3055	$1.00	2N3905	4/$1.00	2N5209	5/$1.00
MJE2955	$1.25	2N3906	4/$1.00	2N5951	5/$1.00
2N3392	5/$1.00	2N4013	3/$1.00	C106B1SCR	2/$1.00
2N3398	5/$1.00	2N4014	3/$1.00	2N5432	$2.00
		2N4123	10/$1.00		

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075
100 VOLT MYLAR FILM CAPACITORS							
.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22
+20% DIPPED TANTALUMS (SOLID) CAPACITORS							
.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/25V	.31	.27	.22
.22/35V	.28	.23	.17	3.3/25V	.31	.27	.22
.33/35V	.28	.23	.17	4.7/25V	.32	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.36	.31	.25
.68/35V	.28	.23	.17	10/25V	.40	.35	.29
1.0/35V	.28	.23	.17	15/25V	.63	.50	.40
MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS							
Axial Lead				**Radial Lead**			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.15	.13	.10	1.0/16V	.15	.13	.10
4.7/25V	.16	.14	.12	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

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Coming Events

LAPORTE WINTER HAMFEST — The LaPorte, Indiana, ARC will hold its Winter Hamfest on the 27th of February, 1977, beginning at 8 a.m. (Chicago time) at the LaPorte Civic Auditorium. Good food, plenty of FREE tables, 50 miles East of Chicago. Talk-in on 01-61 and 94. Donation $2.00 at the gate. Information from LPARC, P. O. Box 30, LaPorte, IN. 46350.

THE CHERRYLAND AMATEUR RADIO CLUB will hold its 4th Annual Swap 'n Shop, Saturday, February 12, from 9 a.m. to 4 p.m. at the Northwestern Michigan College in Traverse City. A donation of $1 includes a chance on all prizes. Plenty of free display tables for whatever you may wish to bring in electronic equipment and parts. Everyone is welcome and a turnout of over 300 Hams and experimenters is expected. For more information contact Bill Mader, WA8WWM, at (616) 326-6392 or Box 2, Empire AFS, Mich. 49630.

MANSFIELD MID-WINTER HAMFEST AUCTION, February 6, 1977, Richard County Fairgrounds, Mansfield, Ohio. Prizes, flea market, auction. Doors open 8 a.m., talk-in 146.34/94, S2/52. Tickets $1.50 in advance, $2.00 at the door. Contact Harry Frietchen, K8JPF, 120 Homewood, Mansfield, Ohio 44906. 419-529-2801 or 419-524-1441.

W6LS 12th Los Angeles Amateur Radio Convention. Saturday and Sunday, May 21 & 22. 2814 Empire Avenue, Burbank, CA 91605.

NEW HAMPSHIRE QSO PARTY, sponsored by the Concord Brasspounders, Inc., W1OC, to promote Worked New Hampshire Award. 2000Z Feb. 12 to 0500Z Feb. 13, and 1400Z Feb. 13 to 0200Z Feb. 14. Stations may be worked once per band mode. N. H. stations may work each other. N. H. stations send RS(T) and county. Out-of-state stations send RS(T), ARRL section or country. N. H. stations score 1 point per QSO, times the no. of ARRL sections plus countries plus N. H. counties. Others score 5 points per N. H. QSO, times the no. of N. H. counties. Suggested frequencies are: CW — 1810, 3555, 7055, 14055, 21055, 28130; Phone — 1820, 3935, 3975, 7235, 14280, 21380, 28575; Novice — 3730, 7130, 21130, 28130; VHF — 50.155, 145.015, FM Simplex (No Repeaters). Awards: Topscorer in each N. H. county, and top scorer in each state, province, and country (50 points minimum). Certificate available for confirmation of all 10 N. H. counties. Send logs, summary and check sheets to: Concord Brasspounders, Inc., C. Halloway, 9 Via Tranquilla, Concord, N. H. 03301 by March 14, 1977. Include business-size SASE for results and/or award.

THE 5TH ANNUAL MIDWINTER SWAPFEST of the West Allis Radio Amateur Club will be Saturday, January 22, 1977 starting at 8 a.m. at the Waukesha County Expo Center. Tickets: $1.50 advanced, $2.00 at door. Reserved tables by advanced reservation only $1.50 per 4 ft. table. Non-reserved tables first come, first served. Talk-in on 146.52 MHz. Directions: I-94 to Waukesha Co. F, south to FT, west to Expo. For information and tickets write: WARAC, P. O. Box 1072, Milwaukee, WI 53201.

IOWA: Davenport Radio Amateur Club Hamfest is Sunday, Feb. 27, 1977 at the Masonic Temple in Davenport, Ia. Admission is $1.50 advance, $2.00 at door. Talk in on 28/88 and 52. Refreshments and tables available. For tickets send S.A.S.E. to Dick Lane, WAØGXC, 116 Park Ave., So. Eldridge, Ia. 52748.

Stolen Equipment

ICOM 22S, SN 0017: Has total of nineteen channels programmed in first 20 positions, no channel 19. All above 15 are 147 meg. Stolen from: Ken Keyte, WØTGL, 303-598-7097, 3812 Windsor Ave., Colo. Springs, Colo. 80907.

STOLEN from locked car in Chicago, IL October 19, 1976, one Motorola Metrum II 25W, Ser. #C 064, one Motorola HT 220 series H23 FFN, serial #TP1174C. Please contact Robert L. Scott, WB9BVT, 200 W. Chicago Ave., Oak Park, IL 60302.

STOLEN from Ross Distributing Co., 26 So. State, Preston, Idaho 83263 on 10-18-76 in unopened carton, one Kenwood TS-700A, Serial #414264.

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WIRE, ETC. Premax heavy-duty 4 ft ground rod + clamp **$4.00** Consolidated antenna wire: #14 stranded **$5.00/100 ft.** #12 stranded **$8.00/100 ft.** #22 GA phosbronze longwire antenna wire **$2.50/1000 ft.**

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CALL US TS520, TS700A, Atlas 210X, ETO. All in sealed cartons.

EXTRAS 5 ea, 1/4" shaft knobs for panel. Very nice **$1.00/5.** Rubber feet **30¢/5.** Buss AGC3 fuse **5¢.** CDE .001/10KV doorknob cap **$1.95.** Mallory 2.5A/1000PIV epoxy diode **19¢ ea.**

COAX Belden coax: RG8U 8237 **19¢ ft.** 8214 RG8 foam **23¢ ft.** 9888 double shield 8214 foam (suitable for direct burying) **35¢ ft.** 8214 white jacket **29¢ ft.** 8210 72 ohm kw twinlead **$19.00/C.** Amphenol PL259 **59¢.** UG175 **19¢.**

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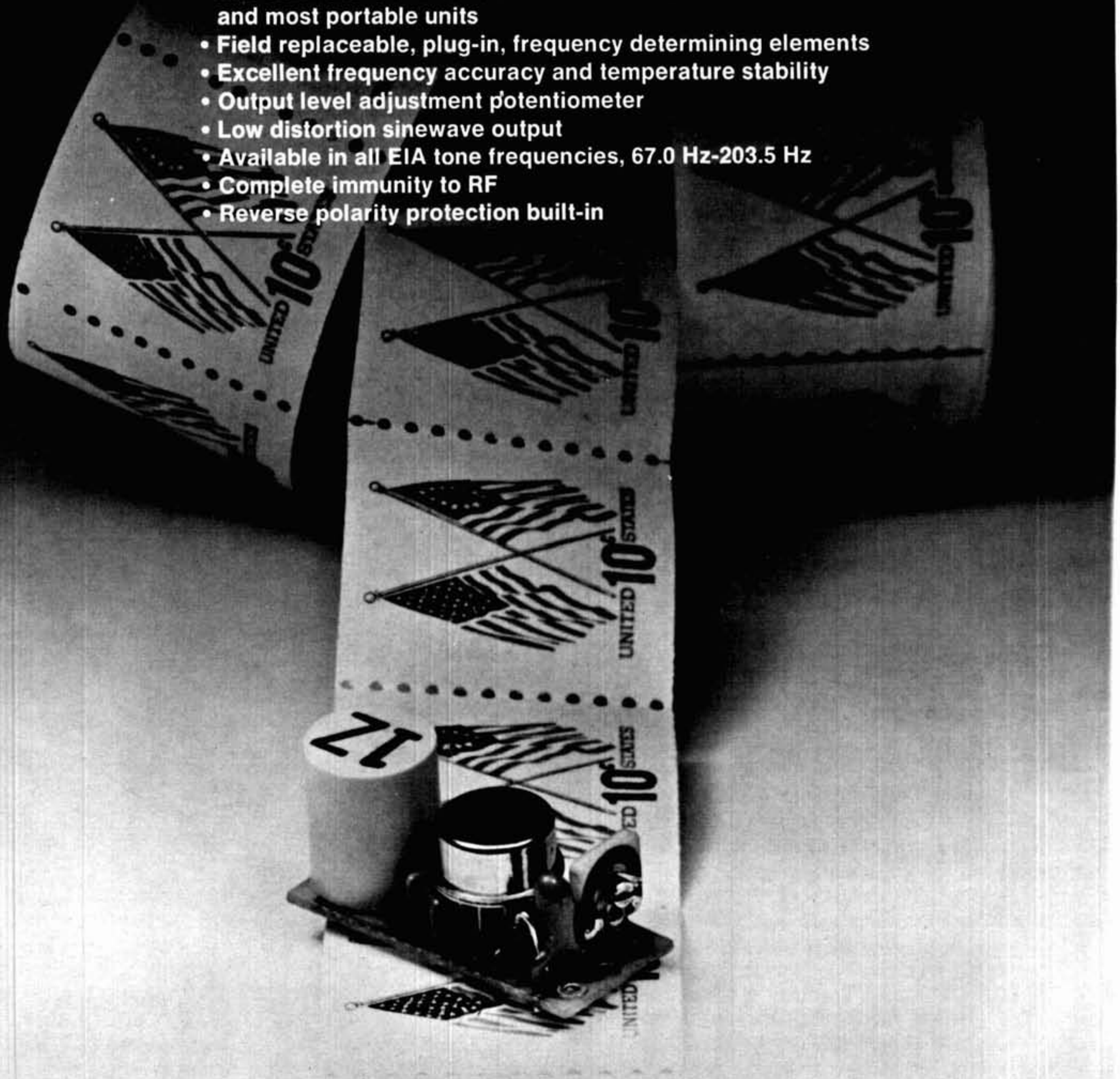

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SHERATON TWIN TOWERS, HOTEL, 5780 MAJOR BLVD. ORLANDO FLORIDA 32805. Rooms single $28, double $36 per day.

*SWAPFEST TABLES WILL BE AVAILABLE FRIDAY FEB. 11 AT 6PM
SWAP AREA WILL BE OPEN FRIDAY NIGHT. No additional charge for Friday night required.

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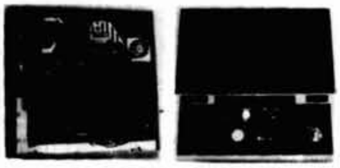
More Details? CHECK–OFF Page 126

SPECIAL OF THE MONTH



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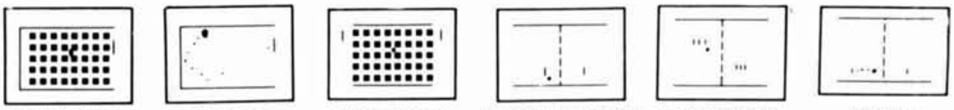

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WIPE OUT the squares — 7 serves from center — 40 squares — 10 pts each square hit by ball. On each serve square disappears when hit by ball. For 1 or 2 players.

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GRAVITY MATCH — You never know how high it will bounce when returning this one.

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Requires 5V + DC 2 Amp

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Controls, switches, speaker, 22 pin edge connector

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To convert video signal to TV signal. Eliminates internal T.V. wire-in

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7402	.20	7443	1.20	74100	1.25	74162	1.35
7403	.20	7445	.89	74107	.26	74163	.76
7404	.20	7446	.87	74109	.35	74164	.80
7405	.20	7447	.69	74110	.50	74165	.90
7406	.39	7448	.81	74116	2.00	74166	1.00
7407	.39	7450	.20	74120	1.25	74167	3.00
7408	.20	7451	.20	74121	.34	74170	2.00
7409	.24	7453	.20	74122	.39	74172	9.72
7410	.20	7454	.20	74123	.50	74173	1.25
7411	.20	7460	.20	74125	.45	74174	.85
7412	.24	7470	.20	74126	.45	74175	.75
7413	.35	7472	.23	74128	.65	74176	.85
7414	.70	7473	.26	74132	.95	74177	.85
7416	.33	7474	.29	74136	.50	74180	.75
7417	.33	7475	.39	74141	.80	74181	2.00
7420	.20	7476	.31	74142	4.00	74182	.90
7422	.50	7479	2.40	74143	4.00	74184	1.65
7423	.28	7480	.69	74144	4.00	74185	1.30
7425	.24	7482	.72	74145	.70	74190	1.00
7426	.24	7483	.75	74147	2.50	74191	.65
7427	.24	7485	.90	74148	1.75	74192	.85
7428	.40	7486	.25	74150	1.00	74193	.85
7429	.40	7488	3.50	74151	.70	74194	1.20
7430	.20	7489	1.50	74153	.70	74195	.55
7432	.28	7490	.39	74154	.90	74196	.80
7433	.34	7491	.65	74155	.70	74197	.83
7437	.28	7492	.39	74156	.90	74198	1.50
7438	.28	7493	.39	74157	.70	74199	1.75
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7440	.20	7495	.50	74159	2.25	74279	1.75

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2501B	256x1	1.75
3107	256x1	4.00
7489	64 Bit R/W	2.00
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2102	AMD9102, ISL7552-1, TMS4033
MM5058	AMD2533, FSC3355, TMS3133
TMS3002	SIG2509
TMS3132	MM4060, FSC3346

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VHF CONVERTERS UHF

	MMc50	MMc144	MMc220	MMc432	MMc1296
RF Freq. (MHz) †	50-54	144-148	220-224	432-436	1296-1300
IF Freq. †	28-32	28-32	28-32	28-32	28-32
N.F. (typical)	2.5dB	2.8dB	3.4dB	3.8dB	9.0dB
Nom. Gain	30dB	30dB	26dB	28dB	20dB
	$44.95	$49.95	$54.95	$59.95	$69.95

†Other ranges, amateur, commercial & scientific to order. Power 12V DC Low N.F. units on special order. Size 1¼" x 2½" x 4½" plus connectors. L.O. output option — $5.00 extra. Shipping: Converters $2.50 each.

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Model 8XY/2M $39.95

Gain 9.5dB in each plane, 50Ω feed.
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48 element J-Beam MULTIBEAM
Gain +15.7 dBd. Feed 50Ω coaxial.
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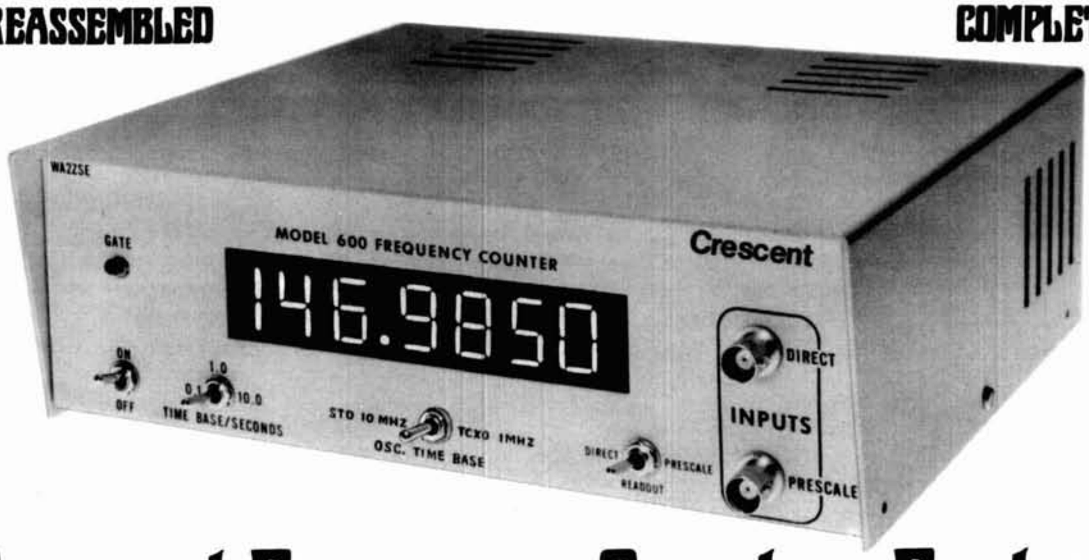
More Details? CHECK—OFF Page 126

PREASSEMBLED **COMPLETE KIT**



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1 High Sensitivity VHF pre-scaler (built-in). 100mv RMS @ 50Ω @ 300MHZ. Frequency range DC through 600MHZ Model 600, DC through 300MHZ Model 300.

2 Excellent temperature compensation crystal controlled time base, yielding ± 1 part/ 10^6 stability per hour after 10 min warm-up, $\pm$ 10PPM worst case, from 0^o to $+ 55^oC$!, at 100Hz @ 450MHZ is attainable, typically if calibrated to WWVL. This is approximately 2 parts in 10^7!

3 7 digit display, resolution 100Hz with 10m Sec. gate interval, pre-scaled! 10Hz resolution with 1 Sec. pre-scaled, 1Hz resolution with 10 Sec. gate interval pre-scaled!

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7 90-Day full coverage warranty.

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More Details? CHECK—OFF Page 126

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• Later, snap-off the BA-1 and snap-on the BP-1 NICAD Battery Pack for *all day* operation as a **High Power 5 Wt. Portable!** (**Not** the usual 1 or 2 wts.) Actually *lighter* than most 1-2 wt. portables, even though our battery has **3X the capacity** of any competitor! BP-1 Pkg.: $89.95.

SC512A-12 CHAN.. . . . . $249.95
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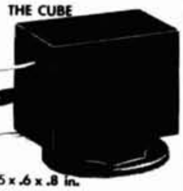

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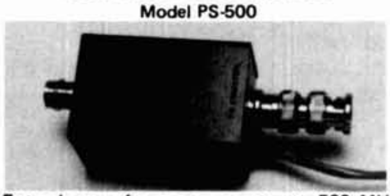

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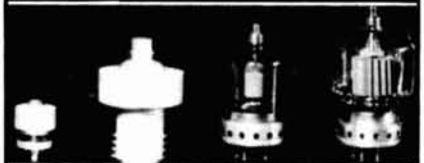

4CX150	4CX1000	4-65	4-250
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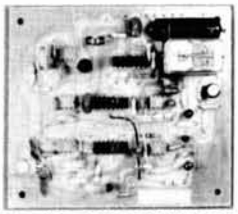
We have changed our company name to TEC-KAN, Inc. and at this time we are offering a special Fall Sale Price on the Brimstone 144. Check with your dealer on the Fall Special and ask for the 6 page full color brochure.



REPEATER AND AUTOPATCH CONTROL MODULE RPT CM-4

If you are planning a repeater and need a control circuit, we have just what you need! Complete control of repeater as well as the autopatch. Local or remote control. If you are using telephone line control for your repeater the RPT CM is ideal because it uses an opti-coupler for complete line isolation and low voltage, low current control.

If you are using the TKI SCAP-3D, you can call your autopatch line number and the RPT CM will automatically answer and connect you allowing you to send tones over the phone to turn the repeater on or off, or access the autopatch and communicate through the repeater over the autopatch phone line.

When calling the repeater on the autopatch line, you have 20 seconds to either access the autopatch or turn the repeater off or on. If the proper codes are not sent within 20 seconds the RPT CM automatically disconnects.

If you call the autopatch number, hang up, wait 30 seconds and call the number again, the repeater transmitter will be keyed and a tone sent each time the phone rings, thus signaling a mobile operator to access the autopatch. If there is no one available to access the patch, it will automatically disconnect after 30 seconds of ringing.

It also features a COR "Hold" circuit, which is adjustable from 1 to 5 seconds, and automatic "time out" timer, that resets each time the receiver COR drops. No need to wait for the repeater to drop out to reset the timer.

If you are planning a repeater, all you need is a good transmitter and receiver and the TKI RPT CM Control Module.

Price $79.95

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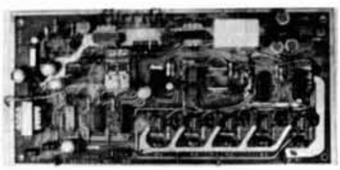
Six Channel Cmos Scanner Kit has provisions to include Mostek Touch-Tone Encoder Chip. Features dwell and normal operation. "Dwell" mode monitors each channel that has a signal on it for 8 seconds. "Normal" monitors in conventional manner. Manual operation locks out the scanner.

Includes LED channel indicators, schematic and installation instructions. Designed for Wilson 1402SM Talkie.

Scanner Kit Model SK1402	$49.95
Includes Touch-Tone Encoder Chip Model SK1402TE	$58.95
Digi-Tran Pad, when ordered with Scanner Kit	$7.50



Size 9 $^{5}/_{16}$ x 4 $^{5}/_{16}$

AUTOPATCH SCAP-3D FEATURES

- 3 Digit access, single digit disconnect.
- 4 sec. time limit on access.
- Anti-falsing tone decoders.
- AGC with 30 Db dynamic range on all inputs and outputs.
- 3 digit on-off control of repeater or other devices.
- Remote inhibit or disconnect of autopatch as well as remote "off" function.
- Monitor amplifier allows monitoring all signals going into and out of the repeater.
- Adjustable level controls on all inputs and outputs.
- Jumpers on circuit board and frequency control pots on tone decoders allow field programming of access codes.
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- Easily connected and adjusted.

Price $199.95

More Details? CHECK—OFF Page 126

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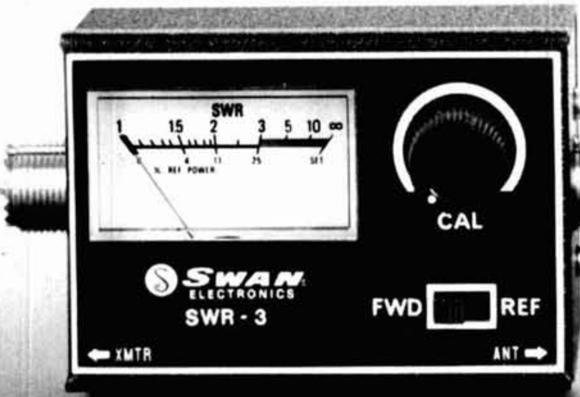

SWR-3 SWR Meter. Why bother with big, bulky meters when this one does the job just as well? Measures 1:1 to 3:1 SWR from 1.7 MHz to 55 MHz with all the accuracy you need. $10.95

(Prices FOB Oceanside, CA)

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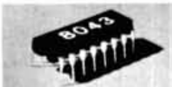

8043; IC only, 50-up group rate	$ 7.95
8043-1; IC, PCB, Manual	$ 24.95
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(See Feb 75 CQ, Apr 75 HR, Feb 76 QST, Radio Handbook 75)

KB4200 Keyboard Keyer (Oct 74 QST)	$549.95
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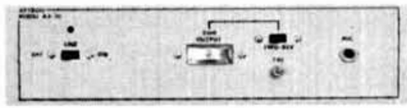

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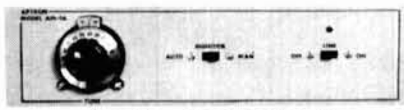

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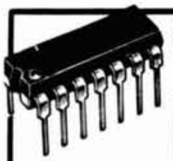

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The MA1002A and MA1010A have a 12 hour display with an AM and PM indicator. The MA1002C and MA1010C have a 24 hour display.

Features include alarm "on" and "PM" indicators, "sleep" and "snooze" timers and variable brightness control capability. The modules are extremely compact, the MA1002 measuring 1.375" by 3.05", the MA1010 measuring 1.75" by 3.75". This small size is achieved by bonding the I.C. to the back of the circuit board.

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2.2/50V	.08	.65/10	100/10V	.10	.77/10	470/16V	.23	1.81/10
3.3/50V	.08	.65/10	100/16V	.11	.85/10	470/25V	.29	2.35/10
4.7/35V	.08	.65/10	100/25V	.13	1.10/10	1000/10V	.24	1.96/10
4.7/50V	.08	.68/10	100/50V	.21	1.71/10	1000/16V	.29	2.35/10
10/16V	.08	.65/10	220/10V	.13	1.08/10	1000/25V	.42	3.33/10
10/25V	.08	.65/10	220/16V	.15	1.16/10	2200/10V	.42	3.33/10
10/50V	.10	.75/10	220/25V	.21	1.71/10	2200/16V	.54	4.30/10
22/16V	.08	.67/10	220/50V	.29	2.35/10	2200/25V	.58	4.67/10
22/25V	.09	.70/10	330/10V	.15	1.16/10	3300/16V	.89	7.14/10
			330/16V	.21	1.66/10			

AXIAL ELECTROLYTICS

.47/10V	.11	.90/10	33/25V	.14	1.15/10	330/16V	.29	2.35/10
1/30V	.11	.90/10	33/50V	.19	1.52/10	330/25V	.32	2.54/10
3.3/35V	.12	.95/10	47/16V	.14	1.15/10	470/16V	.32	2.55/10
3.3/50V	.12	1.00/10	47/25V	.17	1.30/10	470/25V	.37	3.00/10
4.7/25V	.11	.90/10	47/50V	.21	1.17/10	1000/10V	.33	2.65/10
4.7/35V	.12	.95/10	100/10V	.14	1.13/10	1000/16V	.39	3.15/10
4.7/50V	.12	1.00/10	100/16V	.17	1.30/10	1000/25V	.56	4.50/10
10/25V	.12	1.00/10	100/25V	.20	1.55/10	2200/10V	.50	3.96/10
10/50V	.14	1.15/10	100/50V	.29	2.30/10	2200/16V	.62	4.95/10
22/16V	.12	1.00/10	220/10V	.18	1.42/10	2200/25V	.79	6.36/10
22/25V	.13	1.05/10	220/16V	.20	1.55/10	3300/16V	.95	7.63/10
22/50V	.17	1.32/10	220/25V	.29	2.35/10	4700/16V	1.09	8.70/10
33/16V	.12	1.00/10	220/50V	.40	3.23/10	10000/10V	1.15	9.19/10
			330/10V	.14	1.16/10			

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7400	.21	7476	.32	74181	2.15	4012	.23	4520	1.14
7401	.21	7480	.70	74182	.79	4013	.40	4527	1.68
7402	.21	7482	.70	74184	2.19	4014	.96	4528	.88
7403	.21	7483	.70	74185	2.19	4015	.96	4585	1.23
7404	.21	7485	.89	74188	3.50	4016	.40	2102-1	1.99
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7406	.25	7489	2.19	74190	1.23	4018	1.05	CA3046	.75
7407	.25	7490	.44	74191	1.23	4019	.23	LM2111N	1.25
7408	.21	7491	.70	74192	.88	4020	1.14	LM309K	1.80
7409	.21	7492	.44	74193	.88	4021	1.14	LM324A	1.28
7410	.21	7493	.44	74194	.88	4022	.96	LM340T-5	1.25
7411	.21	7494	.70	74195	.88	4023	.23	LM340T-6	1.25
7412	.21	7495	.70	74196	.88	4024	.84	LM340T-8	1.25
7413	.25	7496	.70	74197	.88	4025	.23	LM340T-12	1.25
7414	.89	74100	1.28	74198	1.49	4026	1.68	LM340T-15	1.25
7416	.25	74107	.30	74199	1.49	4027	.40	LM340T-18	1.25
7417	.25	74109	.33	74251	1.09	4028	.89	LM340T-24	1.25
7420	.21	74121	.35	74279	.55	4029	1.14	LM3900N	.88
7421	.25	74122	.44	74365	.67	4030	.23	LM3909N	.69
7423	.35	74123	.61	74366	.67	4033	1.51	MC1456V	1.00
7425	.35	74125	.40	74367	.67	4034	3.50	MC1458V	.53
7426	.25	74126	.40	74368	.67	4035	1.14	MC3302P	1.15
7427	.33	74132	.70	8093	.40	4040	1.14	NE536T	3.24
7428	.28	74141	.88	8094	.40	4041	.79	NE540L	2.04
7430	.21	74145	.70	9095	.67	4042	.79	NE555V	.48
7432	.25	74147	1.63	8096	.67	4043	.70	NE556A	.88
7433	.30	74148	1.30	8097	.67	4044	.70	NE560B	3.83
7437	.25	74150	1.16	8098	.67	4046	1.86	NE561B	3.83
7438	.25	74151	.70	75150	1.16	4049	.40	NE562B	3.83
7440	.21	74153	.65	75450	.88	4050	.40	NE565A	1.25
7442	.53	74154	1.03	75451	.61	4051	1.26	NE566V	1.28
7443	.63	74155	.70	75452	.61	4052	1.26	NE567V	1.36
7445	.70	74156	.70	75453	.61	4053	1.26	uA709CV	.44
7446	.70	74157	.70	75454	.61	4060	1.58	uA710CA	.44
7447	.70	74160	.88	75491	.81	4066	.79	uA711CA	.53
7448	.70	74161	.88	75492	.84	4071	.23	uA723CA	.60
7450	.21	74162	.88	75493	1.09	4072	.23	uA733CA	.75
7451	.21	74163	.88	75494	1.19	4073	.23	uA741CV	.44
7453	.21	74164	.96	82525	2.19	4075	.23	uA747CA	.70
7454	.21	74165	1.15	4000	.23	4081	.23	uA748CV	.49
7459	.21	74166	1.26	4001	.23	4082	.23	uA7805CU	1.25
7460	.21	74170	2.64	4002	.23	4502	.79	uA7806CU	1.25
7470	.30	74173	1.42	4006	1.23	4510	1.14	uA7808CU	1.25
7472	.30	74174	.98	4007	.23	4511	1.05	uA7812CU	1.25
7473	.30	74175	.93	4008	.79	4514	2.80	uA7815CU	1.25
7474	.30	74176	.79	4009	.44	4515	2.80	uA7818CU	1.25
7475	.49	74177	.79	4010	.44	4516	1.23	uA7824CU	1.25
		74180	.70	4011	.23	4518	1.14		

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14 Pin W-W	.26	2.50/10
16 Pin W-W	.30	2.85/10
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6-32 1/2 Screw	.75/C	4.85/M
8-32 3/8 Screw	.90/C	5.85/M
8-32 5/8 Screw	.99/C	7.00/M
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1N5234B	6.2v	.15	$11/C	1N5244B	14v	.15	$11/C
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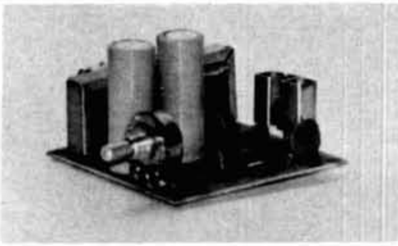
More Details? CHECK—OFF Page 126

ADVA



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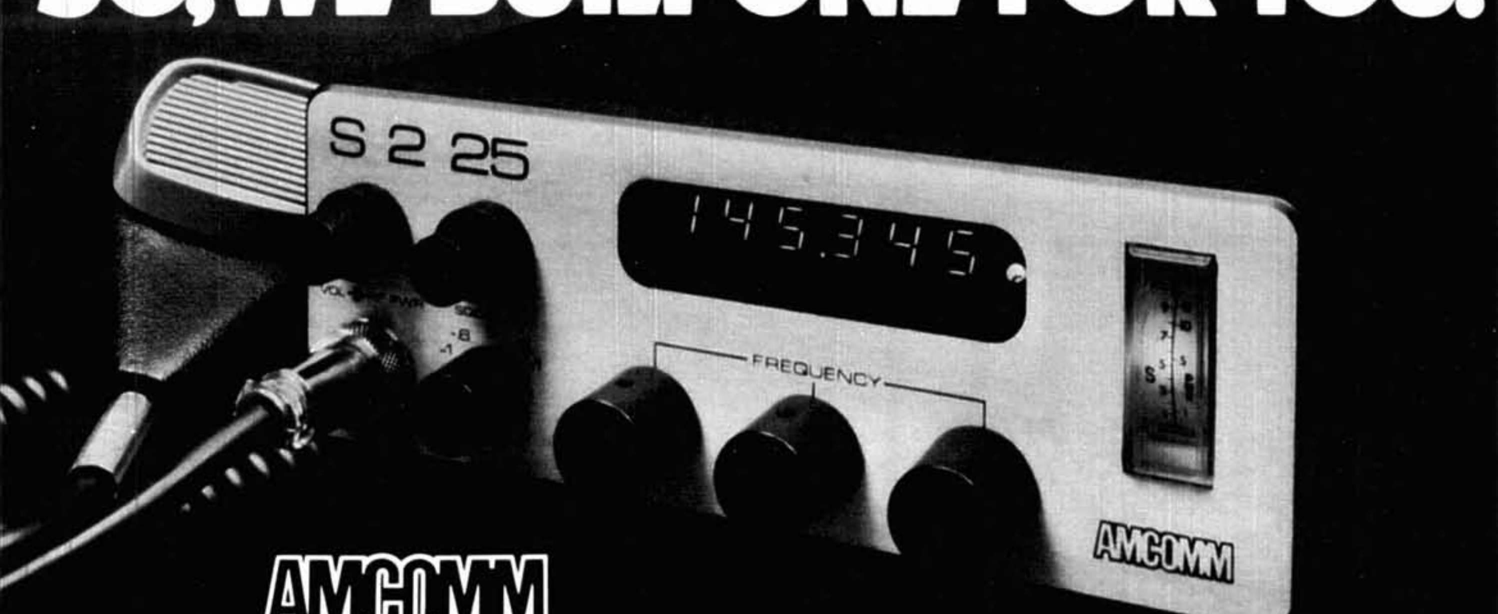

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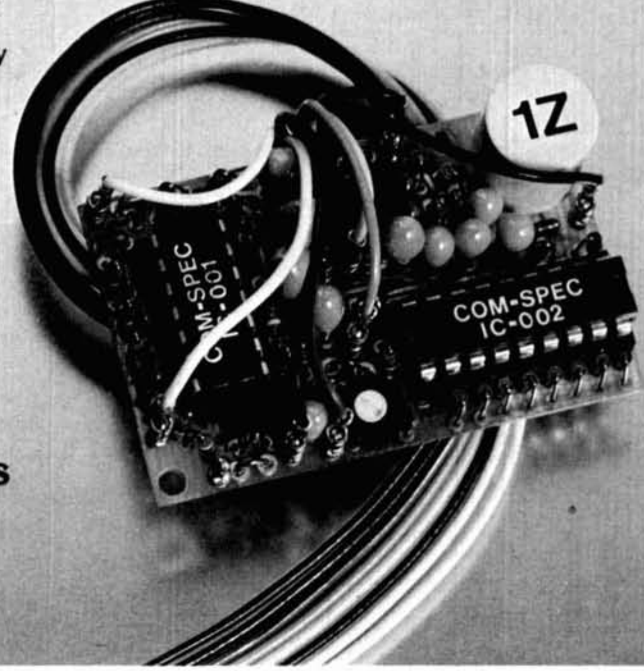

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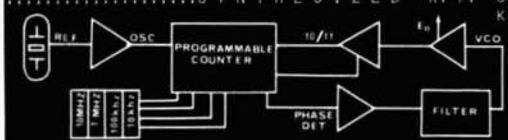

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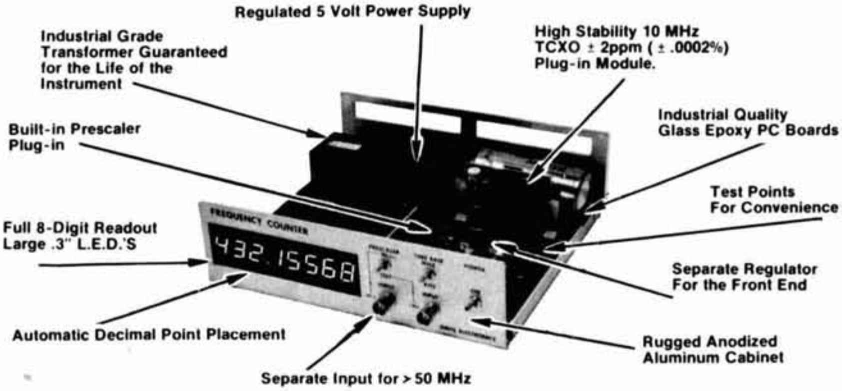

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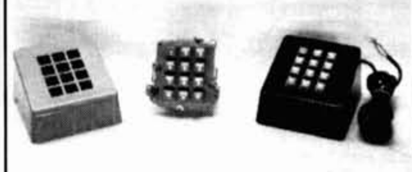

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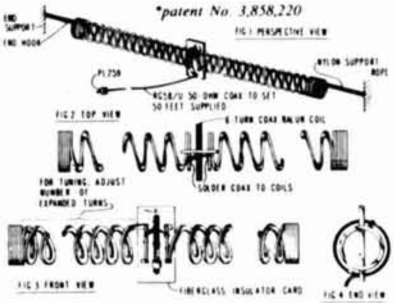

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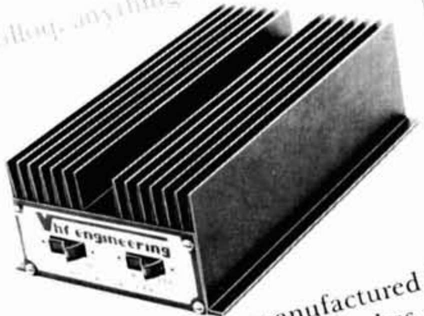

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BLC 30/150	140-170MHz	CW/AM/SSB/FM	30W	150W
BLD 2/60	220-230MHz	FM CW/FM	2W	60W
BLD 10/60	220-230MHz	CW/FM	10W	60W
BLD 10/120	220-230MHz	CW/FM	10W	120W
BLE 10/40	420-450MHz	CW/AM/SSB/FM	10W	40W
BLE 2/40	420-450MHz	CW/AM/SSB/FM	2W	40W
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