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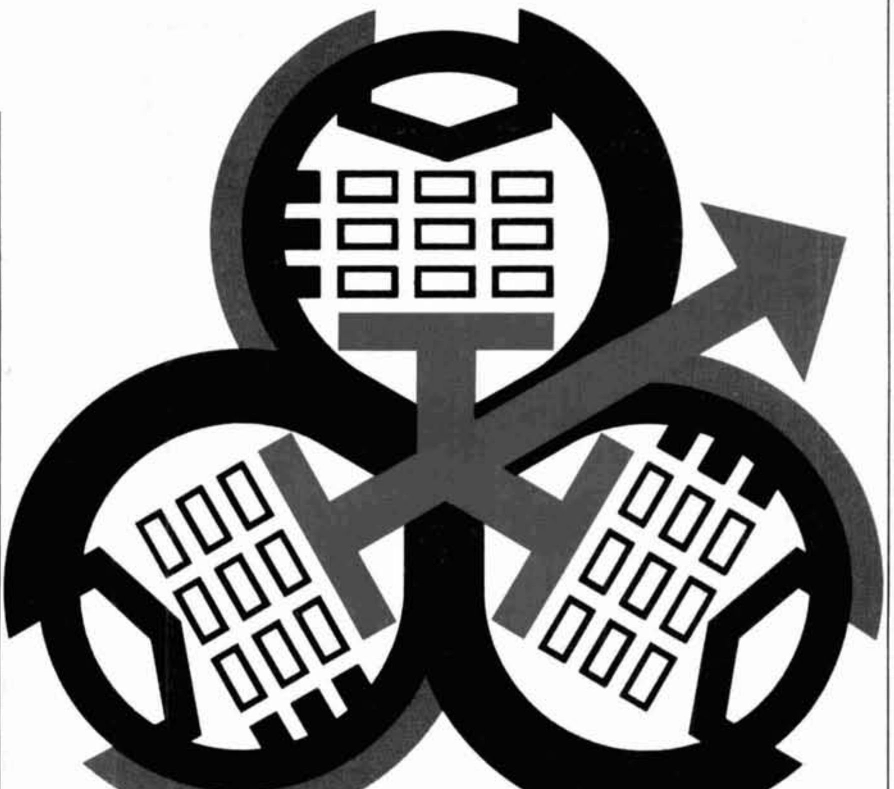

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contents

REFLECTIONS

I must share this with you. I must blurt this out before I bust. We at *ham radio* magazine are so pleased with the turn of events and even more importantly with our glimpse at the future: a larger staff, a very welcome increased advertiser response (it's nice to be adding pages in groups of eight at the last minute), and so very importantly, your response to us. Yes, all the letters will be answered, the many article suggestions considered and encouraged. **Reflections** is our attempt at looking in both directions, remembering the past technical excellence of our hobby, individuals, and industry, while keeping an eye toward the future.

I feel very fortunate to be able to address so large a group of technical and knowledgeable individuals through this page and am taking the opportunity to throw out to the "floor" possibly the first question of our new technical forum section. The problem: *Normal communications channels down.* A fine gentleman, while honorably serving his country, suffered a wound that resulted in Padget's disease. For those not familiar with it, this is a progressively degenerative bone malady. Fortunately, through modern medicine, its destructiveness has been arrested. However one quite intelligent human being with a fine mind is now deaf and almost totally blind. The two normal means of communications that most of us take for granted — seeing and hearing — are "down." But his speech is excellent and his ability and desire to learn new techniques are great. They are surpassed only by his desire to carry on normal communications. I might add that his memory is outstanding. He knows the Morse code (from army days) and he has very slight shadow vision. Are techniques available (such as aural to tactile converters, aural to light converters and so forth) that can be used to provide faster inputting under these circumstances? I am aware of articles on this subject that have appeared in some of the ham magazines. Do any of our readers know of, or have ideas for, other techniques that might help?

Presented below is a preview of some of the subject areas *ham radio* magazine will cover in 1983. Please feel free to respond with your suggestions for additions or changes:

Antennas
Filters
Future technology
Ham computers
Ham towers
Oscillators and synthesizers
Phased verticals
Preamplifiers
Propagation
Receivers
Repeaters
RFI

Two thousand miles of almost non-stop driving during my move from Denver, Colorado, to join *ham radio* in Greenville, New Hampshire, gave me plenty of time to reflect on and appreciate another wonderful aspect of ham radio, the ability to communicate with a cross-section of Amateurs from Salinas and Topeka, Kansas; Kansas City and St. Louis, Missouri; Indianapolis, Indiana; Zanesville, Ohio; Wheeling, West Virginia; Pittsburgh and Scranton, Pennsylvania; through Binghamton, New York — to name a few. The miles melted away with the good company provided by local hams as we discussed everything from lightning protection for highly exposed repeaters to elaborate test procedures for squeezing out that last tenth of a dB in a high-gain Yagi array. There is real joy in hearing a warm voice coming from the 2-meter transceiver telling one very weary driver that there are motels just ahead where a late arrival might find a welcome bed. How I appreciated each transistor, resistor, and capacitor in my mobile unit, the repeaters I worked through, Maxwell's equations, and, most of all, the operators and technicians who made it all possible. To the many Amateurs I talked to during this recent trip, a hearty thank you.

Rich Rosen, K2RR
technical editor

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comments

BCD addition/ subtraction

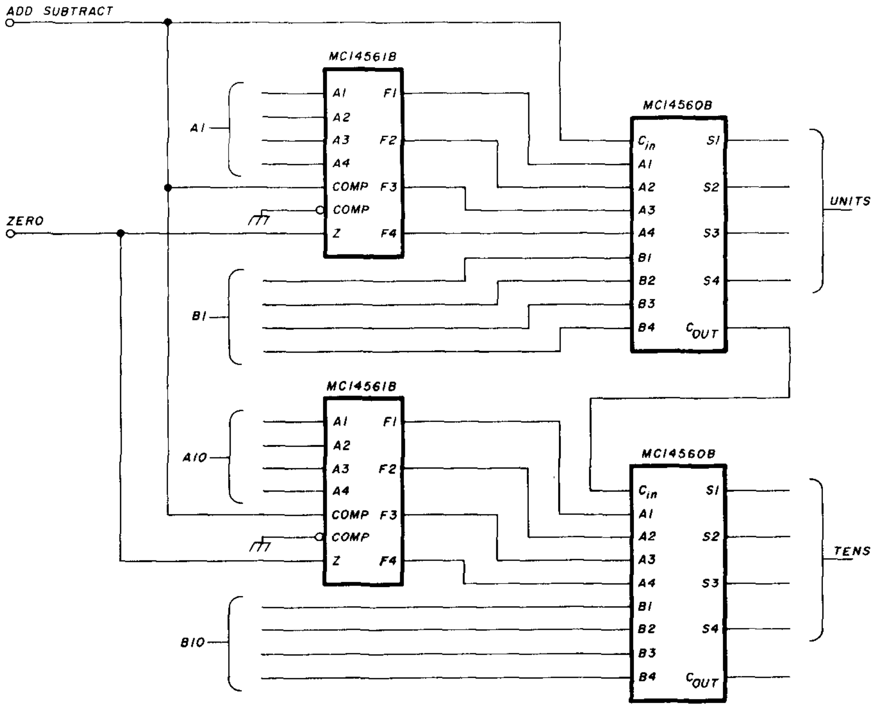
Dear HR:

After reading the April issue of *ham radio*, I would like to comment on the Ham Notebook item by Mr. Foot, WA9HUV. He is not alone in his desire for a method of BCD addition/subtraction. However, Motorola already solved this problem many years ago with the introduction of a chip pair combination, the MC14560B and the MC14561B. The first is an NBCD adder and the second is a 9s complementer.

Connecting the units as shown in the data sheets (and reprinted in **fig. 1**) permits the user to choose a thumbwheel-selected number to program his synthesizer, or shift the number a fixed amount plus or minus. This feature is useful for setting a frequency source at a particular channel and then being able to shift its output to the upper or lower sideband.

The approximate cost per BCD digit is $5.40 in unit quantities. It's a slightly more expensive approach, but one that does not require clocking and can be easily cascaded. For further reading and more application assistance, I would recommend Motorola's application note AN-738, which covers the subject more completely.

Jeffrey L. Schiffer, Pres.
Phasetec Corporation
West Peabody, Massachusetts



TRUTH TABLE

ZERO	ADD/SUBTRACT	RESULT
0	0	B plus A
0	1	B minus A
1	x	B

x = DON'T CARE

fig. 1. Connections for an NBCD adder and 9s complementer allowing a thumbwheel selected number or a number shift of a plus or minus fixed amount.

quad versus Yagi

Dear HR:

Quad lovers awake! We are again being attacked by the Yagis (*ham radio*, May, 1982, "Quad Owner Switches"). It is not immediately apparent that the quad was given a fair shake by the test procedure. For example, a five-element Yagi on a 32-foot boom is matched up against a three-element quad on a 27-foot boom on 20 meters. On 15 meters a five-element Yagi was up against a four-element quad. On 10 meters, where the correlation is best except for the reversal of directivity, the match is five versus five.

The next problem I had was whether there were any matching devices at the antennas. Were baluns used, were their losses equal, was each antenna delivering maximum power to the line?

What bugs me most is that the authors took boom height as a reference height for both the quad and the Yagi. If the quads were fed at the center of the lower element, that point should be taken as the height of the quad. This would put the current loop for each antenna at the same height. It would seem that the procedure used in the tests handed the Yagi a height advantage on the order of 12 feet on 20 meters, 9 feet on 15 meters, and 6 feet on 10 meters. This would be expected to affect the vertical angle of the main lobe of the quad. Some Amateurs have advocated feeding the center of the upper element of the quad to improve the gain. Of course, there is a current loop in each of the horizontal elements if they are fed, but the loop at the feedpont will be greater.

C'mon home, guys. Wouldn't you rather fight than switch?

Howard B. Mouatt, W6BQD
Palm Desert, California

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More Details? CHECK—OFF Page 132

presstop de W9JUV

"CQ 30 METERS" HAS FINALLY BECOME A REALITY for U.S. Amateurs. FCC Commissioners voted October 28 to grant "temporary access" to the new band. Acting on a suggestion made by Senator Barry Goldwater, K7UGA, in an August letter to Chairman Mark Fowler (October Presstop), the Commissioners permitted General class and above to use 250 watts input, narrowband (CW and RTTY) modes only, from 10.1 to 10.15 MHz. The 10.109-10.115 MHz slot, however, was held back to protect existing users. The band was opened at 1900Z on the 28th, with W1AW, K1ZZ, W1XX, and W9JUV among the many taking part in the U.S. 30-meter inaugural.

A Possible Conflict with the new band and also the 18 and 24 MHz bands has surfaced in FCC General Docket 82-625, released mid September. This Notice of Proposed Rule Making would open many segments of the 2-25 MHz HF spectrum, including the three new WARC bands (but no other Amateur frequencies), to various licensees in industrial radio services. Telephone and power companies plus oil, gas, and mineral exploration firms would all be authorized to use these frequencies when it was in the "national interest."

These Proposals Conflict With Other New WARC 79 Assignments as well as with the new Amateur bands, but it's predicted that frequencies conflicting with WARC allocations will be deleted as the NPRM is reviewed. The ARRL did, however, file comments pointing out the conflict prior to the comment closing date of November 5.

A "SPACE DXPEDITION" IS ALMOST CERTAIN FOR NEXT YEAR, when astronaut Owen Garriott, W5LFL, will fly the space shuttle *Columbia*'s ninth mission. After lengthy negotiations, NASA Houston agreed to let him take a specially reworked 2-meter handheld along, to operate when possible with a ground plane in the cargo bay. Only final approval from Washington is still needed for the October, 1983, operation, which would last seven days.

NOVICE EXAMS WOULD BE PREPARED AND GRADED as well as administered by Amateur volunteer examiners under an NPRM put forth by the Commissioners at their October 19 agenda meeting. It's proposed that examiners would make up an exam using the FCC Novice syllabus as a guide, let the applicant answer the questions, and then grade it. If the applicant passes both the written and the CW test, the examiner would note that on the applicant's Form 610, which would then be sent to Gettysburg where a license would be issued.

Some 97% Now Pass The Novice Exam under present procedures, which require the FCC to issue and grade Novice exams, so little compromise of standards is anticipated. In addition, the simpler procedures would drop about eight weeks from Novice licensing. Comment due date for PR Docket 82-727 had not been released at press time.

The ARRL Detailed Proposal for the preparation and administration of exams by Amateurs was delivered to the FCC on October 22. It should be released as an RM shortly.

Amateur Logbook Requirements Would Be Entirely Eliminated by another NPRM agreed to at that same agenda meeting. In this proposal the few remaining operating log requirements, such as noting changes in control operator, would be deleted, though certain station records would still need to be maintained. Comment due date for PR Docket 82-726 had not been released at press time.

SACRAMENTO AMATEURS MUST GET PERMISSION from a local pay TV Company before acquiring microwave equipment, according to a preliminary injunction issued by a superior court judge. He issued the order after hearing a suit from California Satellite Systems, Inc., against a local Amateur dealer who was also selling down-converters and antennas for the 2150 MHz pay TV band. He made the unusual ruling to "protect" the pay TV company, since they do not encode their signals and Amateur 2300-MHz equipment could be used to intercept the movie channel signals.

"AUTOMATIC CONTROL" OF AMATEUR RADIO BEACONS was authorized by the Commissioners on October 21. This means that operators of U.S. Amateur beacons will no longer have to shut down when they are unavailable to perform control operator functions.

CW Credit For Any Class Amateur License was also granted to holders of any class commercial CW ticket at the same meeting.

BURBANK CITY OFFICIALS ARE IN DEFAULT under federal court rules for having failed to respond to the complaint filed against them to test their severe antenna restrictions (see Observation and Opinion, August, 1982, *Ham Radio*, and recent Presstops). The judge hearing the case has set November 4 for a status report by the parties. Attorney W9MU, representing Burbank's Amateurs, intends filing a motion for class certification and preliminary injunction prior to the November 4 court date to keep pressure on Burbank officials.

FCC'S POWER MEASUREMENT NPRM, PR Docket 82-624, proposes changing power limits for all classes except Novices to 1500 watts PEP output. Novices would be limited to a 200-watt PEP output. Due date for comments is February 15, 1983; reply comments are due by March 1.

SONIC CABLE TV WAS FINED $6,000 by the FCC for 2-meter interference following a two-year battle by WB6GVO. One third of the fine was for failing to correct the cable channel E problem after citation by an FCC engineer, while the remaining $4,000 was imposed for the California company's on-going illegal interference to Amateur operations on 2 meters!

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design and construction

Practical design techniques using common power tubes and parts provide 10-40 meter kilowatt amplifier

Constructing a linear amplifier is one way an Amateur can save money. It's not so much that commercial amplifiers are overpriced for the components they contain, but because of OEM pricing, components bought singly may add up to more than the cost of an assembled unit. Home construction allows you to take advantage of a readily available supply of parts (well-stocked junk pile) that can be used or traded for other items.

When constructing your own amplifier, it's usually not possible to exactly duplicate a published design. Modifications are often required to accommodate differences in components. For this reason, a specific design, and more importantly, the steps used to arrive at it, are presented. By providing sufficient data, minor and even major deviations from the specific design can be made while still obtaining good performance.

A review of amplifier design information, such as found in Bill Orr's *Radio Handbook*, in addition to this design data, is helpful prior to starting the project. Other good source material may be found in the *ARRL Handbook* and articles by W6SAI.

tubes

Tubes, and their availability, greatly influence the design approach to be taken. Good sources for low cost tubes are:

1. Surplus, often WW-II
2. Pull-outs from stations on a maintenance schedule
3. TV sweep tubes

A strong recommendation is in order: get the tubes you want to use *before* you start and get at least twice as many as you need, preferably two complete sets of spares. This will save you much trouble later, and possibly much expense (such as buying a low-production tube or making a design change). Test the tubes first, if at all possible, in a friend's rig or by

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table 1. Low-cost tubes for linears.

tube type	E_p, volts	I_p, mA, max.	rated/class C maximum dissipation	notes
6DQ5	800	250	24/100	1
6JE6	800	242	30/100	1
811	1200-1700	160	50/65	2,4
812	1200-1700	160	50/65	2,4
813	2000-2500	250	100/125	2,4
4-125	2000-3000	260	125	3
572B	2750	275	160	3
810	2500	300	125/175	2
4-250	4000	345	250	3
250TH	2000-3000	350	250	3
304TH	2000-3000	900	300	3
4-400	4000	317	400	3

Notes:
1. Average/peak ratio
2. CCS/ICAS ratio
3. Rated dissipation (ratings nomenclature depends on reference used)
4. A number of these tubes are no longer manufactured. Obtain spares prior to starting the design.

using a pair of transformers, one with the proper filament voltage, and a second at 300-700 volts. Test the tube as a diode with a series resistor to give rated current. This test lets you separate out most bad tubes.

Some of the common tubes to look for are listed in **table 1**. Though possibly considered old-fashioned, out of style and even obsolete, they are inexpensive and perfectly usable. If you have a set, with spares, or can find a set, don't be afraid to use them. This includes out-of-date or unusual tubes such as the 810 or the 715. There are some design considerations to look out for, however. These will be covered later.

TV sweep tubes have two ratings, one for average loads and another for peak loads, such as the flyback pulse in a sweep circuit. Average peak and duty cycle terms are important in the operation of any tube, and consequently are important design factors.

In amplifiers used in fm or teleprinter service a constant signal is present at all times, that is, the duty-cycle is 100 percent. With CW, the carrier is keyed on and off with a resulting duty cycle of approximately fifty percent. With SSB voice, the average energy is far below the peak, normally 10-16 dB down. This results in a duty cycle of ten percent or less. Use of clippers and other speech processors can raise SSB signal duty cycles to fifty percent or more. However, thirty to forty percent is probably nearly optimum. Low average power requirements of SSB service is the reason why modern linears can be made so small and why separate ratings are required for SSB and CW operation.

It makes quite a difference in component size if the rig is to be used for SSB only, or if it must also handle FSK teleprinter. This is one of your major design choices. If you are primarily interested in one mode, it's best to design for it and accept the performance you get with other modes.

In my case, eight 4-125s and four 813s were available. A review of some of the local ham stock showed more 813s available. Though nearly equivalent, the greater ruggedness of the 813 plate and the more severe cooling design requirements of the 4-125s tilted the choice toward the 813s.

The next factor considered is the design for input power level. I have never used a linear except on SSB. There didn't seem to be much reason for a linear unless it was well above the output of a normal rig (provided by most modern transceivers). This indicated a 2 kW PEP design. Experience indicates that a moderate amount of speech processing is best, with heavy processing only needed during pile-ups. Consequently, a normal duty-cycle of twenty to thirty percent seemed appropriate, with a capability of increasing to fifty percent. This allows for pile-up processing and CW if ever needed. It's preferable to design for peak outputs of at least twenty percent greater than normally used. A design capable of thirty percent duty-cycle at 2200 watts input, but with normal operation set for about 1800-1900 watts, would satisfy this requirement.

Amplifier efficiency for SSB operation is normally fifty percent at an average input level, versus sixty-five percent for CW. At an average input of 600 watts, approximately 300 watts of dissipation is indicated. This requires three 813s, with some safety factor, or two 813s with some overloading or operation at reduced power levels.

However, average dissipation is not the whole story. Peak operation must also be considered. At 2200 volts a 2200 watt capability means one ampere of plate current. This is twice the rating of a pair of 813s, and thirty-three percent more than three would supply.

One solution is to use four 813s. However, there is another approach. To see this, look at the tube ratings in **table 2**. Note that the major differences between continuous commercial and Amateur service is a lower plate dissipation, plate voltage, and current. The instantaneous plate voltage is allowed to go to 3200 volts and the peak plate current to 300 mA in the CCS a-m service, and even higher, to 4000 volts and 400 mA in the Amateur a-m service. Continuously-applied voltage is allowed to go to 2500 volts in the Amateur af amplifier service. However, in all cases, the plate dissipation must not exceed the CCS and Amateur limits of 100 and 125 watts, respectively.

The point is, we can choose a combination of operating conditions to suit the service we plan, within reasonable limits, as long as we do not exceed the rated plate dissipation. For example, for the 813:

For several continuous hours of teleprinter

$$E_p = 2,000,\ i_p = 180\ mA,\ P_{out} = 275\ watts$$

For typical CW

$$E_p = 2250,\ i_p = 220\ mA,\ P_{out} = 375\ watts$$

For non-processed SSB, at peak input

$$E_p = 2500,\ i_p = 300\ mA,\ P_{out} = 450\ watts$$

For SSB, with compression, at peak input

$$E_p = 2250,\ i_p = 220\ mA,\ P_{out} = 375\ watts$$

We could even raise the plate voltage for SSB to 1.5 times the normal commercial voltage, or approximately 2700-3000 volts. This isn't really good for the 813, since the internal construction leakage path is short. Other tubes, such as the 250TH or even some sweep tubes, have longer leakage paths but they already have maximum specified high voltage ratings. (Higher voltage operation makes it easier to drive the tube to peak output.)

We can now make another selection, the amplifier input, and the number of tubes required. Let's assume that a full "gallon" was the goal. For continuous teleprinter use, three 813s are required. CW could be handled with two 813s, and SSB operation, with or without processing, requires three tubes. (The allowable PEP input decreases from 2 kW with no compression, since the average input must be kept under 1000 watts, as indicated by a meter.)

Other types require an even larger number of tubes. The extreme would be the sweep tubes, where eight or even ten would be required to achieve 2 kW PEP. As we will see, the design for this is special, but by no means impossible.

Incidentally, during the design stage we find there is some difference in circuit parameters for the CW, teleprinter, and SSB conditions. Simple designs represent performance compromises for some services. An alternative is to change the tube voltage-current operating point to suit the circuit, as done in the big Henry amplifiers.

I chose three 813s, with plate voltages between 2250 and 2500. Since SSB was the primary mode of operation, no special provision for CW or teleprinter seemed necessary. However, each designer should decide what modes are important and how much of a performance trade-off he's willing to accept.

power supply, part 1

At this point it's a good idea to consider some of the other large components — those in the power supply. The plate transformer is the key to this, and you may find some trading or surplus purchasing necessary (have you priced new kW supply transformers lately?).

Though large-capacity high voltage electrolytic capacitors aren't as common as they were a few years ago, they are still available. Because of size and weight problems, choke input and half-wave filtering are not attractive. The remaining choices are full wave, bridge and full-wave doubler circuits. For these, and capacity input, the transformer should have an RMS high voltage rating of about the plate voltage times 1.12, 0.56, and 0.3, for the three types respectively. DC voltages of 2200-2500 equate to 2500-2800 volts (CT) for the full wave, 1250-1400 volts for the bridge, and about 675-750 volts for the doubler.

Transformer power ratings are 1 kW continuous for teleprinter and CW, about 2 kW intermittent for heavily-processed SSB, but as low as 300-500 watts for SSB with no processing. This amounts to perhaps 60, 40, and 20 pounds, respectively — quite a difference due to duty cycle.

When you get a transformer with the required voltage and rating, you are ready to proceed with the design. My transformer turned out to be 925 volts each side of center tap, at 500 mA dc, ample for 300 watts continuous or a full gallon at a thirty percent duty

table 2. Typical operating characteristics.

tube type	811	572B	813	4-125
E_{FIL}	6.3	7.5	10	5
I_{FIL}	4	4	5	6.5
E_B	1700	2400	2500	2500
I_p rest	30	20	30	15
$I_p$max	160	250	200	110
I_g max	28	45	50	55
R_K	320	215	270	340
R_L	5200	4500	7000	13500
drive power	15	30	11	16
input power	270	600	500	275
output power	175	350	350	190
average dissipation	65	160	150	85
	for 2 kW PEP input			
no. tubes	4	4	3	4
Z plate	1300	1150	1750	3350
C tank-in (note 1)	300 pF	450 pF	225 pF	128 pF
L tank (note 1)	7.9 μH	5.4 μH	10.1 μH	17 μH
C tank-out (note 1)	1420 pF	1850 pF	1100 pF	50 pF

Notes:
1. Component values are given for 3.5 MHz
2. Design data is for 2 kW PEP grounded-grid linear service. Based on *Radio Handbook* data.

cycle. This was chosen over another rated at 725 volts each side of center-tap at 1.3 amperes, simply because of size and weight.

When selecting a transformer, don't forget to look at combination possibilities. If the transformers are rated for high altitude operation or show an adequate test voltage, it's safe to put two secondaries in series. Two identical secondaries in parallel are also okay. Don't forget the possibility of a low voltage transformer connected to buck or boost line voltage to allow use of the odd-voltage transformers you sometimes find, for example, with 170-volt or 265-volt primaries.

While you are searching for a transformer, look for filter capacitors. You will need a minimum (capacitance) of:

For full-wave or bridge rectifiers:

$$C = \frac{50,000\, I_{max}}{E_p} \text{ microfarads}$$

For a voltage doubler:

$$C = \frac{150,000\, I_{max}}{E_p} \text{ microfarads}$$

For a 2200-volt bridge-rectifier type of supply, capable of one ampere, this amounts to 22 μF, or to 132 μF at 450 volts working with six in series, and 175 μF at 350 volts working with eight in series. These include an allowance for voltage surges. If possible, use even larger capacitors.

the plate circuit

With the basic tube operating conditions established, final design can start. As is common today, a single-ended design with tubes in parallel is assumed, since multi-band operation is much simpler.

The plate circuit looks like a generator, with an impedance of

$$R_p = \frac{E_p}{k \times i_{p\,design}} \text{ ohms}$$

where k equals 1.57 for a linear amplifier and 2 for a Class C amplifier. For an amplifier designed with reserve power capability, for example, one ampere at 2200 volts in linear operation, the plate resistance is 1400 ohms. For Class C operation it would be 1100 ohms. (Alternately, we could change the operating conditions of the tube to give the same impedance, say to 2500 volts at 850 mA.) The other alternative is to operate Class B for CW as well as SSB. This was the approach taken in this design.

A pi-matching circuit is normally used to transform this impedance to 50 ohms, needed for coax feed. The input capacitor reactance is:

$$X_c = \frac{R_p}{Q} \text{ ohms}$$

where a Q of ten is considered optimum. For the 813 design, this amounts to a reactance of 140 ohms, corresponding to an input capacitance of about 35 pF at 30 MHz, and to 340 pF at 3.5 MHz.

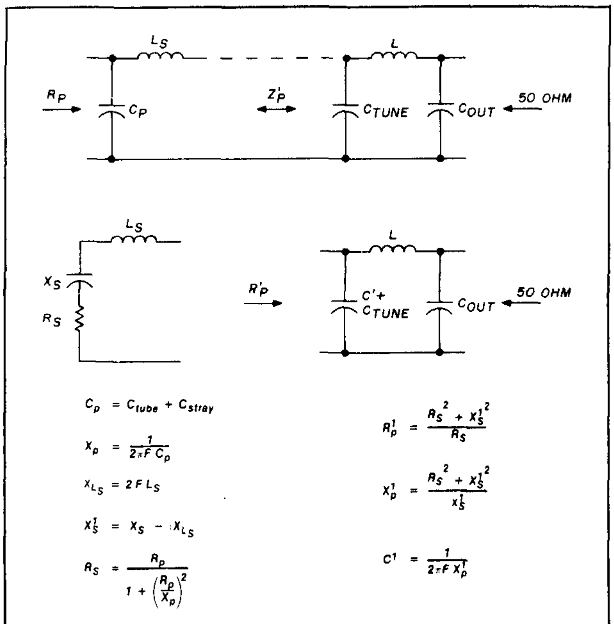


fig. 1. Principle of L-pi-network design for high tube capacity systems. The equations are for parallel-series, series-parallel transformations.

Here we run into a small problem. The plate circuit capacity of a single 813 is 14 pF, so we are faced with a capacity of 42 pF for the tubes alone. Adding 5 pF for strays, and 10 pF for tuning-capacitor minimum gives a pi-input capacity of 57 pF, too much for a *Q* of ten. The problem would be even worse if sweep tubes are used, eight in parallel giving as much as 160-pF plate capacity, with a total circuit capacitance of 180 pF. (Of course, the plate circuit resistance goes down also, to about 320 ohms, so a *Q* of 10 would allow as much as 150 pF.)

One way of solving this problem is to accept a higher *Q* on 10 and perhaps 15 meters. Using the previous values, this equates to a *Q* of 12, normally considered somewhat high, but acceptable.

Another way to handle this is to abandon the pi-network circuit. A push-pull tank could solve the problem. Past editions of the *ARRL Handbook* show a tapped-coil sweep-tube design, fine for a single band, but a nuisance for multiple band operation. Or, we could simply regard the output as a low impedance capacity-shunted source, as is done in transistor designs.

There is another approach which doesn't seem to have been described before. As a matter of fact, it should be considered in any matching design network above 14 MHz. The approach regards the output circuit as two networks in series. One of these is the normal pi-output circuit, and the second is the L network composed of tube and associated stray capacitance, plus the inductance of the lead from the tube or tubes to the pi-network. Its equivalent circuit with the given design parameters is shown in **fig. 1**.

To see the importance of the technique use the given values: 1400 ohm plate impedance and $42 + 5 = 47\,pF$ of tube and stray capacitance. Assume that the lead from the tank circuit to the tubes is only four inches long, with a diameter of one-eighth inch, giving an inductance of about 0.05 μH, and a reactance of about ten ohms at 30 MHz. Performing the parallel-to-series conversion, reducing the capacitive reactance by this amount and converting back again, gives an equivalent driving point impedance of 1170 ohms, and a shunt reactance of 109 ohms, or 50 pF. With a tank circuit *Q* of 10, the value of X_{C1} becomes 117 ohms, or 55 pF. A capacitor of 5 pF minimum capacity can be used and still obtain a pi-section *Q* of 10.

If the allowable capacity is still less than the tube and stray capacitance, the length of the plate lead can be further increased. However, the equivalent drive resistance will also decrease. Several more repetitions may be needed to obtain a workable combination.

Once the values have been obtained for the highest band, repeat the calculation for the next few lower bands. When the equivalent resistance approaches the tube resistance, use this for the lower bands, while maintaining a *Q* of 10. The values of the pi-network elements are then calculated using the formulas in **fig. 2**. Don't forget to use the equivalent impedance for R_1 at the higher bands.

What type of inductance should be used? Roller coils allow one to closely adjust circuit parameters for maximum efficiency, but they are expensive. Tap switching is perfectly acceptable, and there are many old tuner switches available that provide rugged low-resistance design. Looking ahead with eight bands between 3 and 30 MHz, the number of taps may be excessive. You may want to consider having one linear for 1.7-7.5 MHz, and another for 10-30 MHz.

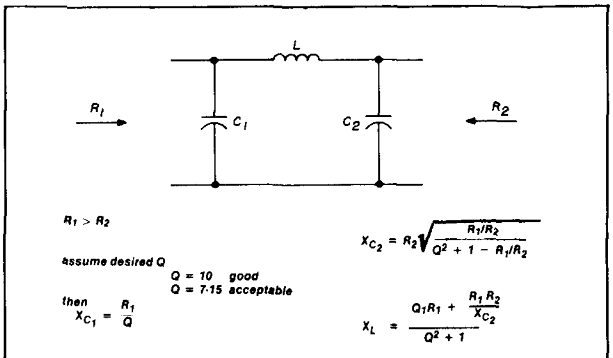


fig. 2. Circuit relations for pi-networks. If Qs below ten are necessary, harmonic rejection is low. High-Q circuits increase operating loss.

This was my choice. It certainly makes design a lot easier.

the input circuit

The driving-point impedance, Z_K, of a grounded-grid amplifier is

$$Z_K \approx \frac{e_{g\,max}}{i_{1\,max} + 1.5\,I_C} \approx 0.6\,i_p$$

where e_g = *rms grid drive voltage*
I_C = *cathode current*
i_{max} = *fundamental current*

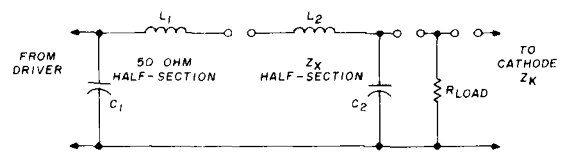
For most combinations of tubes, this will probably be between 50 and 150 ohms.

The input circuit must be reasonably well-matched to the driving amplifier. It must also provide a load to the amplifier when the tube is cut off (Class C), or nearly so (Class B).

While the drive power used in grounded-grid operation is much greater than for grounded-cathode service, provisions must be made to prevent an overdrive condition from occurring. (Modern transceivers have more than sufficient output power). An automatic overdrive protection circuit is one possibility.

The usual way of preventing overdrive is to use a low Q tuned circuit in the cathode, say a Q of 2, plus ALC feedback to set the level. This is perfectly acceptable if the ALC is not forced to work too hard. However, the added coil switching is a nuisance.

An alternate method that doesn't use switching is shown in **fig. 3**. A lowpass filter, used in the drive circuit, provides an impedance transformation from 50 ohms to the tubes' input resistance. The filter output drives the tubes' cathodes and a resistor bank. The latter provides a load to the driver during the entire input cycle, and dissipates part of the driver's excess power.



$m = \frac{Z_X}{50}$

$C_2 = C_1/m$

$L = (1 + m) \cdot 50 \cdot \frac{1}{2\pi \times 10^6} = 0.177(1 + m)\,\mu H$

For 1 ohm, 1 radian

C_1 = 1 farad

$L = L_1 + L_2 = 1 + m$ Henries

$C_2 = 1/m$ farads

For a cutoff of 45 MHz

$C_1 = \frac{1}{50} \times \frac{1}{2\pi \times 45 \times 10^6} = 70\,pF$

fig. 3. Circuit relations for impedance matching low-pass filters. This is used instead of a tuned input in order to simplify the design.

Circuit losses and a varying driver load complicate the calculation of the required resistance. As an approximation for designs where between thirty to fifty percent of the rated driver output is required, a resistance of five times the cathode impedance has worked well. Basically, start with a higher resistance and monitor the drive level. If it is still excessive reduce the loading resistance until the exciter's maximum output just drives the amplifier throughout its linear range.

High power-rating resistors are not needed. For example, if the total drive is 50 watts, the resistors dissipate only 10-12 watts of it (using the above rule of thumb). A bank of six two-watt resistors will do.

Even though 813s have an isolated cathode, a filament choke is a good idea. For a kW amplifier, the choke core can be a 6-8 inch (150-200 mm) long, ½-inch (12.7 mm) diameter ferrite rod. If the amplifier is to cover only the higher bands, 10 through 40, the winding can be trifilar, with two elements the filament conductors, the third a nylon cord, or other non-moisture absorbing spacer with the same wire diameter. For low frequency use, the filament leads can be bifilar wound. Number 12 wire is ample for three 813s, but be sure to estimate the voltage drop and allow for it when selecting a filament transformer. Low filament voltage causes problems with linearity and tube life.

One nice feature of the 813 is that it doesn't require bias in grounded-grid operation. If the operating mode requires bias, it can best be obtained by using a Zener diode. Shunt it with a resistor that will draw approximately ten percent of the expected grid plus plate current. This helps prevent instability. If a power Zener is not available, the circuit of **fig. 4** can be used.

power supply, part 2

Let's return to the power supply, keeping it simple. Our basic requirements are:

1. Apply only filament power for an adequate warm-up period.
2. Initially apply power to the plate circuit at a low level, to hold capacitor charge current down.
3. Apply full power to the plate circuit.
4. Remove plate and filament power simultaneously, or plate before filament.

We also want adequate protection for ourselves and the equipment. We can accomplish these functions manually, semi-automatically, or in a fully automatic mode. However, cost increases as the system becomes more automatic (complex).

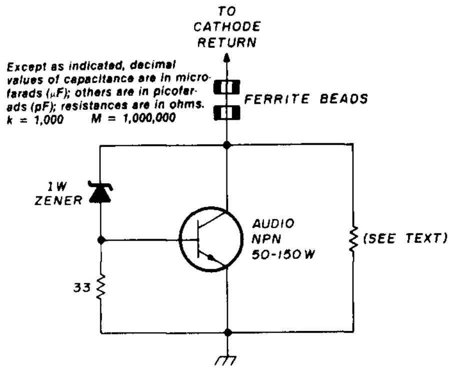


fig. 4. High power Zener diode substitution circuit. The drop across the circuit will be slightly greater than the voltage across the low power Zener.

A simple way of achieving partially protected manual operation is to use a progressively-operated switch for the transformer primary, as shown in **fig. 5A**. The first position turns on the filaments. After a short delay, the switch is placed in the second position, feeding power to the plate transformer through a dropping resistor. After an additional (short) delay full power is achieved by placing the switch in the operate position. This can be further modified by including one more intermediate voltage switch position.

For 120-volt operation, a single section switch can be used, as shown. Old TUs and Navy surplus are a good source of multi-position or rotary type switches. For 220-volt operation, both sides of the line should be switched for safety.

A simple semi-automatic version is shown in **fig. 5B**. Filament power goes on when the master switch is on. This enables a relay circuit, picked up when the transmitter is keyed. It applies power to the plate circuit and a series resistor holds this low until the capacitors charge up. This is controlled by another relay across the transformer primary, which activates when the charging current drops, shorting the series resistor. The first relay can be the antenna changeover relay.

This circuit is easily made automatic by activating the first relay from a time delay device, such as a fluorescent lamp starter. The relay removes power from the delay device when it activates. It should be separate from the antenna relay.

metering, antenna switching and ALC

Though simple metering is desirable, it must be remembered that good metering can help improve performance and extend tube life. Also, the FCC requires input power-level monitoring if it exceeds 900 watts (or 1800 watts PEP).

If automatic drive limiting is used and set at the 1800 watt level, safe, legal operation with simplified metering is possible. **Figs. 6A** and **6B** show two possibilities, the first measuring cathode current only, the second measuring grid and plate current. An external output wattmeter should also be used.

A plate voltage indication is also useful, and can serve as an ON indicator. An inexpensive type uses a neon bulb, connected across the bottom capacitor of the filter bank. The indicator warns of unusual conditions, including shorted or open capacitors, and excessive drain. Note that two resistors are shown across each filter capacitor. One serves as a bleeder and voltage-equalizing resistor and is normally wirewound. The second is a composition resistor, of 1 watt rated dissipation. It is a safety device that ensures filter discharge in case the wirewound resistor opens up. Good design practice is to choose the bleed resistors so that the sum of their drain plus the

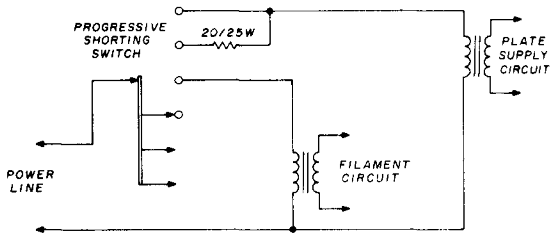


fig. 5A. Manual power-supply switching using a progressive shorting switch. The switch should be left ten to twenty seconds in each position. This provides filament preheat and in-rush surge protection.

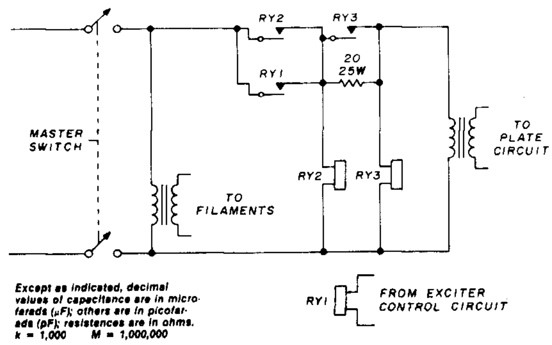


fig. 5B. Semi-automatic power-supply switching. Filament power is applied when the master switch is on. Plate power is brought up in two steps when the transmitter is keyed. This is after a ten to twenty second initial delay.

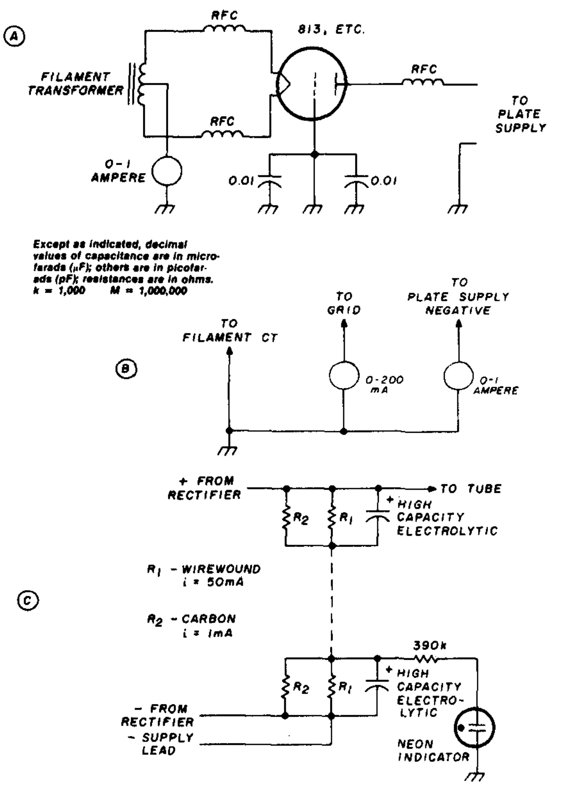


fig. 6. Metering circuits. At (A), a single meter is used to read total cathode current. At (B), two meters read plate and grid currents. At (C), a neon tube indicates plate voltage, and serves as a safety indicator.

idling current of the tubes is about ten percent of the design peak current.

I prefer to use a multiple pole relay in the antenna change-over circuit, wired as shown in **fig. 7A**. This provides protection for a receiver-transmitter combination, or a separate receiver used with a transceiver. (A 6-10 dB pad can be connected in this separate circuit to reduce signal loss in the *main* path due to paralleling mismatch.) Separate contacts on the relay can be used for power control, or for control of external devices.

While the trick of loading the input circuit can eliminate the need for an automatic level control, it's still a good idea to provide this. For one thing, you may want to use a different transmitter than designed for, and the back-up protection is beneficial.

The simplest approach to ALC is to use an rf level measurement technique to develop a threshold voltage. An ALC circuit is shown in **fig. 7B**. Assuming the grid loading has been adjusted, the ALC threshold control is set to give a barely discernible deflection on a VTVM at maximum design output. It can then serve as a backup for improper load.

TVI Prevention

Prevention of TVI is a design goal for any transmitter. Most of the basic steps can be handled fairly late in the design stage, but there are a few that must be initially considered. One of these is the nature and extent of needed output coax filtering. Lower circuit *Q* increases the need for filtering. For example, with a *Q* of 10, a two-section, lowpass filter will probably be sufficient though a three-section filter is better. For higher harmonic rejection, it's a good idea to install a form of suck-out trap. On a low-frequency transmitter, it can be placed across the plate circuit. However, the added capacitance is undesirable on the higher-frequency bands. For these, a trap at the point of attachment of the output coax to the pi-section loading capacitor is indicated. The trap can be a high-pass filter, with a small bank of load resistors to dissipate any harmonic energy present. A design using a 50-ohm load seems to work well. The cutoff frequency should be between the highest operating frequency and the TV i-f frequency of 45 MHz.

The filters will probably not be effective if the self-resonant frequencies of the grid and plate circuits occur at the same frequency and near any of the TV bands. Unfortunately, there is a version of Murphy's

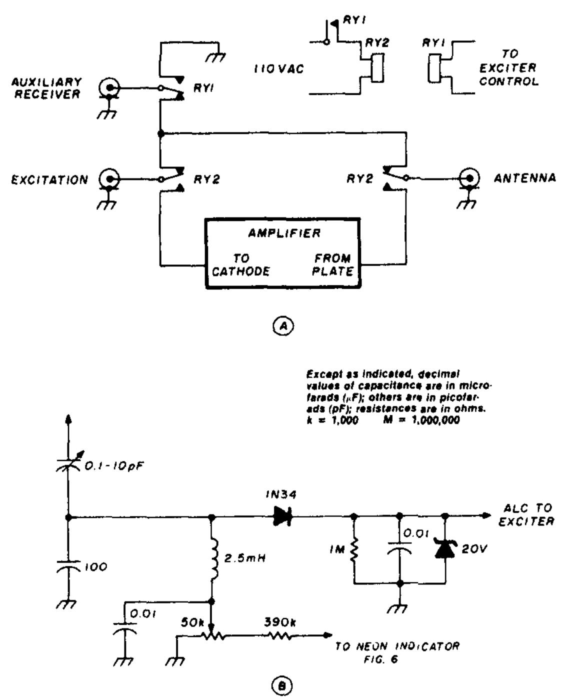


fig. 7. (A). Antenna changeover relays provide a spare contact to feed an auxiliary receiver and ground it during transmit. (B). An ALC circuit provides an adjustable threshold voltage from the plate tank circuit.

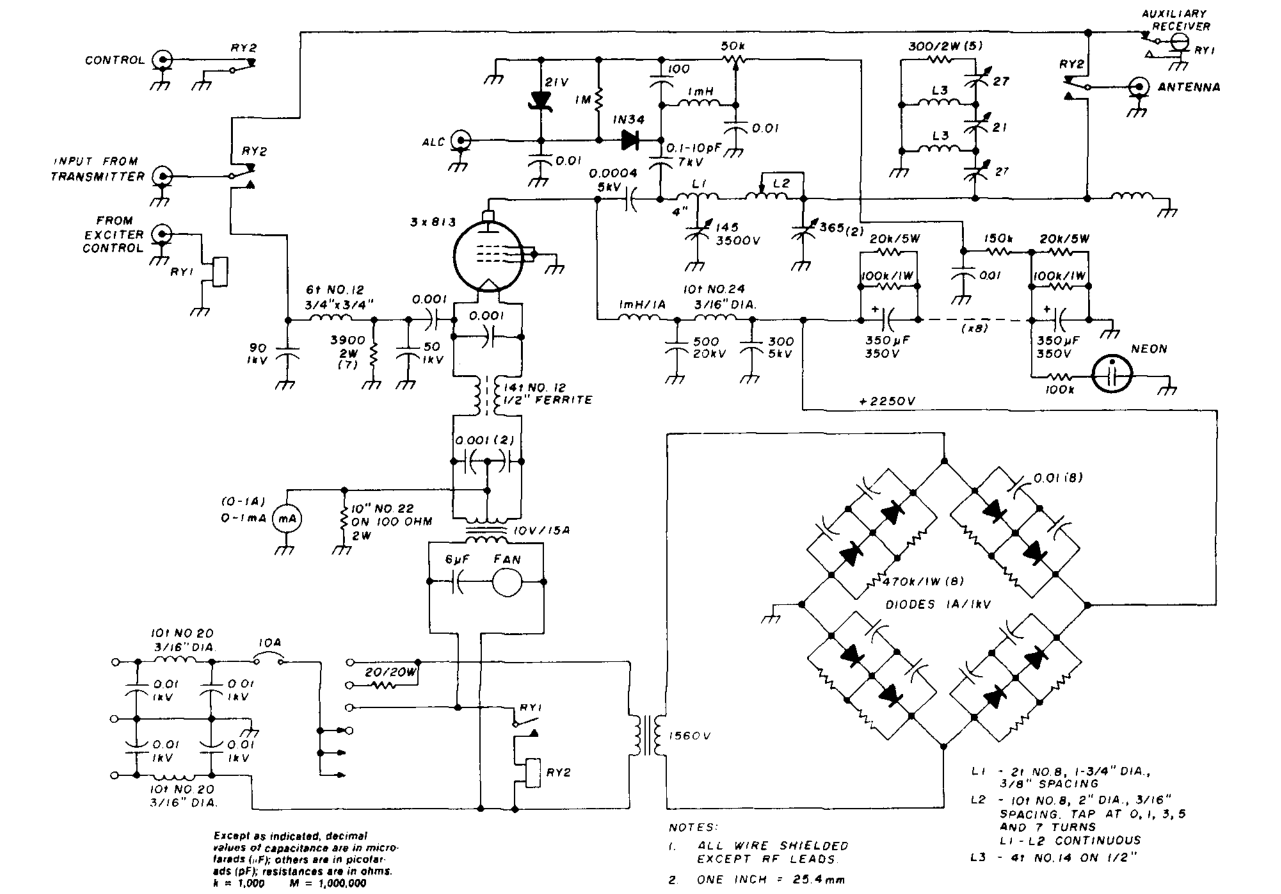


fig. 8. Complete circuit of a full-gallon linear using three 813 tubes. Note the harmonic trap at the output. A series filter is also externally used.

law which applies here. Try to design the circuit components and layout to give high self-resonant and well-separated frequencies. The filter-drive grid circuit helps, but the plate load modification using series inductance can be a handicap, forcing a high *Q* tank for TVI prevention. Measure the resonant frequencies as the construction progresses, and modify the design if necessary.

In addition, all the standard TVI prevention practices should be followed. Each lead should have an LC filter where it enters the shield enclosure. Internally, use shielded (high capacity) leads. Dial shaft holes should be small, and a metal shaft should have a ground spring contact on the inside of the cabinet. It should have this for safety anyway if high voltage is near it. Meters should be metal-cased, with filters at the terminals, or have a piece of screen wire across the face, with the entire meter case inside the formed shield.

Internally, watch the ground current paths. Keep joints out of the path, and don't forget to provide a path for the rf flowing through the tuning capacitor to get back to the tube cathode. If the tube is to be recessed below a chassis, make the mounting holes sufficiently large.

Parasitics, another cause of TVI, are reduced or eliminated by placing suppressors in the plate circuit. Neutralization may be called for in grounded-grid design, and certainly in grounded-cathode circuits. The use of loading to absorb excess driving power greatly reduces the problem, however, and may be a sufficient measure in itself. It might eliminate the need for neutralization. This is easily added by a small tertiary winding on the filament choke, grounded at one end and coupled to the plate from the other end through a variable neutralizing capacitor.

mechanical construction

Kilowatt amplifiers, especially single package types, are large. Don't try to shoehorn everything in. Try to leave at least two-inch clearance for all rf components. The power supply isn't critical, but *don't* *forget cooling*. This is vital for the tubes. Cool tubes are less likely to fail prematurely.

Symmetry in the tube area of a multiple tube design is recommended. Keep lead lengths the same. These techniques help equalize the load distribution. Elsewhere, symmetry is not necessary. Don't force the layout to give a symmetrical front panel.

For homebrew construction, a dual-chassis layout seems to work well. A horizontal section contains the tubes and rf components, and a vertical section the power supply. Input and control elements are under the horizontal section. Front and rear panels, plus a U-shaped top and end and a flat bottom part, complete the mechanical elements. Use angles along the top and sides of the panels.

Perforated aluminum is fine for the top, ends, and bottom of this design, but a lot of screws will be necessary to make the joints rf-tight. A better way of fastening is to use 1/8-inch aluminum strap along all edges, clamping the thin perforated metal between this and angle sections, with screws every six inches or so. Front panel appearance is improved if the strap projects a 1/4-inch (6.4 mm) over the shield edge.

A compact linear layout is possible if the power supply is built separately. The two-chassis design works well with the tubes mounted horizontally. Four 811s or even 872s can be placed in a cabinet measuring 5-1/2 × 10 × 12 inches (140 × 254 × 305 mm). Rf components will be a little crowded, though, and a good cooling fan is a must.

Home-built designs don't need to be sloppy in appearance. Be careful to avoid dents and scratches, and paint the completed unit, either to match other gear or to contrast with it. (Don't paint mating-shield surfaces.) Use appropriate size stick-on or transfer lettering to label controls and the unit itself.

A special note: use honest-to-goodness dials, with engraved marks or a digital readout that can be preset to one degree or better. Keep a log of readings for each band. If manufacturers were more careful with their dial designs, we would have far less tune-up QRM on the bands.

putting it all together

Fig. 8 is the schematic of the linear used at W4MB for several years. These basic design goals were considered:

1. Legal limit with good linearity
2. Drive from two 6146s
3. 10-40 meter operation, with new band operation considered
4. Separate antenna tuning
5. Separate lowpass filter

fig. 9. General view of the amplifier of fig. 8. Note the TU-type bar knobs, and the vernier dials with calibrated scales for tune and load (makes band changing easier). Note the screen-wire shield over the meter.

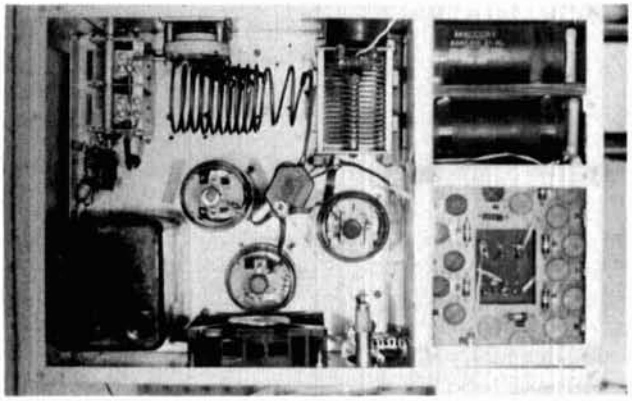


fig. 10. Top view of the amplifier. The rf section is at the top, the plate supply on right, and the filament transformer at the lower left. The harmonic trap is just above the filament transformer. The tank coil is constructed from a continuous length of heavy wire. The ALC circuit is at the bottom center.

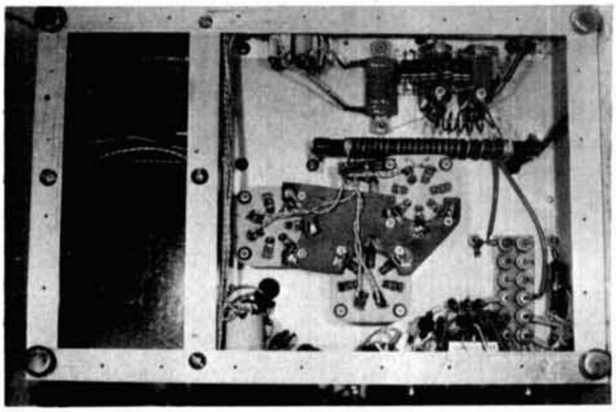


fig. 11. Bottom view of the amplifier. The copper plate in the center grounds all grids to chassis using metal standoffs. The grid filter and loading resistors are at the upper right. The coil is adjusted by spreading or squeezing turns to set the cut-off frequency above the 10-meter band.

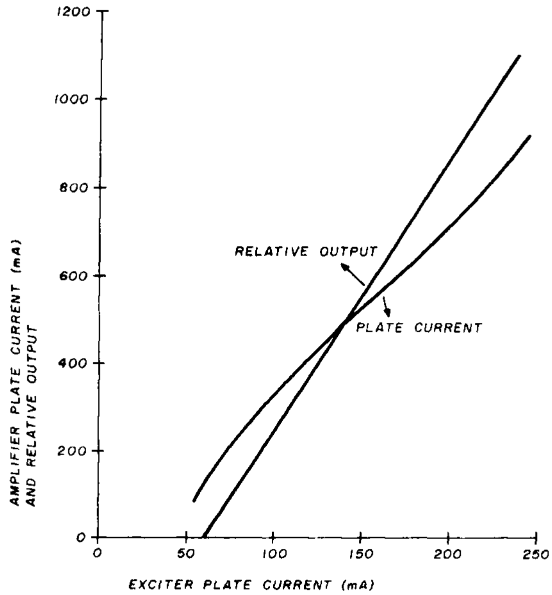


fig. 12. Linear performance of the W4MB-W4LDY three (tube) 813 amplifier is shown. Actual flat-topping starts at about 1250 mA of plate current, well above the legal limit. This illustrates how an extended linearity design is an important factor in providing a clean signal.

6. Use tubes and components on hand
7. Simple switching

Fig. 9 provides an overall view of the transmitter, **fig. 10** the inside top view, and **fig. 11** the bottom view. Note the use of a copper plate to connect the various drive grounds together, and the arrangement for making filament lengths the same. Plate leads are also the same length. The layout lead length brings the effective *Q* of the tank circuit to about 10.5 on 10 meters.

A graph of amplifier linearity is shown in **fig. 12**. More output is possible, but the combination of input loading and ALC limits the maximum input to 1800 watts PEP (note that this is above the legal limit if appreciable speech processing is used).

As seen in the photographs, there are no parasitic suppressors in the plate circuit in this design. No instability was noticed during testing. There have been one or two reports of a wide signal, so possibly some instability can arise as a result of load variation or mis-tuning. All solicited critical signal checks have agreed with the data and with unsolicited reports. This amplifier, as intended, produces a clean signal, and, because of its simplicity, is also a pleasure to operate.

ham radio

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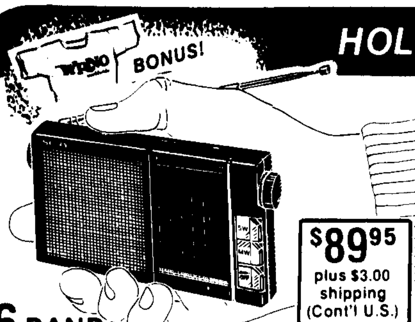

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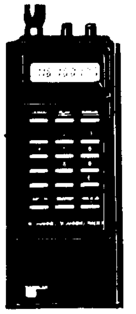

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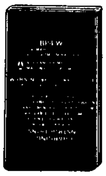

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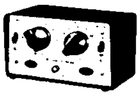

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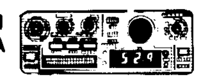

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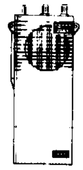

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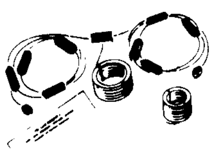

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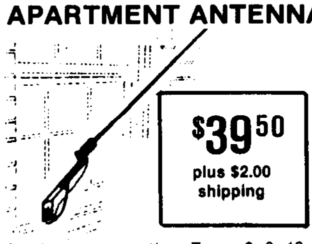

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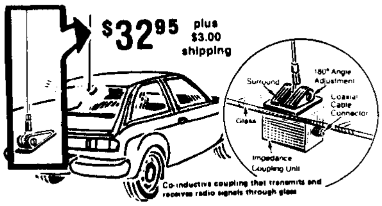

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More Details? CHECK—OFF Page 132

an improved TouchTone* decoder

ITT's device provides simple, reliable crystal-controlled decoding of DTMF signals

Several years ago, ITT (International Telephone and Telegraph) introduced a single integrated circuit capable of decoding TouchTone* signals. Using this device, we can construct a decoder system suitable for use in remote control applications with a microprocessor.

Nearly all remote control of Amateur Radio equipment, be it of a repeater, an autopatch, or a remotely controlled station, is at least in part accomplished by the use of TouchTones, also known as DTMF (Dual-Tone, Multiple-Frequency) signals. Since most modern Amateur VHF and UHF equipment now on the market is available with DTMF-encoded keyboards that provide either twelve or sixteen combinations, the transmitter end of a control link is readily available.

At the receiving end, some means must be provided to detect and decode the incoming DTMF signals (as the name implies, each signal consists of a pair of tones transmitted simultaneously). In the case of a twelve-key pad, one of a set of three tones is combined with one of a set of four tones, to provide twelve different codes. For a sixteen-key encoder, eight tones total are needed, as shown in **fig. 1**. The decoder must detect these tones and provide some indication that a valid DTMF code has been received); at the same time, the decoder must not be spoofed by the randomly occurring tones in speech sent over the same channel.

prior technology

In the past, Amateurs have often used decoder circuits consisting of a detector tuned for each of the seven or eight tones. The detectors are usually either resonant reed filters, or more recently, monolithic tone-decoder PLL (phase-locked loop) integrated circuits, usually type 567.

My own experience is with this type of decoder system. Typically, they consist of seven 567 ICs, one for each frequency, a demultiplexer circuit to convert the two-of-seven output to a more useful code, such as one-of-ten, or binary. Such decoders work, but they can be a bit tedious to align initially, as each PLL must be individually adjusted. Furthermore, since the accuracy of each PLL detector depends on its RC network, they can drift with temperature changes or with time as the frequency-determining components age. These problems are usually depressingly familiar to anyone who has tried to keep a repeater autopatch decoder operating for any length of time.

an integrated decoder

In the last few years, the telecommunications industry, fueled by tremendous growth in the commercial markets, has begun to integrate many previously discrete components into more compact monolithic circuitry, in order to reduce the size and cost of communications equipment. Examples of this process are seen in ICs that replace the hybrid transformer in telephones, in the replacement of bulky analog filters by monolithic active filters and, recently, with the development of integrated DTMF decoder circuits.

One such DTMF decoder IC is ITT's 3201, which can decode all sixteen standard TouchTone signals to provide a four-bit binary output (see **table 1**). It uses an inexpensive 3.57945 MHz TV colorburst crystal as the frequency reference, so that temperature and age drifts are practically eliminated. In addition, it has excellent immunity to false outputs caused by

By Jerry Hinshaw, N6JH, 4558 Margery Drive, Fremont, California 94538

*TouchTone is a trademark of the Bell Telephone Company.

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You won't buy any other communications terminal once you have studied all the advanced operating convenience built into the **Drake Theta 9000E**. It's complete.

DRAKE Theta 550 The **Drake Theta 550** is a compact receive-only communications terminal and is designed to demodulate and display the three most popular over-the-air modes of data communications: CW (Morse Code), RTTY (Baudot), and ASCII. Any standard TV monitor can be used.

A full-featured microprocessor controlled unit, the Drake Theta 550 has selective calling, battery backed-up memory, audio monitor, and informative L.E.D. tuning indicators. There is also interfacing to permit the addition of a dot matrix printer for "hard" copy and a keyer paddle input to permit CW transmission with full iambic operation.

CW automatically tracks over a speed range of 5 to 50 words per minute and RTTY modes offer nine selectable standard speeds of transmission. 12 volts DC is required.

This unit is ideal for shortwave listeners and hams who have been missing the increasing volume of data communications over the air.

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ROW 1 697 Hz	1	2	3	A
ROW 2 770 Hz	4	5	6	B
ROW 3 852 Hz	7	8	9	C
ROW 4 941 Hz	*	0	#	D

fig. 1. Sixteen-key TouchTone pad shows how each key is assigned a discrete pair of tones.

table 1. Code list of the output of ITT's 3201 DTMF decoder IC.

input TouchTone code	outputs binary	decimal equivalent
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
0	1010	10
*	1011	11
#	1100	12
A	1101	13
B	1110	14
C	1111	15
D	0000	0

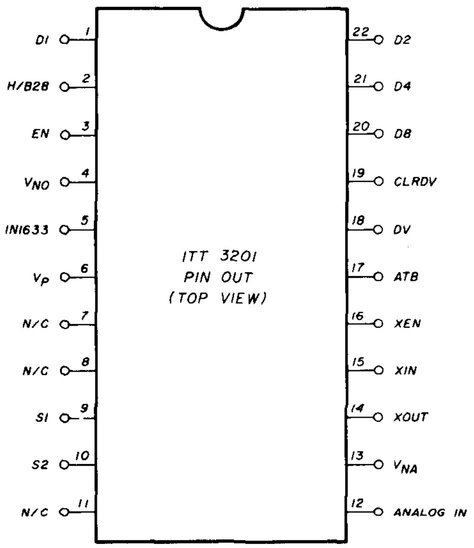


fig. 2. Pin assignments of the 3201 decoder.

speech or noise on its input. In this single IC are all the functions that my old 567-type decoder board failed to duplicate fully with ten ICs.

Fig. 2 shows that the 3201 is a CMOS LSIC (large-scale integrated circuit) housed in a 22-pin DIP. It requires only a single power supply, and draws little current. No front-end filtering is required, nor does the input have to be split into high and low bands, as some other DTMF ICs require. Audio from the receiver is fed directly to the 3201, and is automatically decoded.

The only catch, if there is one, is that the price is still higher than for the 567-type decoder. At the time of writing, the single-piece price for the 3201 is about $43.00, but that price should fall as the production quantity increases. In fact, the price has already fallen quite dramatically since the introductory price of $95.00. (The trend in semiconductors is that they are expensive when introduced, and the price then steadily falls as the volume of use rises; this IC should not be an exception to that industry-wide rule).

My own feeling is that the cost of the device, if a bit high, is more than compensated for by the utter simplicity of its construction and adjustment, and by the long-term benefits of stable, crystal-controlled operation.

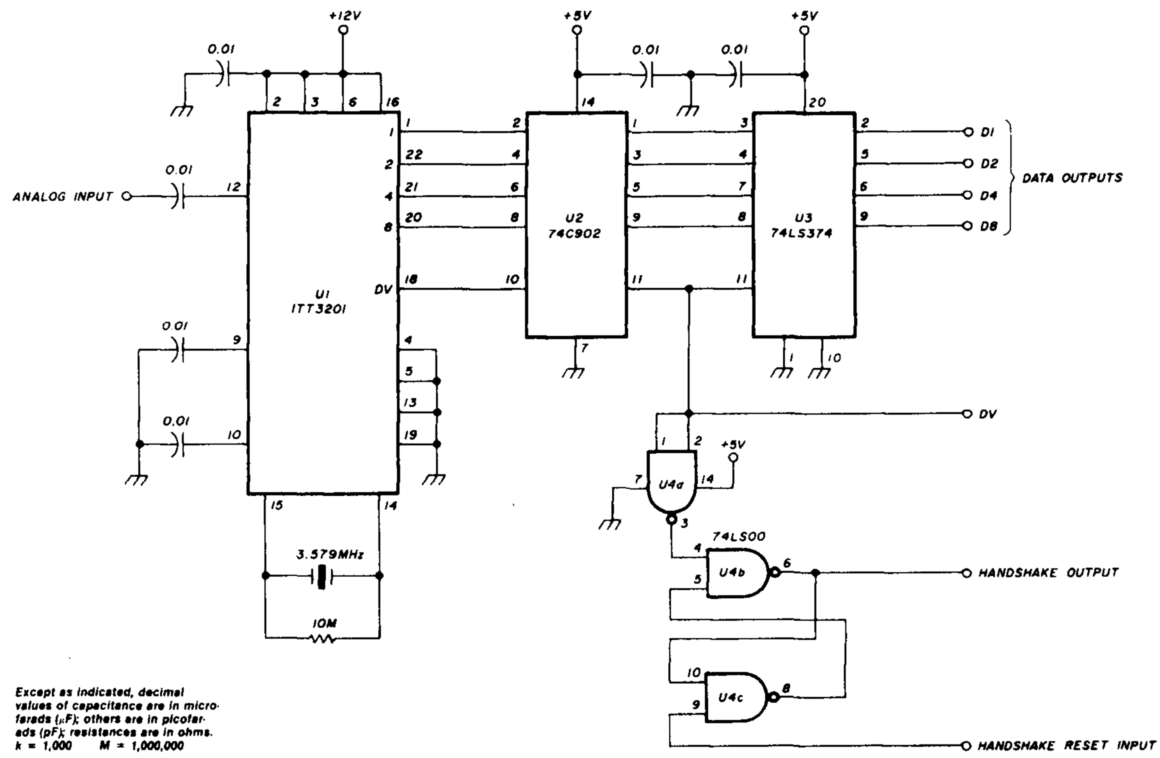


fig. 3. Schematic diagram of a decoder system. This circuit accepts a TouchTone input signal and produces a four-bit TTL-level output.

circuit description

In **fig. 3**, audio from the receiving system is fed to the high-impedance analog input of the 3201. If the input signal is a valid DTMF tone pair, the 3201 produces an output on the four data lines. During the time a tone is being received and decoded, the DV (Data Valid) output goes to the logic-high state.

The DV line serves as a signal that the four data outputs contain valid data; while DV is high, the data are good, and so the transition of DV from low to high can be used to latch the output of the decoder. The data latch (U3 in the diagram) is needed so that fleeting input signals (which may be as short as 40 milliseconds in length) can be held and read at a later time.

The output of the 3201 is CMOS level, and is not directly compatible with the usual TTL interface circuitry used in most microcomputers. This incompatibility is corrected by U2, the 74C902, a CMOS-to-TTL level converter.

Thus, when a valid DTMF signal is fed to the input of the 3201, properly-decoded output signals appear at the output lines of U2, and the DV output goes high. This transition of DV from low to high is used to clock U3, the 74LS374 octal data latch, which holds the decoded equivalent of the last DTMF signal received.

In order for a microcomputer system to tell the difference between a *newly* received DTMF input and a previously stored word, a handshake circuit has been included. This handshake is set by the DV line, and is reset after the word has been read by the computer. In other words: the output of the handshake latch goes high when the 3201 puts a new word into the data storage latch, and is reset again when the computer reads the output of the data latch. Therefore, if the computer is programmed to first look at the handshake output, it can determine if a new word is waiting to be read.

Since any computer that monitors the decoder can scan the output lines much faster than an operator's finger can press a button on the DTMF encoder keyboard, it is also a good idea to have the computer watch the DV line so it can tell a long input tone, which it has already read, from a newly received tone. The DV line, used in this way, is a form of key debouncing and prevents reading one tone as a series of several digits.

construction and testing

Layout and construction of this circuitry is noncritical. The few discrete components, such as the crystal and the bypass capacitors, can be soldered to the IC socket pins, and the rest of the wiring com-

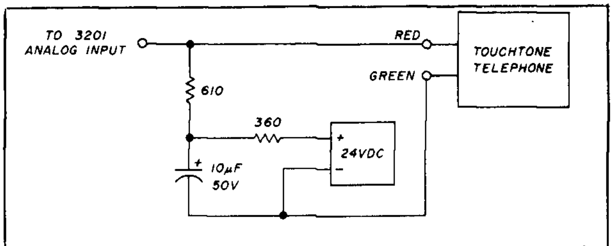


fig. 4. Simple test set uses a TouchTone telephone and a matching network to provide DTMF signals.

pleted with wire-wrap interconnections. (I built my decoder on a small prototype board with an edge connector to which the input and output were wired.)

Once the wiring is completed, and the supply voltages have been checked at the socket pins, the ICs can be installed. Keep in mind that the high-impedance input of the 3201, which is a CMOS device, is sensitive to damage by static electric charges. It is a good idea to keep the 3201 in the protective packaging it comes in until it is to be installed, and then equalize the potential of the circuit and the protective package by touching them together. Remove the 3201 and install it in its socket. Once the IC is installed, the danger of static charge damage is reduced.

There are no adjustable components (this is my kind of circuit!) so the unit should work when power is turned on and a DTMF signal is applied to the analog input. The circuit shown in **fig. 4** is a simple test set that uses a standard TouchTone telephone to determine if the decoder is properly decoding the twelve tones. The telephone is disconnected from the phone lines, and hooked as shown to the network, which provides power for the phone's internal tone generator and matches the normal line impedance of 600 ohms.

If the decoder fails to work, check the wiring first. The DV line at the 3201s pin 18 should rise to nearly +12 volts when a DTMF signal is applied; if it does, the problems are probably elsewhere than in the 3201's circuitry.

summary

This decoder is a simple, modern alternative to the DTMF decoders of the past. It provides dependable performance, and should make remote-control systems easier to set up.

Except for the 3201, all the components are standard types and widely available. The 3201 can be obtained from the manufacturer at this address: ITT North Microsystems Division, 700 Hillsboro Plaza, Deerfield Beach, Florida 33441; telephone 305-421-8450.

ham radio

a rotary dial and encoder
for digital tuning

A digital controller using multiple dials and microprocessor logic

The shift to digital and microprocessor control of ham gear makes rotary dial encoding more popular. Earnshaw's approach to dial encoding, simplified and improved by Opal, offers a practical method for the Amateur builder.[1,2] Both require discrete components for each dial.

This article describes another method incorporating multiple dials using microprocessor logic.[3] This method reduces the number of components necessary and is suitable for digital controllers having concurrent tasks.

why encode the rotary dial

Switches are inherently digital; they are either on or off. Conventional tuning dials have an infinite number of positions. A digital tuning dial is not infinite; you must select the position closest to a desired setting.

Most 2-meter fm gear uses some form of discrete, digital frequency selection. This is difficult to use on lower bands without channelized frequencies: that rare DXCC contact may be between positions and will never be reached.

If you have a digitally-controlled master oscillator, one tuning solution is to use a potentiometer (pot) with an analog-to-digital converter. This has limits: an inexpensive pot has less than a full turn and an expensive, ten-turn pot can't be spun continuously (nor does it have the range) of conventional tuners.

A better way is to use the continuous, segmented digital rotary dial and an encoder to determine direction and amount of rotation. Each dial position, or state, is used to drive a counter. The counter provides an input to the controlled function. Encoding may be accomplished through discrete circuitry or through a microprocessor program. The position resolution is limited only by the dimensions and construction quality of your encoding design. I resolve two hundred positions per revolution easily. Opal resolved four hundred, with a larger encoder disk and better construction.

the technique

Earlier rotary dial methods provided continuous updating of dial position, or state-change. This system polls four dials in sequence, to determine if any dial status has changed from the previous poll.

I selected a four-dial input because a station can require several. Four uses might be main tuning, bandspread, filter frequency setting and keyer or keyboard speed control. Four inputs also work well with an 8-bit microprocessor.

the basic dial

Fig. 1 shows the progression of logic states from a pair of optical interrupters scanning the marks on a disk. For any given state, movement of the dial disk

By **C.A. Eubanks, N3CA,** P.O. Box 127, Valencia, Pennsylvania 16059

will yield a new state that defines direction of rotation.

Table 1 summarizes all possible state-change combinations, original state to new state. Valid rotation is implied if only one of the optical interrupter inputs changes. Invalid rotation sensing occurs if both interrupters see a change; this change must be ignored. Invalid sensing could occur if the polling speed is too slow, or sensing could indicate the wrong direction if an even number of state changes were missed.

The microprocessor system used in dial sensing performs other tasks as well. Polling speed is subject to trade-offs. To test the speed, I tentatively selected Opal's fifty-mark encoder disk. Some experimentation with a conventional transceiver proved that the dial spins easily at one revolution per second. This became the design rotation-rate goal. Assuming the rotation algorithm senses all state changes: *(1 rev./Sec) × (50 marks/rev.) × (4 states/mark) = 200 states/Sec.* All else being equal, polling rate must occur once every five milliseconds.

Everything else is *not* equal, however. First, the dial spin rate is not constant. Sudden starts and stops create faster state changes. Second, interrupters are not ideally spaced; some state changes occur at a lesser angular displacement and the state-change rate can increase.

With these factors in mind, I finally selected a two millisecond polling rate. The encoder still losses a few counts on rapid dial movement, but I've noticed no erroneous counts.

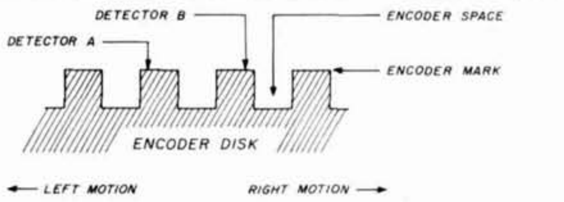
table 1. Matrix diagram (Karnaugh Map) of all possible logic states of one dial's optical interrupter detector. A_0 and B_0 are the previous A and B interrupter states while A_1 and B_1 are the current states. L indicates left motion in *fig. 1*, R is right motion. N/C is no change; dial has not moved. N/A is a not-applicable condition resulting from non-allowed state-change progression of motion in either direction. The logical expression is used by the process subroutine shown in *fig. 4*.

B_1B_0 \ A_1A_0	00	01	11	10
00	N/C	L	N/C	R
0	R	N/A	L	N/A
11	N/C	R	N/C	L
10	L	N/A	R	N/A

$$L = \bar{A}_1A_0\bar{B}_1\bar{B}_0 + A_1\bar{A}_0B_1B_0 + \bar{A}_1\bar{A}_0B_1\bar{B}_0 + A_1A_0\bar{B}_1B_0$$
$$R = \bar{A}_1A_0B_1B_0 + A_1\bar{A}_0\bar{B}_1\bar{B}_0 + \bar{A}_1\bar{A}_0\bar{B}_1B_0 + A_1A_0B_1\bar{B}_0$$

the interface circuit

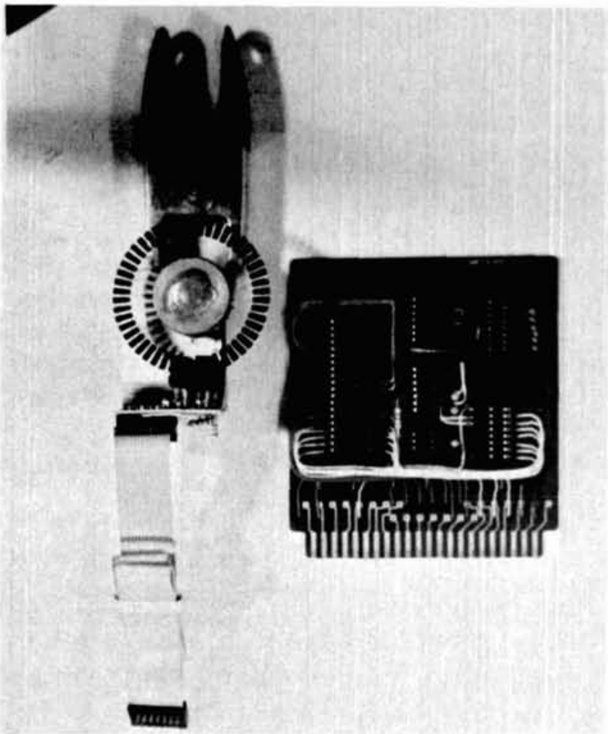
Fig. 2 is a schematic for one application card of the Intelligent Controller.[3] The darlington output of each optical interrupter is buffered by 7414 hex schmitt inverters. This buffer provides hysteresis to prevent jit-



SAMPLE TIME	LEFT MOTION	RIGHT MOTION
	A B	A B
T0	1 1	1 1
T1	1 0	0 1
T2	0 0	0 0
T3	0 1	1 0
T4	1 1	1 1

PASSAGE OF ONE COMPLETE MARK & SPACE (T0–T4)

fig. 1. Encoder optical interrupter detectors relative to encoder disk and resulting logic states. Logic 1 is a mark seen by the detector, logic 0 a space.



The application card and one rotary dial assembly. Optical interrupters are visible at the disk bottom, just above the bracket for the ribbon cable DIP socket. The large chip on the card is the 8255 PPI with hex inverters at top center. Other card components are for another application not described here. The clamp is for photographic support of the dial assembly.

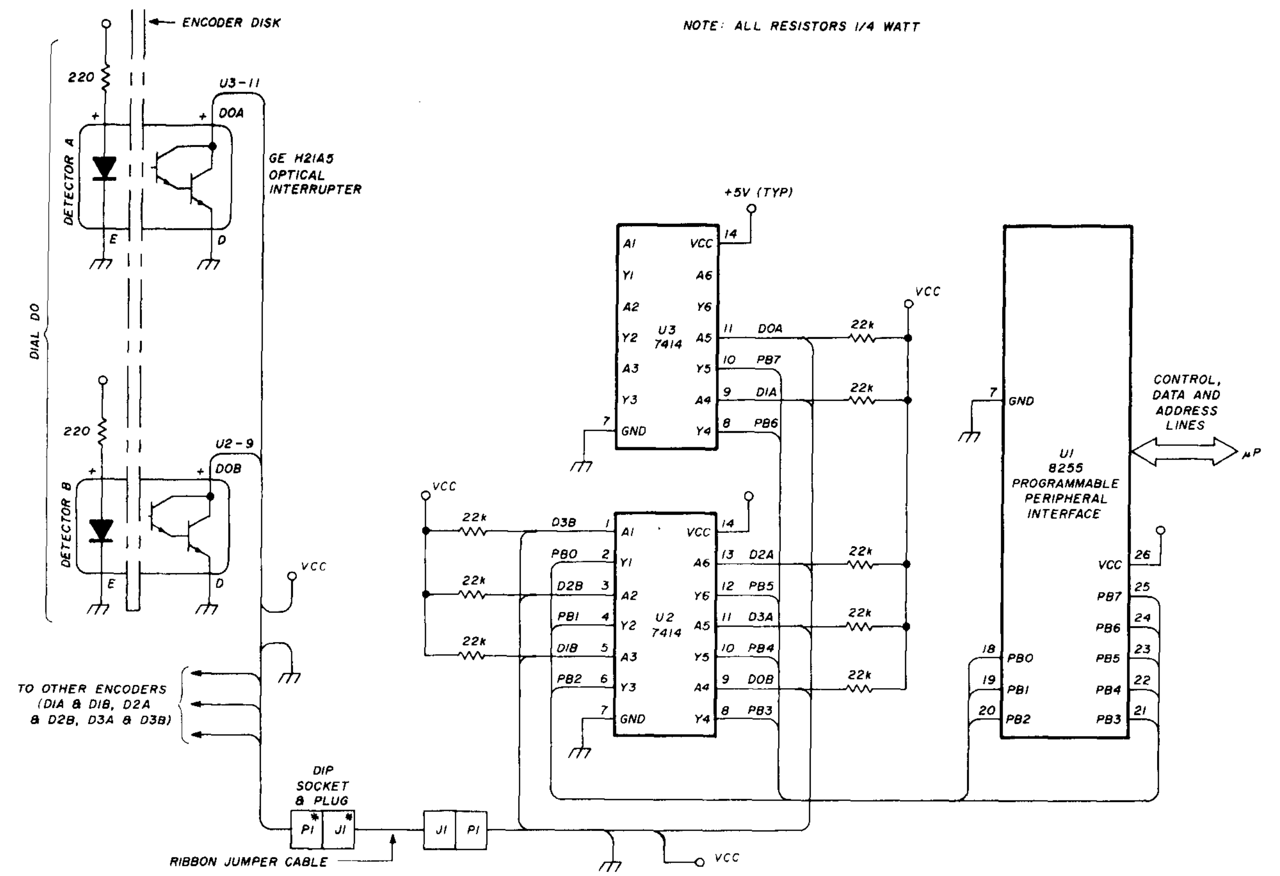


fig. 2. Schematic of the four-dial application card for the Intelligent Controller. The optical interrupter circuit may be repeated for three additional dials.

ter when an interrupter is near a dial mark edge.

An Intel 8255 Programmable Peripheral Interface (PPI) is the link between the inverters and the Intelligent Controller's HAM BUS. The 8255 was chosen because it is compatible with other system components, readily available, and one of the least expensive input/output (I/O) devices available.

The PPI is shown with connections to port B. Each 8255 has three ports, and the remaining two ports may be used for other functions in the Intelligent Controller.

motion algorithm

This algorithm was developed for a 6502 microprocessor but is of general nature and should work equally well on other microprocessor systems. General flow for motion sensing is shown in **fig. 3**, and is executed once every two milliseconds. Any state change detected due to dial motion will call the process subroutine detailed in **fig. 4**.

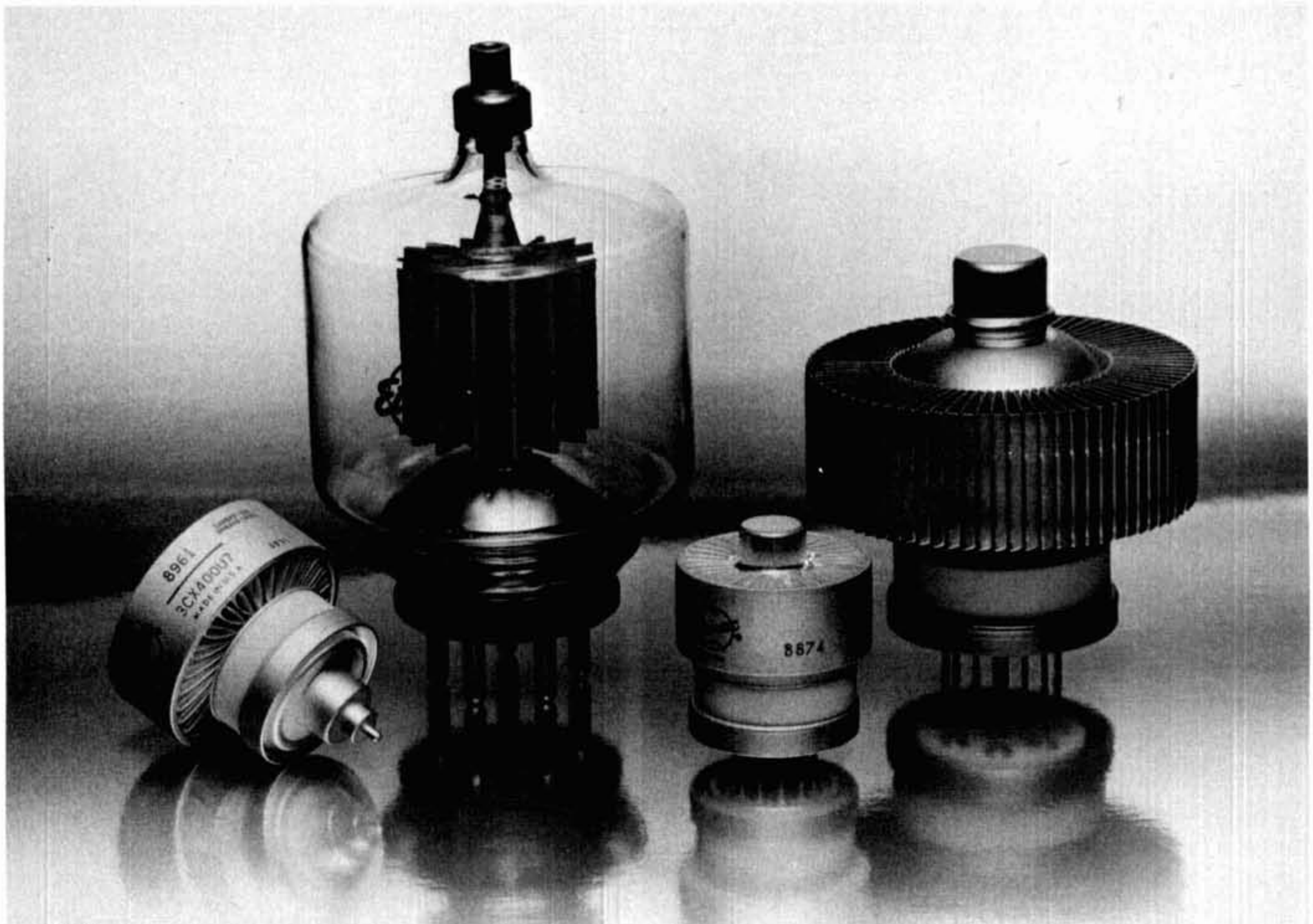
Twelve bytes of storage are required by both routines. Three are temporary, for scratch-pad storage, labelled TEMP1, TEMP2, and TEMP3 on the charts. OLDIAL holds the status of all four dials from the previous poll. Four bytes are the old dial logic (ODL) registers, one for each dial. The remaining four are direction registers (one for each dial), to indicate dial position.

Direction registers may be used in a service routine to remember dial motion. In my application they indicate positive ($01 to $7F) on the increments and negative ($80 to $FF) on decrements.

The microprocessor program allows other tasks to be executed between dial readings. Details on the flow charts and program operation are found in the appendix.

construction

As a disclaimer, I am more impressed with K3CU's mechanical construction than my own. For breadboarding purposes, I used parts taken from a ten-turn pot for its shaft and bushing. The dial and optical interrupters were mounted on a small piece of unetched PC board stock. It is very desirable to



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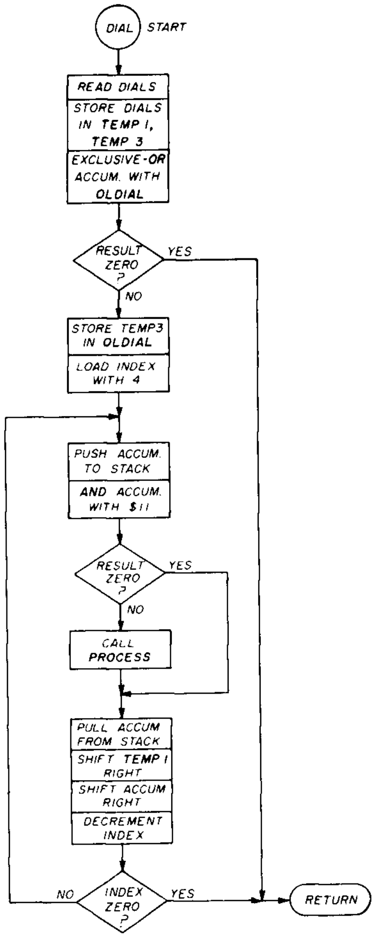

fig. 3. Flow diagram of the dial polling routine.

mount the interrupters with the shaft bushing for proper optical adjustment.

The dial subassembly holds a 16-pin DIP socket for interconnection to the application card. Flat-cable DIP plug cables are readily obtained. (Mine was an 18-inch (46 cm) cable from Radio Shack, part number 276-1976.)

I made the encoder disk in two steps: first I made a photocopy from the optical mask in **fig. 1** of Opal's article, then transferred it to a thermal-contact transparency. This gives satisfactory results, but you can purchase finished disks directly from K3CU.*

Opal suggested cementing the disk to a large knob for support. I soldered a circular piece of PCB stock to the shaft and attached the disk with rubber cement. My technique takes less space, while Opal's is easier.

The exact location of the optical interrupters is not critical. The illuminator center should be near the mark mid-radius. Once assembled, the relative interrupter positions can be set by bending the leads. Two cautions: keep the interrupter leads long enough and be careful not to pull off the PC board foil.

The dial shaft should have some friction device to prevent drift or coasting. I included a short piece of helical compression spring between bushing and encoder disk. This takes up any axial play and provides the necessary friction.

The inverters and PPI were mounted on a Radio Shack prototype board (part number 276-157). This is compatible with the intelligent controller. The extra chips seen in the photo are to support a Morse keyboard. The two spare 8-bit ports of the PPI may be used for other purposes.

operation

I had some initial problems providing sufficient signal for inverter inputs. I believe the interrupter collector resistor values given in **fig. 1** to be adequate for variations in both the interrupters and inverters. To make certain, the inverter and interrupter outputs can be checked with a high-impedance voltmeter. Inverter output should be low when interrupter output is high, and vice versa.

I wrote a simple program to drive a display for 256 counts to test the device. Depending on the spacing between interrupters, the count may go in either direction. The proper direction is obtained by repositioning the interrupters or modifying the service routine. I prefer the latter, having had some bad experiences with interrupter leads and foil peeling on the encoder subassembly.

Program documentation and burned 2716 EPROMs for the Intelligent Controller are available from the author. Please send a self-addressed, stamped envelope for information.

acknowledgment

The author wishes to express appreciation to Chet B. Opal, K3CU, for his comments and review of this article.

references

1. Lester A. Earnshaw, "A Tunable Synthesizer," *ham radio*, November, 1978, page 18.
2. Chet B. Opal, K3CU, "Rotary-Dial Mechanism for Digitally Tuned Transceivers," *ham radio*, July, page 14.
3. C.A. Eubanks, N3CA, "An Intelligent Controller for Ham Gear," *ham radio*, October, 1982, page 12, and November, 1982, page 25.

appendix

The flow chart details presented here will be useful if you are interested in converting to a microprocessor other than a 6502 or are not familiar with programming.

*Photo disks are available from K3CU for $1.00 each. Please send SASE to Chet B. Opal, K3CU, 5414 Old Branch Avenue, Temple Hills, Maryland 20748.

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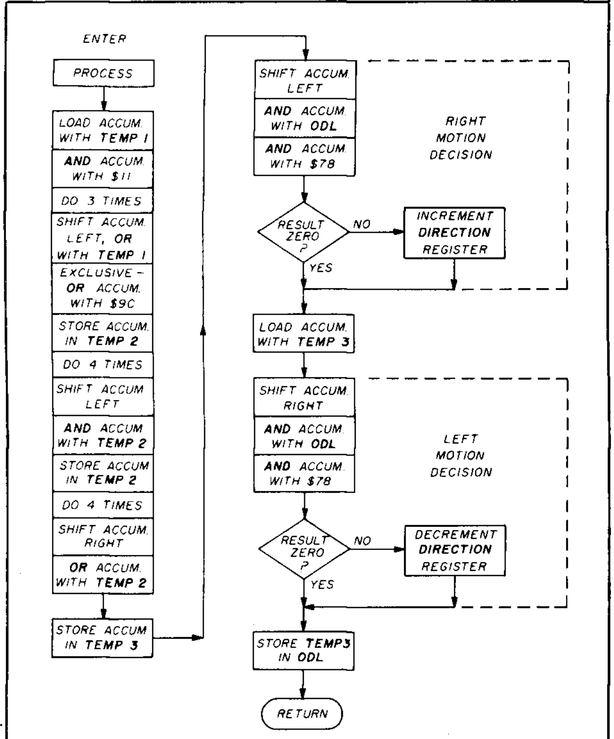

fig. 4. Flow diagram of the process subroutine to determine dial motion.

The dial routine in **fig. 3** is invoked by a two-millisecond timer interrupt in the Intelligent Controller. This routine reads the status of all dials and compares that status with the previous status stored in the OLDIAL register. If there is no charge, the routine returns from processsor interrupt.

Change of dial input is indicated by one or more bits set to logic 1 after the exclusive-OR with OLDIAL. Each dial is then polled in a loop. The loop starts with dial status in the accumulator as follows:

$$A_0\ A_1\ A_2\ A_3\ B_0\ B_1\ B_2\ B_3$$

The accumulator is first pushed onto the stack (temporarily saved), then masked by ANDing with a bit pattern of 00010001 ($11 in hexadecimal notation). The result, on the first loop pass, will have A_3 in bit 4, B_3 in bit 0, and all other bits zero. If all bits are zero, *no change in that dial occurred*, the accumulator is restored by pulling it from the stack, and the accumulator is shifted right once. The index register (loop counter) is decremented, tested, and program flow continues at the loop start.

The purpose of right-shifting the accumulator is to provide separation in the $11 AND for the next dial. The second loop pass will have A_2 in bit 4, B_2 in bit 0. Each loop pass will test individual dials in decreasing order.

Any non-zero result of the AND accumulator with $11 will jump to the process subroutine shown in **fig. 4**. Entry to this subroutine will have TEMP1 holding an individual dial status in bits 4 and 0. Another mask with $11 is assurance that the three accumulator left-shifts and ORs with TEMP1 will have an individual dial input arranged as:

A A A A B B B B

The accumulator is exclusive-ORed with a bit pattern of 10011100 or $9C. The result of the exclusive-OR will set up the accumulator for subsequent testing of motion direction. Logic representation in the accumulator is now:

$$\bar{A}\ A\ A\ \bar{A}\ \bar{B}\ \bar{B}\ B\ B$$

Bit patterns in the accumulator will be as follows for the four possible optical interrupter state combinations:

A B = 01100011	$\bar{A}$ B = 10010011
$\bar{A}$ $\bar{B}$ = 10011100	A $\bar{B}$ = 01101100

Only one pattern will exist for one dial, stored in TEMP2.

The next two instructions set the accumulator to hold a logic 1 in one of the higher four bits for one of the previous state combinations. This is done by left-shifting the accumulator four times, then ANDing with TEMP2. The next two instructions (four right-shifts and OR with TEMP2) will duplicate the higher four accumulator bits into the lower four. The accumulator is now set for motion determination and is stored in TEMP3. The accumulator and TEMP3 will have one of the following bit patterns dependent on dial status:

A B = 00100010	$\bar{A}$ B = 00010001
$\bar{A}$ $\bar{B}$ = 10001000	A $\bar{B}$ = 01000100

One of these bit patterns will be loaded into a dial's ODL on subroutine exit.

The first motion decision occurs when the accumulator is shifted left once, then ANDed with the existing ODL (from a previous subroutine call). The result is ANDed again with 01111000 ($78) to strip any extraneous bits. If the second AND yields a non-zero accumulator, right motion was detected and the direction register for that dial is incremented.

The second motion decision is made by loading the accumulator with TEMP3, shifting the accumulator right once, then ANDing with the existing ODL. The second AND with $78 strips any extraneous bits. A non-zero result indicates left motion and the direction register is decremented. The final operation is updating the ODL with the current dial logic stored in TEMP3.

A key element in motion decision is the direction of accumulator shift prior to ANDing with the ODL register. This can be seen by examining the logic expressions in **table 1**, or the following state-change progression:

Right motion: AB → AB → AB → AB → AB →
Left motion: $\bar{A}\bar{B}$ → $\bar{A}$B → AB → A$\bar{B}$ → $\bar{A}\bar{B}$ →

The current state combination must always be compared to the previous one.

Any out-of-sequence state combination will pass through the subroutine without effect on the direction register. Start-up may produce an arbitrary bit pattern in the ODL register byte and may cause an increment or decrement of the direction register; only one change occurs since subroutine exit will update ODL to the new dial logic. Set-up prior to motion decision ensures a minimum number of direction register glitches.

Each left-shift assumes a zero entering the least-significant bit. Each right-shift assumes a zero entering the most-significant bit. 6502 coding uses ASL and LSR instructions, respectively. TEMP3 is the Y-register of the 6502 with the X-register used as an index for each ODL and direction register in RAM.

Calculated execution time of the four-dial program in the Intelligent Controller is 141 μs with no dial change, 355 μs with one dial change, and 436 μs with two dial changes. Clock period is one microsecond and there is adequate time between 2-millisecond interrupts to execute other tasks in the controller program.

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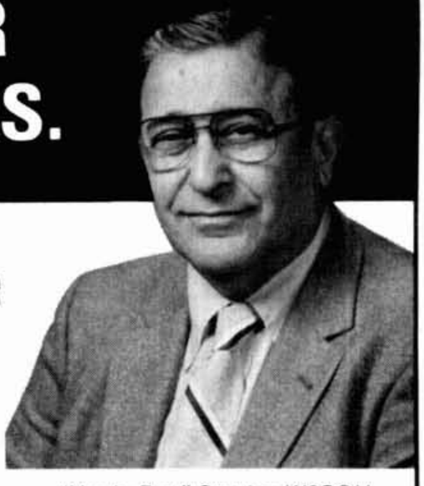

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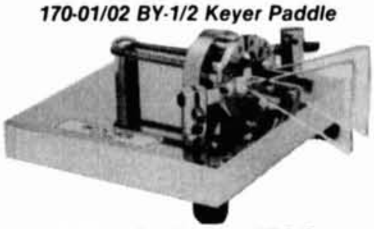

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EDT	Slow Code Practice	MWF: 9 A.M., 7 P.M.; TThSSn: 4 P.M., 10 P.M.
	Fast Code Practice	MWF: 4 P.M., 10 P.M.; TTh: 9 A.M.; TThSSn: 7 P.M.
	CW Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M., MTWThF: 10 A.M.
	RTTY Bulletins	Dy: 6 P.M., 9 P.M., 12 P.M., MTWThF: 11 A.M.
	Voice Bulletins	Dy: 9:30 P.M., 12:30 A.M.
CDT	Slow Code Practice	MWF: 8 A.M., 6 P.M.; TThSSn: 3 P.M., 9 P.M.
	Fast Code Practice	MWF: 3 P.M., 9 P.M.; TTh: 8 A.M., TThSSn: 6 P.M.
	CW Bulletins	Dy: 4 P.M., 7 P.M., 10 P.M.; MTWThF: 9 A.M.
	RTTY Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M.
	Voice Bulletins	Dy: 8:30 P.M., 11:30 P.M.
PDT	Slow Code Practice	MWF: 6 A.M., 4 P.M.; TThSSn: 1 P.M., 7 P.M.
	Fast Code Practice	MWF: 1 P.M., 7 P.M.; TTh: 6 A.M.; TThSSn: 4 P.M.
	CW Bulletins	Dy: 2 P.M., 5 P.M., 8 P.M.; MTWThF: 7 A.M.
	RTTY Bulletins	Dy: 3 P.M., 6 P.M., 9 P.M., MTWThF: 8 A.M.
	Voice Bulletins	Dy: 6:30 P.M., 9:30 P.M.

1 (Wed)

BBC CELEBRATION – Commemorating the 50th anniversary of the Empire Service in conjunction with the Ariel Radio Group – **1-31***

BOREALIS ARC SPECIAL EVENT – Will present the Worked All North Pole Certificate from Fairbanks, AK – **1-31***

2 (Thur)

3 (Fri)

ARRL 160-METER CONTEST – **3-5**

4 (Saturday)

ANNUAL HANDI-HAM WINTER HAMFEST – Held at the Eagles Club in Faribault, MN. For more info contact WØFIT, 1114 Frank Ave., Albert Lea, MN 56007 – **4**

EVERGLADES ARC OPERATING EVENT – Celebration of Everglades National Park – **4-5***

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TELCO PIONEERS QSO PARTY – **4-6**

5 (Sunday)

17TH ANNUAL HAZEL PARK ARC SWAP & SHOP – Held at the Hazel Park High School in Hazel Park, MI. For more info send SASE to Hazel Park ARC, P.O. Box 368, Hazel Park, MI 48030 – **5**

ARGONNE ARC COMMEMORATION TO NUCLEAR EXPERIMENT – To be held on the University of Chicago campus – **5***

6 (Mon)

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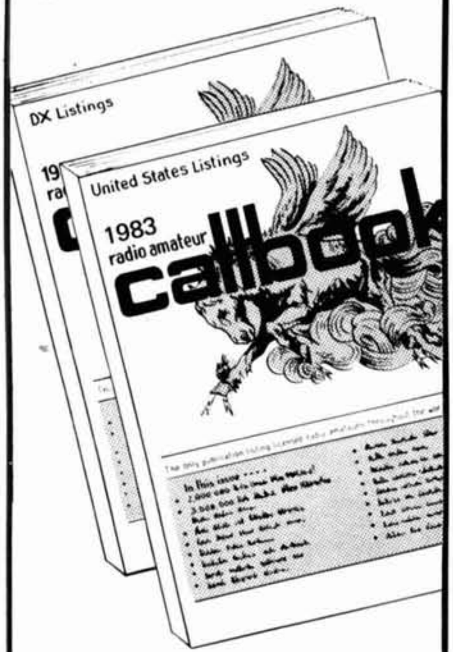

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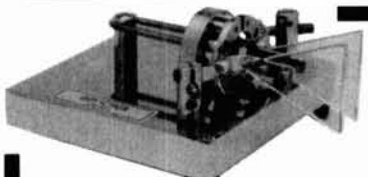

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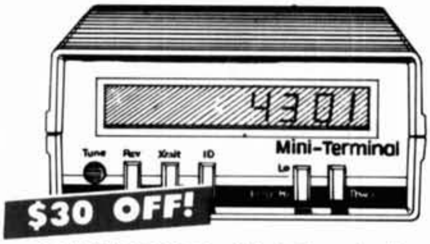

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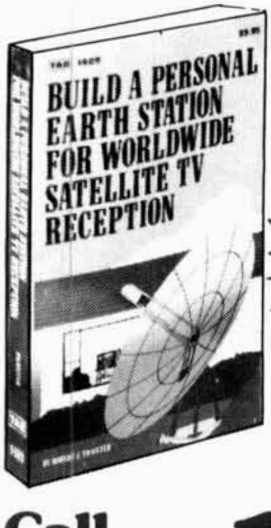

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More Details? CHECK—OFF Page 132

a 40-meter transmitter-receiver

Useful construction hints for a versatile, complete package

A 40-meter transmitter and receiver using semi-break-in keying is described in this article. It uses transistors in all the circuits except for the final tube, driver and T-R switch.

This article indicates problem areas and cures. Many hobbyists like myself build circuits acquired from handbooks and magazine articles and they don't always work. During construction things change. Perhaps the layout, perhaps a fine copper short on a PC board which can only be seen with a magnifying glass. I have spent hours searching for opens on parts which appeared to be soldered only to find no connection actually existed. I now scrape all component leads before I solder to ensure good electrical contact.

Access to parts represents another variable and the constructor must choose from his collection or from other sources. For example, I had silver-plated, nylon-covered wire available which I used for the VFO coil. It works quite well and provides stable VFO operation.

PC board construction

Printed circuit board construction takes practice and experience. I start by cutting the copper PC board with a hacksaw, holding the board in a vise between two pieces of angle iron. I smooth the edges and rub the surface of the copper with steel wool until it's bright. Black paper tape and drafting dots are used for circuit layout, and I keep a pencil sketch of the work. The dots and holes are center-punched. The board is placed in a cut-out milk container and ferric chloride solution is poured over it. Fresh etching solution is used each time since it weakens after several applications. A 75-watt lamp, placed over the container, hastens the etching process. I use steel tweezers to turn the board and pick it up because the solution can stain your fingers badly. Don't spill or drop any of it on the floor or sidewalk — it won't come off!

After the board is etched and washed the tape is removed and cleaned with paint thinner and the board is rubbed with steel wool again. Sometimes I put the board in a tinning solution if I have any on hand. If not, I hot solder-wipe the board. Holes are made with a number 60 drill and parts mounted and soldered one at a time with the board secured in a vise. Always check the board after you are done wiring. Run a scribe between the segments and look at the board with a magnifying glass. This sounds like a small point but can prevent problems such as shorts and open circuits.

Making boards by hand may seem to be time-consuming, but you will find it is fun and a good way to build. More elaborate methods include making negatives of the artwork and exposing photo-sensitized copper plates. However, that is a more expensive technique.

Occasionally, breadboarded circuits do not perform when printed on copper boards. Once again poor layout should be suspected. Above all, don't try to build an entire circuit and expect it to completely work initially. Build and test one section at a time.

power supply

A good place to start is by building a power supply. I built two receivers with an inexpensive 18-volt rms transformer using an LM 340-T regulator IC. The first two units worked. However, after constructing the third unit all the LM 340-Ts self-destructed though neither a capacitive nor resistive load had yet been connected. Exchanging the T unit with an LM 340-k-12 apparently solved the problem. An added benefit of this change was a total elimination of audio motor-boating. (A better transformer had also been introduced).

By Ed Marriner, W6XM, 528 Colima Street, La Jolla, California 92037

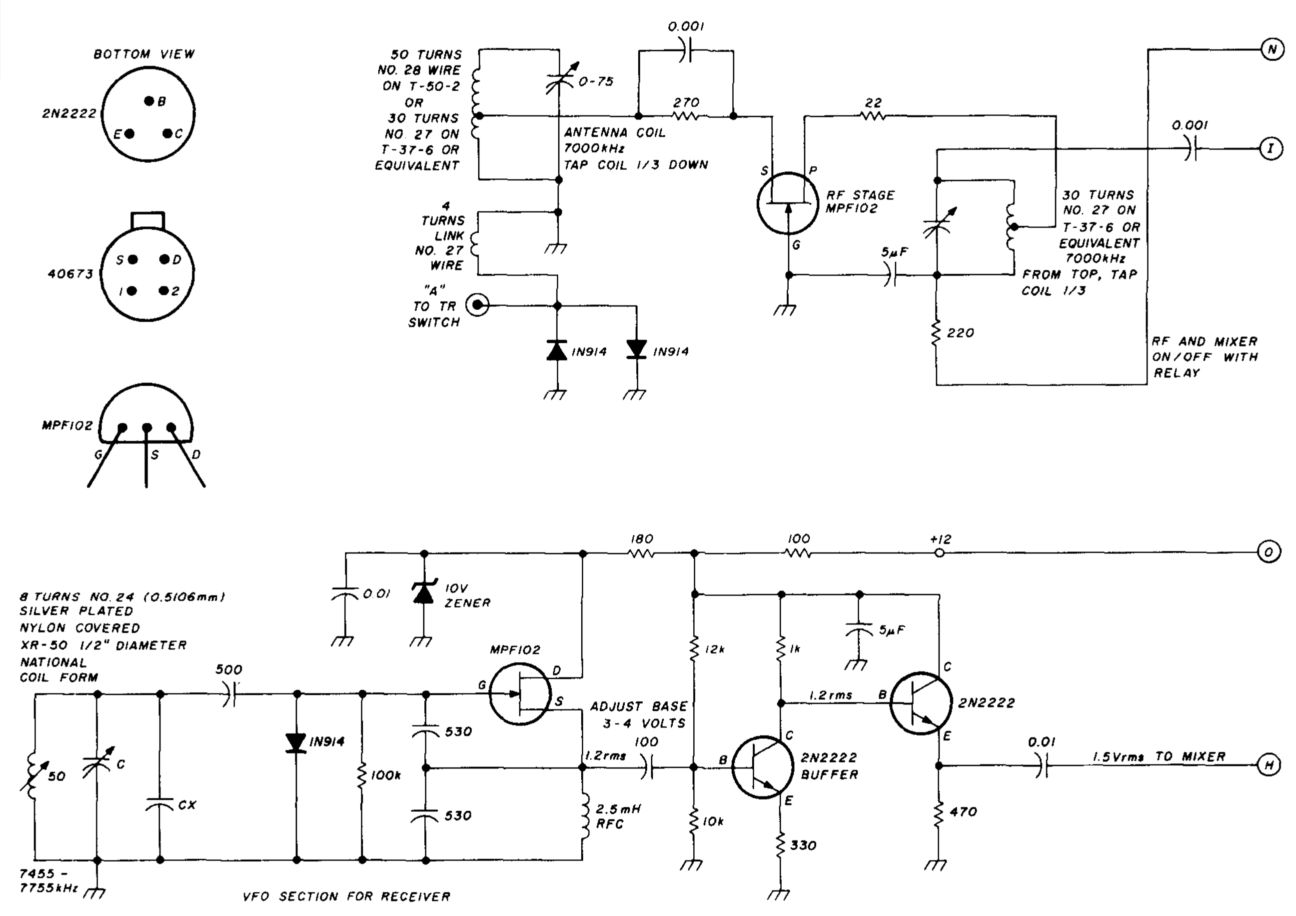

fig. 1A. Schematic diagram for the 40-meter transmitter-receiver.

Some experimenters use batteries (12-volt storage or Ni-Cds) to independently power their circuits. It also helps pinpoint causes of hum, unwanted oscillations and audio motor-boating. It's a good idea to run all the stages to a separate point, isolating each power lead with a 100-ohm resistor and five or more microfarad by-pass capacitors. This prevents interstage coupling.

audio amplifier

Now you have a working power supply, the next logical circuit to build is the audio stage. LM 380N chips work well and provide sufficient audio output. A 0.1 µF capacitor on the input pin prevents hum when the volume control is lowered.

A common practice is to use between two and ten microfarad capacitors for coupling audio stages. I found the audio stage would block with this large a value and reduced it to 0.02 µF. For CW low-frequency coupling is not necessary. The audio stages in this set are left on at all times to enable sidetone oscillator injection for CW monitoring.

product detector

A 40673 MOSFET is used as a detector and gain element. It eliminates the need for another i-f stage. Sufficient CW signal output is obtained from the mixer when a 1.5 V rms BFO level is injected. The 1k resistor and 0.05 microfarad capacitors form a filter that suppresses high frequency hiss (a mixer byproduct), preventing its introduction into the audio stages.

bfo

A crystal BFO is simpler to build than a variable one. However, it is more difficult to make the 453.5 kHz crystal stage oscillate. After some research, the circuit in **fig. 1.** was tried. By placing an rf choke in the collector lead, and adjusting the capacitors from base to ground, the oscillator provided 10 volts rms output. I used a variable capacitor to experimentally determine the optimum values (200 pF from base to ground and 70 pF from collector to ground). The transistor oscillated only when the emitter was not grounded.

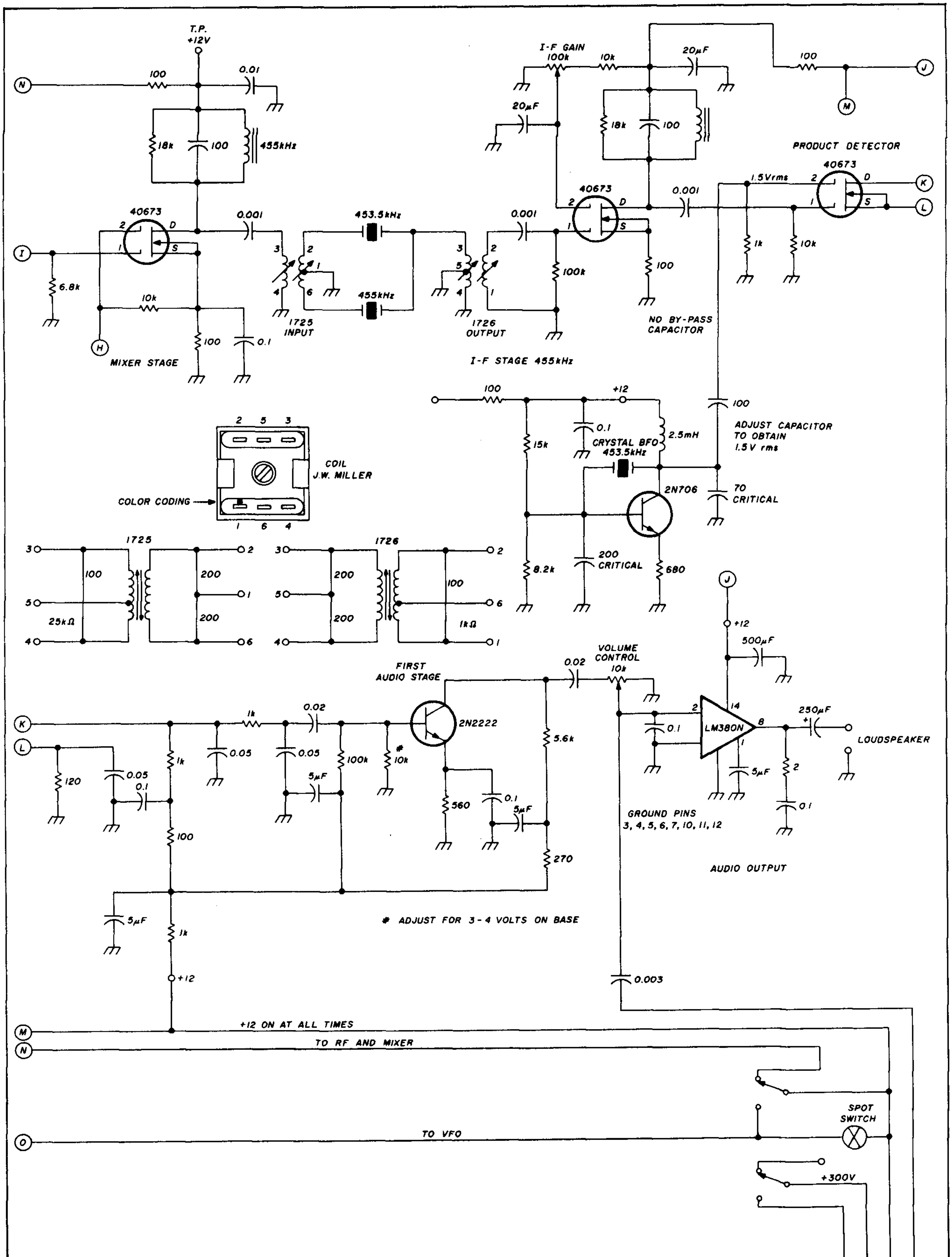

fig. 1B. Schematic diagram for the 40-meter transmitter-receiver.

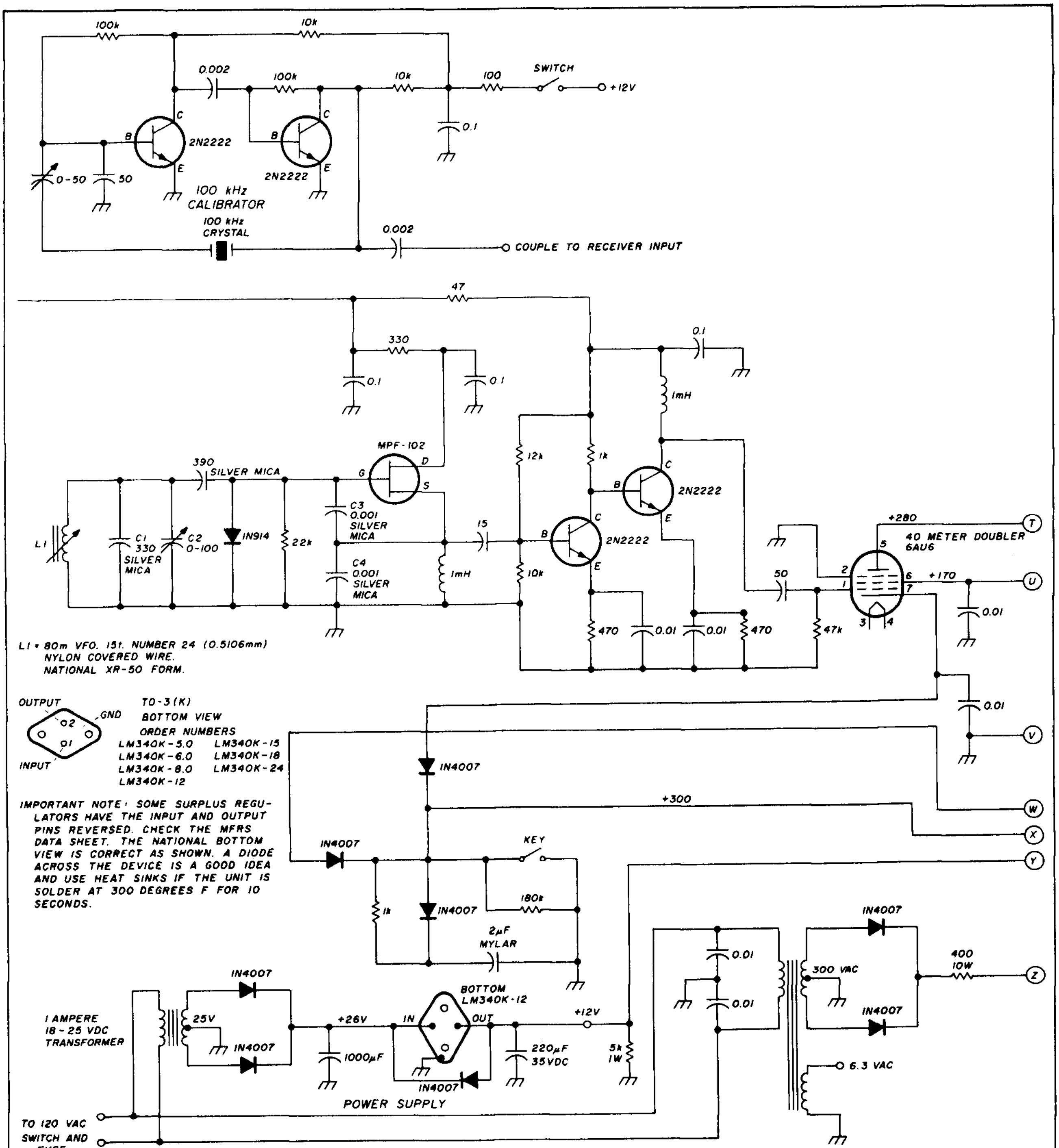

fig. 1C. Schematic diagram for the 40-meter transmitter-receiver.

i-f stage and filter

I-f filters are expensive and hard to find. A CW and SSB filter can be constructed using two low-frequency crystals, one at 455 kHz and the other at 453.5 kHz. The J.W. Miller crystal-matching i-f transformers, types 1725 and 1726, complete the crystal filter assembly. The transformers can be mounted on a PC board and must be grounded. Care must be observed when tuning the i-f slugs. Do *not* screw the slug in too far or it will damage the internal wiring. Peaking is accomplished by listening to off-air signals or by feeding in a 455 kHz signal.

The i-f stage transformers are small potted toroids which resonate at 455 kHz with a 100 pF capacitor. A J.W. Miller 330 microHenry unit also works. A paral-

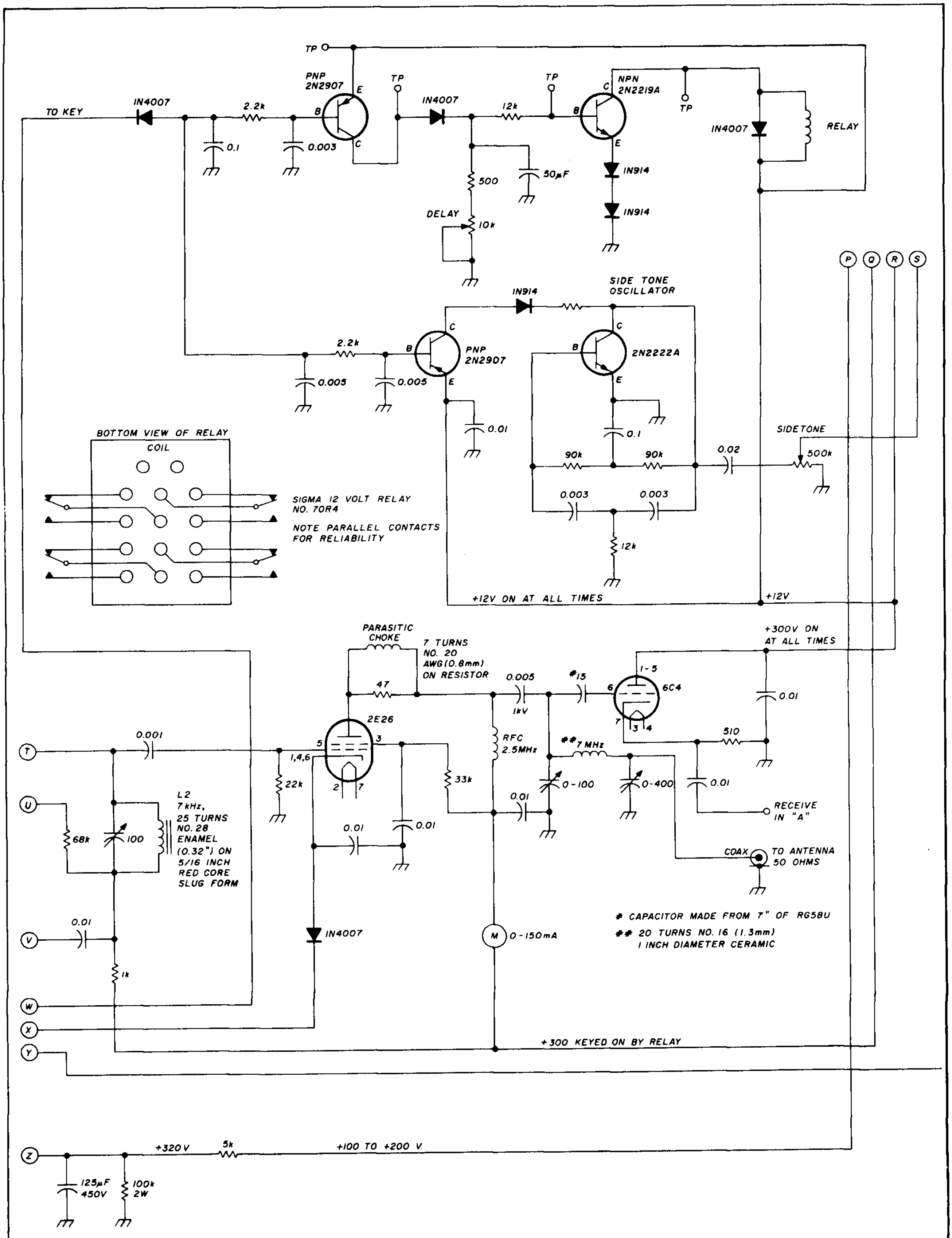

fig. 1D. Schematic diagram for the 40-meter transmitter-receiver.

Parts List	
coils	*J.W. Miller Co., 19070 Reyes Ave., Compton, California 90224.*
semi-conductors	*Semiconductors from Circuit Specialists, Box 3047, Scottsdale, Arizona 85267 or telephone 1-800-528-1417.* *Some semi-conductors can be found at Integrated Circuits Unlimited, 7889 Clairemont Mesa Blvd., San Diego, California 92111.*
printed circuit tape	*Drafting tape for printed circuits. Mesa Design Reprographics, 4925 Convoy St., San Diego, California 92111, telephone 714-565-4724.*
dots	*Dots are called donut pad D144 for .150 od × .031 inch (3.81 mm × 0.79 mm).*
tape	*I use Bishop precision slit tape #201-250-11 which is .250 inch wide (6.35 mm).* *Tape 201-125-11, .125 inch (3.18 mm).* *Also some .062 inch wide tape is useful. The tape comes in all widths, from Bishop Graphics, Westlake Village, California 91359.*
toroids	*Amidon Associates, 12033 Otsego St., North Hollywood, California 91607.*
i-f coils	*Radio Shack sometimes has an assortment bag of coils. Check here for i-f coils. Those used in this set were potted in ceramic, red color and have two leads projecting out. No number for stock.*
etching	*Try WA3OJF, PO Box 398, New Cumberland, Pennsylvania 17070. You can get mixed solution at your local chemical supply house.*

leled 18k resistor reduces the Q and chance of oscillation. The FET's source by-pass capacitor was left off to reduce the possibility of self-oscillation in the i-f stage.

rf and mixer stage

The rf and mixer stage is keyed by the relay for semi-break-in. Amidon (red) toroids are satisfactory for the coils as long as they resonate on 40 meters. Slug-tuned coils can be used as well. However, it is easier to tap down on toroid windings. The idea here is to sharpen the tuning without loading the circuit too heavily.

1N914 diodes inserted back-to-back on the antenna link coil reduce the rf if it exceeds 1 volt. The T-R switch reduces the transmitter leak-through rf level to about 2 volts.

vfo

A Colpitts' configuration is preferred for the receiver VFO. The 500 pF coupling and two fixed 530 pF capacitors are appropriate values needed for oscillation. The tuning capacitor, affected by these capacitors, requires careful matching for specific range coverage. The MFP-102 transistor stage provides 1.4 volts, enough to drive the buffer and emitter follower. This circuit eliminates frequency pulling by reducing mixer influence. The base voltage on the buffer is adjusted to read between 3 to 4 Vdc. This is accomplished by carefully selecting the 12k and 10k resistors. The 1.5 volts from the crystal filter provide one of the mixer inputs. Its injected level determines the mixer output.

transmitter

The transmitter VFO was designed for 80-meter operation to prevent 40-meter rf interference. The VFO is actuated when the relay closes. Better performance is achieved using this technique rather than keying the VFO directly. Drive is increased by placing an rf choke in the collector lead and taking the output from the collector rather than from the emitter. The emitter by-passing increases the rf drive to the 6AU6 doubler on 40 meters. The 6AU6 provides enough drive to the 2E26 with 300 volts on the plate. When lightly-loaded, the 2E26 plate has a pronounced tuning dip if sufficient drive is applied. The 6AU6 and 2E26 output stages are keyed and isolated by 1N4007 diodes. The keyed semi-break-in and sidetone circuits are also isolated from each other by diodes. A keying network, introduced by VU2JN, produces a clickless signal.

relay circuit

When the key is closed a positive pulse is transmitted to the 2N2219A base. The two 1N914 diodes ensure 2219A cutoff when the key is released. The diode across the relay eliminates any hang-up problems. The relay hold-in time is determined by the delay potentiometer and the 50 μF capacitor. A positive voltage, from the sidetone keyer, applied to the base of the 2N2222 turns it on. The sidetone oscillator, which provides a clean, adjustable level, monitoring signal, is lightly-coupled to the LM 380N input.

ham radio

More Details? CHECK—OFF Page 132

data bandwidths compared

Bandwidth requirements for four competitive data modulators

With increasingly crowded Amateur bands, will hams begin using more sophisticated digital-data modulation schemes in the future? FSK (frequency-shift keying) is the predominant modulation scheme used to transmit data in the Amateur service; but this may not always be the case, because there are several other possible schemes which are better than FSK in some ways. This article will compare the bandwidth requirements for four competitive methods of modulation data.

It is in our interest to use our limited spectrum space as efficiently as we can. I will be discussing FSK, CW, and two forms of PSK (phase-shift keying), that is, two-phase PSK, also called Binary PSK, or BPSK; and four-phase PSK, also called Quaternary PSK, or QPSK.

the fast-Fourier transform

In the discussion that follows, the signal spectra presented were generated by performing a spectrum analysis on a computer simulation of typical data modulated by each of the different schemes. This was done by creating a mathematical model of a data signal consisting of a sequence of 128 samples with 156 microsecond spacing and modulating it by each of the four methods. The results were then processed by a Fast-Fourier Transform computer program that produced a power spectra plot (showing energy content as a function of frequency) for each of the signals. I will not be discussing how this program operates, but only the results of this analysis.

The horizontal axis of each plot is frequency (in Hertz), and the vertical axis is the signal power for each frequency component in (dB relative to the strongest component). As a convenient reference, we will define the bandwidth of the signals as the band over which frequency components greater than − 15 dB relative amplitude are present. This standard will allow bandwidth comparisons between the different modulation schemes.

frequency-shift keying

FSK is the most popular data mode today because it is comparatively simple to generate and demodulate. The output frequency of the transmitter is shifted between one of two different frequencies (mark or space) depending upon the data bit being sent (0 or 1). The demodulator can be two simple filters, one for each of the frequencies, and rectifiers and a slicer to determine which frequency channel has the most energy at any time.

An FSK signal using 1200 Hz and 1600 Hz was modelled for this analysis, and a data rate of 400 BPS (bits per second) was used. (This is about the maxi-

By J.T. Dijak, W9JD/2, 215 Tareyton Drive, Ithaca, New York 14850

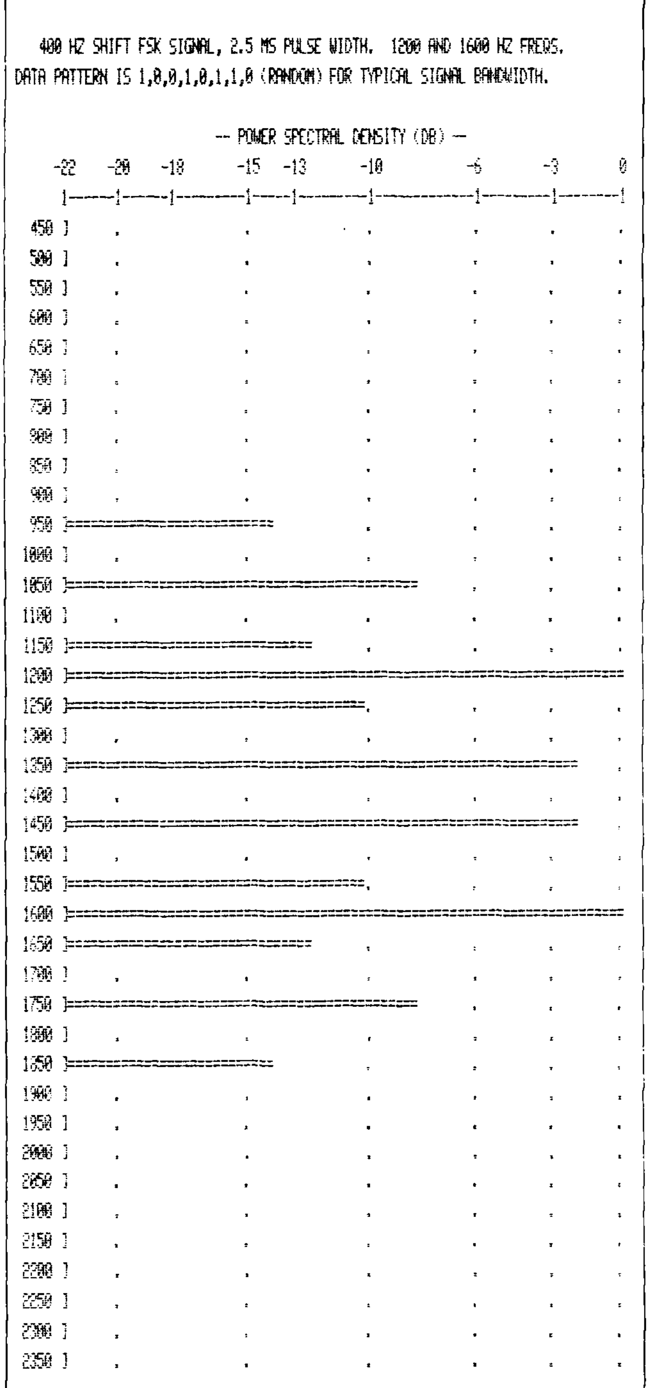

fig. 1. Analysis of frequency-shift keyed signal: the data rate of 400 BPS requires a bandwidth of 900 Hz, and provides moderate error protection.

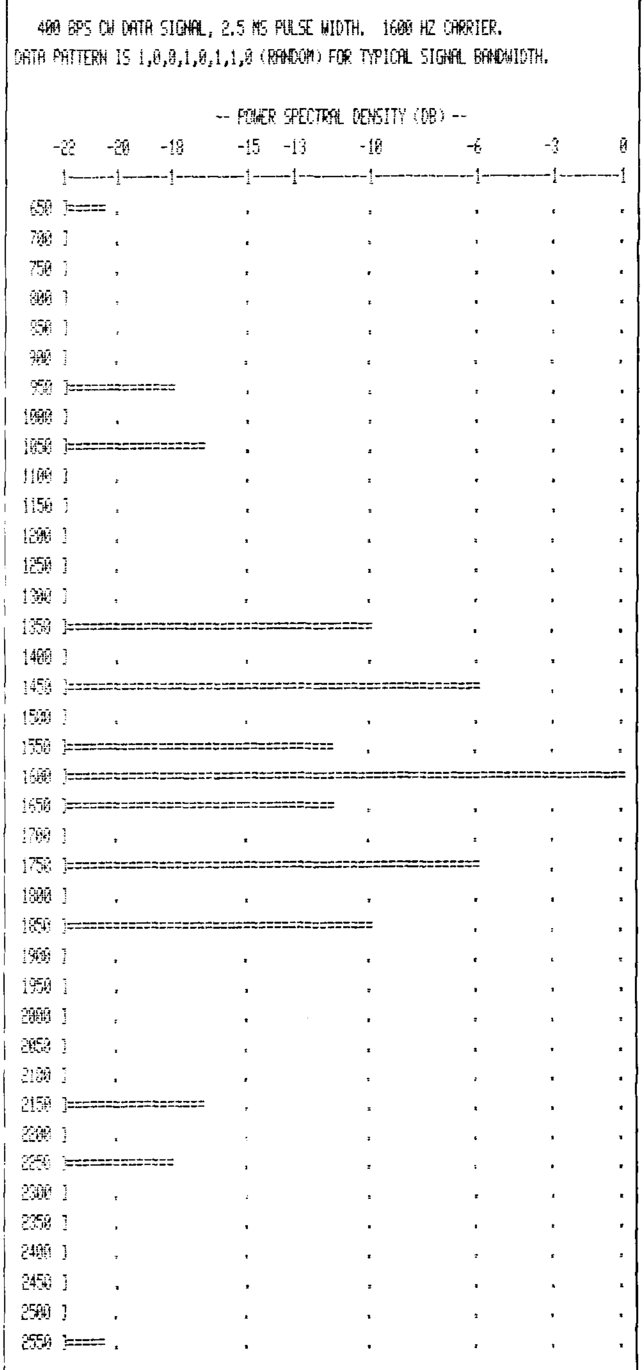

fig. 2. Analysis of CW signal: the 400 BPS data rate requires only 500 Hz bandwidth, but has an error rate worse than that of the FSK method.

mum reliable data rate that can be sent via FSK with a 400 Hz shift.) A sequence of eight data bits in a random pattern composed the signal sequence.

Fig. 1 shows the spectrum plot for the FSK signal. We can see that the frequency components extend only from 950 to 1850 Hz, which makes for a tightly knit signal of 900 Hz bandwidth. This is our first spectrum, and we will use it as a reference in discussing the others.

CW

We could also send data using a CW signal where the presence of the signal could indicate a mark, and the absence, a space. This signal is also very simple to generate, and simple to demodulate. The error rate versus signal-to-noise ratio is not as good as that for an FSK signal, however. This is because it is easier to tell a mark from a space when we are considering two different frequencies than when we must determine the presence or absence of one signal in a noisy channel.

For this analysis, a CW signal at a 400 BPS data rate using 1600 Hz as the center frequency was used. The same data pattern used with the FSK signal was used with this signal.

Fig. 2 shows the spectrum plot for the CW signal. We can see that (considering only −15 dB components or greater) the signal bandwidth (500 Hz) is narrower than for the FSK signal. We can also see that there are now other components farther out from the carrier. We can expect a small amount of signal distortion in the demodulator if we use filtering to limit our bandwidth to something on the order of what was required for FSK.

It is reasonable to expect the CW data signal to show higher harmonic spectral components than the FSK signal. The FSK waveform had smooth transitions between mark and space bits. The only difference between the two signals was a difference in frequency, and the transitions were made at a zero-crossing of the signal. Therefore, there were no abrupt changes in the FSK waveform. The CW signal, on the other hand, imposes very abrupt changes in the signal when it goes from mark to space — from no signal present, to full signal present. We know that higher harmonic terms are required in a signal spectrum to accomplish any abrupt transition like this in the waveform.

BPSK

Binary PSK sends a continuous carrier at one frequency, but the phase of the signal is shifted 180 degrees for a space bit. This signal, while requiring more complicated modulators and demodulators than either FSK or CW, provides an error rate superior to either other mode for a given signal-to-noise ratio.

Fig. 3 shows the spectrum plot for the 400 BPS BPSK signal. The same data pattern used in the previous examples was again used. We can see that the BPSK signal is wider than either the CW or FSK signals. This is not a surprise, since we know the BPSK waveform has very abrupt transitions at the bit boundaries where the phase of the carrier signal goes from +180 degrees to 0 degrees. In order to reproduce these abrupt transitions, the signal requires the higher harmonic spectral components that we see.

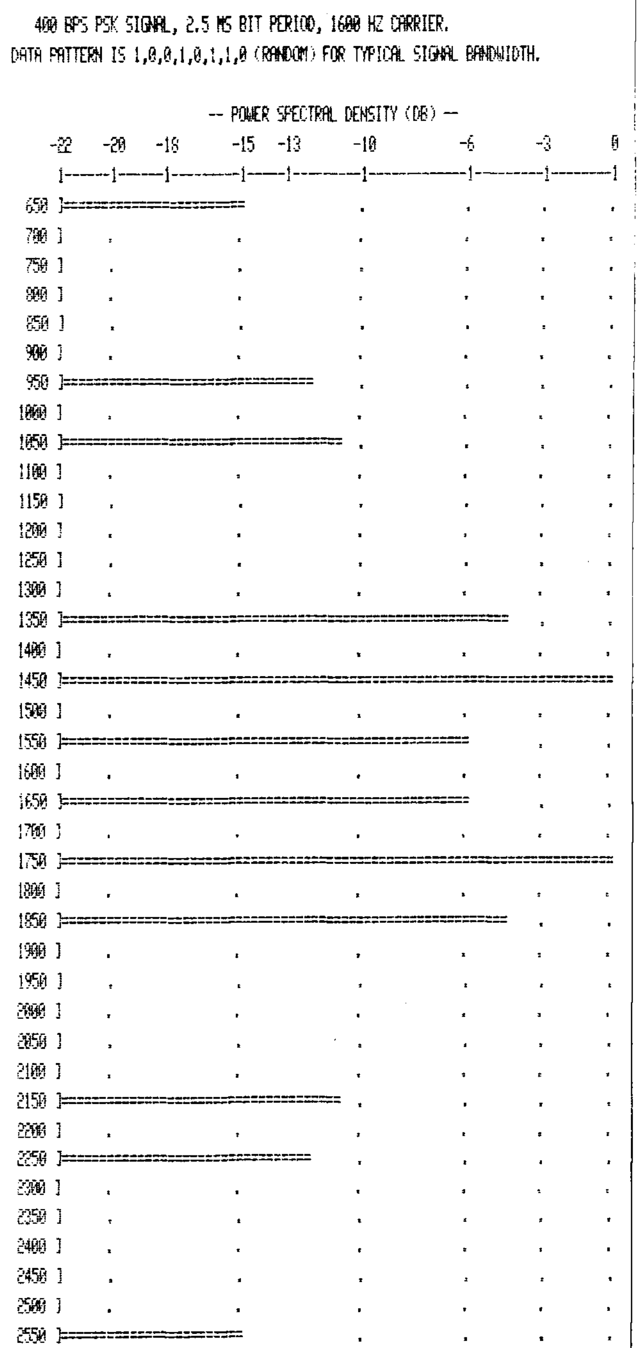

fig. 3. Analysis of binary phase-shift keyed signal: because of the high error protection provided by the BPSK method, the signal can be filtered to require less than 500 Hz bandwidth at 400 BPS; but the hardware required is more complex.

From this we can say that an unfiltered BPSK signal will require a wider signal bandwidth than CW or FSK for the same data rate; however, due to the superior synchronous detection process used (and required) with PSK, we can discard many of the

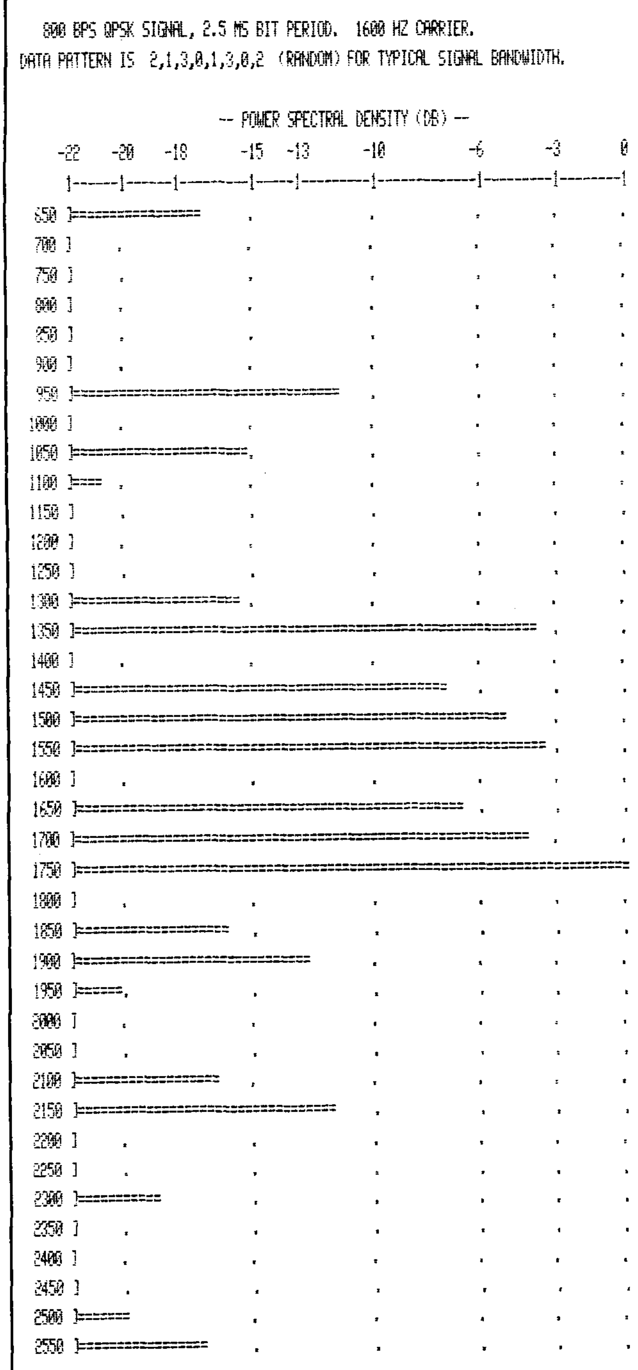

Fig. 4. Analysis of quaternary phase-shift keyed signal: because each bit in this system can have four states, filtered QPSK signals provide twice the data rate for the same bandwidth as the BPSK method (although the hardware is even more complex). The error rate is slightly worse than with the BPSK method.

higher harmonic spectral components (by filtering). This blurs the transitions between bits, but does not seriously disturb the most important signal information for each bit. We could use a filter at the transmitter to limit signal bandwidth to that required for FSK, and the detection process would still work well. Then, in exchange for the added complexity of the BPSK modulator and demodulator, we could obtain superior error-rate performance at the same data rate and in the same bandwidth as FSK.

QPSK

Quaternary PSK sends a carrier with one of four possible phase states at any time (that is, 0, +90, +180, or +270 degrees). Rather than sending one of two possible signals during each bit interval in the channel, we now send one of four possible signals, so each channel can be used to send two data bits (also called a di-bit). This is how a QPSK signal using a 400 BPS signalling rate in the channel can maintain an 800 BPS data throughput.

Fig. 4 shows the spectrum plot for an 800 BPS (throughput) QPSK signal — twice the rate for the previous examples — operating at a 400 BPS signalling rate in the channel. The spectrum looks somewhat similar to the BPSK spectrum, except that there are now several additional frequency components close-in near the carrier.

The higher harmonic components decrease in amplitude at a rate similar to those for the BPSK signal. We are sending di-bits through the channel at a 400 BPS rate, so we can again filter the transmit signal to pass only components within 400 Hz of the carrier and obtain good receiver performance. (In fairness, we must note, however, that QPSK does not exhibit error-rate performance as good as BPSK — this is because it is more difficult for the decoder to make the proper decision from the more complicated signal set.)

The main advantage of QPSK is that, assuming we can tolerate a slightly worse error rate than with BPSK, we can send twice the data rate while using the same bandwidth as BPSK or FSK. This is especially important in Amateur Radio VHF fm applications where we have good signal-to-noise ratios, but limited bandwidths.

summary

FSK is currently the most popular data-modulation scheme, due to its simplicity; but, when Amateurs become interested in better error-rate performance and maximum data throughput for a given signal bandwidth, they will probably start moving toward filtered BPSK or QPSK. This will be especially true at VHF and UHF where the frequency-diversity advantages FSK enjoys at high-frequency frequencies are much reduced.

ham radio

battery charge sensor

A small sensor that warns you before your Ni-Cds discharge

Many a nickel-cadmium cell has been destroyed by depletion of its charge below the protective voltage level.[1] As many Amateurs know, when a Ni-Cd cell is discharged to near zero voltage there is a good possibility the cell may take on a reverse charge. The reason for this is the small differences in capacitance between cells; the cell reaching full discharge first is reversed charged. This condition can be prevented if the protective voltage level is detected and the cell is recharged.

My slightly vintage crystal 2-meter rig (a Kenwood TR2200A) uses ten Ni-Cd AA cells arranged in a four- and six-pack as its power source. The rig does have provision for monitoring the voltage level of the battery pack using the combination RF/S/battery-meter. This is fine if you operate in enough light to read the meter, which is, even under best conditions, somewhat inconvenient and difficult to read. But suppose you have no light — such as on your patio in the evening or in the forest on a camping trip. The battery meter is not of much use under these conditions.

My solution to this problem is a sensor circuit designed to continuously monitor the battery voltage and detect the approaching protective voltage level. When this level is reached, the sensor activates an alarm, which in my rig flashes the built-in channel pilot lamp at a 1-Hz rate. I chose to set this voltage level to 11 Vdc, which allows some additional time after the alarm to end a QSO. The lamp will automatically stop flashing when, during charge, 11 Vdc is exceeded. The sensor circuit and lamp are powered in such a way that the main ON/OFF power switch will turn off everything.

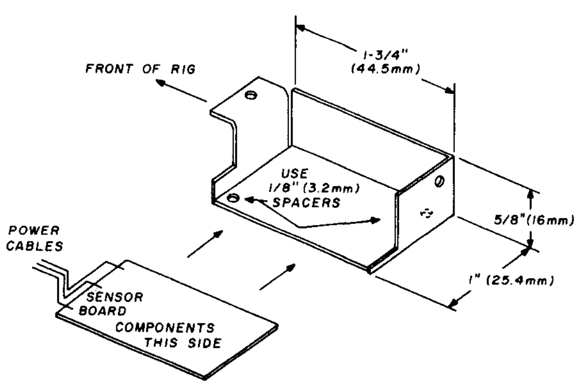

fig. 1. The battery compartment box, showing placement of sensor circuit board.

By F.T. Marcellino, W3BYM, 13806 Parkland Drive, Rockville, Maryland 20853

Introducing incredible tuning accuracy at an incredibly affordable price: The Command Series RF-3100 31-band AM/FM/SW receiver.* No other shortwave receiver brings in PLL quartz synthesized tuning and all-band digital readout for as low a price.† The tuner tracks and "locks" onto your signal, and the 5-digit display shows exactly what frequency you're on.

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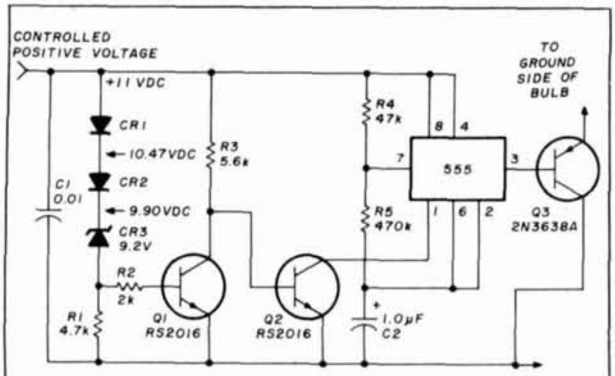
Because my 2-meter rig is a Kenwood TR2200A, placement of the sensor was not difficult. In the battery compartment, the manufacturer had installed a rectangular box to take up space next to the four-cell pack. The box is removable by taking out two Phillips-head screws. The inside measurements of the box are 1 × 1-3/4 × 5/8 inches, which lends itself to housing a miniature circuit board. **Fig. 1** shows the removable portion of the box and how I mounted a hand-wired circuit board in place. **Fig. 2** is the circuit board showing layout of parts.

circuit description

Assume the Ni-Cd battery pack has a charge between 11 Vdc and full charge. Under those conditions, the zener diode, CR3, will be biased into its forward breakdown region, developing a voltage at the junction of R1 and R2. If this voltage is above 0.65 Vdc, Q1 will be saturated with its collector pulled down essentially to ground. This condition prevents Q2 from conducting, and so the ground pin No. 1 of the 555 will be held high near the battery voltage. The 555 will not start oscillating until pin 1 is grounded. The output of the 555 is pin 3 and it is internally held at the battery voltage at this time. A PNP transistor, Q3, is used to control the alarm/channel lamp. The lamp will light every time Q3's base is grounded — or flash if the base is pulsed to ground.

As the battery pack depletes itself and the terminal voltage approaches 11 Vdc, CR3, a 9.2-Vdc zener, will stop conducting because it is biased above ground by CR1, CR2, and the emitter-base diode of Q1. **Fig. 3** shows the sensor circuit, including the zener voltage drops for battery levels of 11 Vdc to full charge. To achieve the proper protective voltage level it is necessary for CR1, CR2, and Q1 to be silicon devices. Germanium components will not do because of their lower forward bias voltages, placing the level far too low. When Q1 stops conducting, Q2 will saturate and ground pin 1 of the 555. At this time the channel lamp will begin to flash at a 1-Hz rate.



Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms.
k = 1,000 M = 1,000,000

fig. 3. Battery-charge sensor diagram with zener current path voltage drops.

The sensor circuit is composed of fourteen components plus the circuit board. With a typical ham's junkbox, the sensor can be produced for less than five dollars. The circuit requires three hard-wired connections to the rig: a power ground, a connection to the ground side of the channel lamp, and a controlled positive battery voltage.

Normal operation of the TR2200A's front panel lamp switch is not impaired by the sensor circuit. The channel lamp can be turned on at any time — even when the lamp is flashing. The standby current drawn by the sensor is 5 mA at a battery charging voltage of 13.6 Vdc and it tapers to 2.28 mA just prior to the lamp's flashing at 11 Vdc. These current levels are constant and do not change under transmit conditions. I consider this current drain a small price to pay for Ni-Cd reverse-polarity protection. In my rig the original standby drain was 45 mA, so an additional 5 mA amounts to slightly more than 10 percent.

One nice feature of this sensor is that it can be removed quite easily for resale purposes. The rig would regain its original unmodified status with no unwanted front panel holes. But once the purpose of the sensor has been explained to the buyer, he probably would gladly accept the rig with the modification included.

ham radio

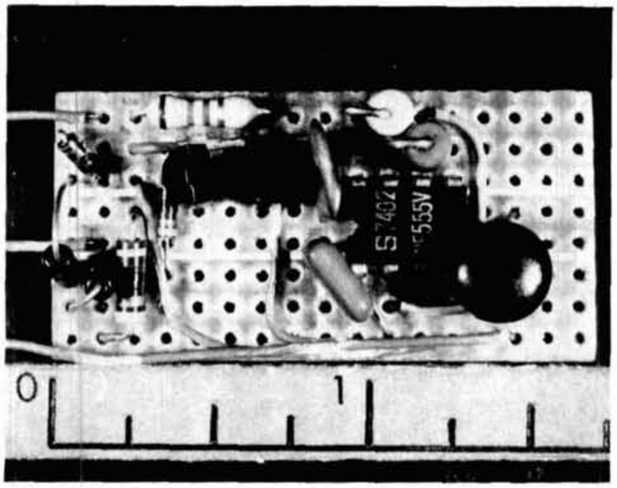


fig. 2. Sensor circuit board and parts layout.

reference

1. "Eveready Battery Applications and Engineering Data," Union Carbide Corporation, 1968.

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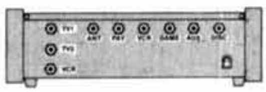

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8	8CE14-PWD	Electrolytic Capacitor Kit, 14-pieces	6.95
9	9CC20-PWD	Ceramic Disk Capacitor Kit, 50 WV, 20-pcs	7.95
10	10CT5-PWD	Varible Ceramic Trimmer Capacitor, 5-65pfd, 5-pieces	4.95
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ham radio TECHNIQUES

Bill Orr W6SAI

The fall antenna construction season is almost over and the winter months are close at hand. Not much time left this year for antenna experimentation!

Even so, here's some interesting and useful data on the inverted-V dipole antenna. This simple antenna is very popular. It has the forgiving characteristics of the dipole (easy to get into operation), it is inexpensive, a good radiator and it can be supported from a single center point.

This past summer some extensive tests were run on the inverted-V dipole by JA5COY (Japan) and were reported in a recent issue of *CQ-ham radio*, published in Tokyo.

JA5COY made measurements summarized in **fig. 1**. The first tests were on an 80-meter dipole (**fig. 1A**). The antenna exhibited a feedpoint impedance very close to 73 ohms, as expected, and the bandwidth between the 2-to-1 SWR points was about 330 kHz.

He then dropped the ends of the dipole to form an included angle of 120 degrees and repeated his tests (**fig. 1B**). The feedpoint impedance dropped from 73 ohms to 50 ohms and the bandwidth dropped to 310 kHz. In addition, the resonant frequency of the antenna dropped about 15 kHz.

The last experiment was to decrease the included angle to 90 degrees (**fig. 1C**). The feedpoint impedance dropped down to 30 ohms at resonance and the bandwidth further decreased to 210 kHz between the 2-to-1 SWR points of measurement. And, finally, the resonant frequency dropped about 35 kHz from that of the straight, horizontal dipole. Antenna height during these tests was not noted.

This is handy information, as it provides all that is needed for a pre-cut inverted-V dipole antenna. The summation is:

Dipole antenna:

Length for resonant frequency

$$= \frac{468}{f(MHz)}\ feet$$

(Feedpoint impedance approximately 73 ohms.)

Inverted-V dipole antenna:

Included angle = 120 degrees

Length for resonant frequency

$$= \frac{465.6}{f(MHz)}\ feet$$

(Feedpoint impedance approximately 50 ohms.)

Inverted-V dipole antenna:

Included angle = 90 degrees

Length for resonant frequency

$$= \frac{463.3}{f(MHz)}\ feet$$

(Feedpoint impedance approximately 30 ohms.)

As an example, suppose you want an inverted-V dipole for 80-meter phone operation to cover the range of 3750 to 4000 kHz. This is a span of 250 kHz. An antenna with an angle of 120 degrees included will do the job as it provides a bandwidth of about 310 kHz and — best of all — has a feedpoint impedance of about 50 ohms when mounted at a reasonable height above ground.

The mid-point of the chosen range is 3875 kHz, so the dipole is cut for this frequency:

$$Inverted\text{-}V\ dipole\ length = \frac{465.6}{3.875}$$

$$= 120.15\ feet,\ or\ 120\ feet,\ 2\ inches$$

(round it off to 120 feet).

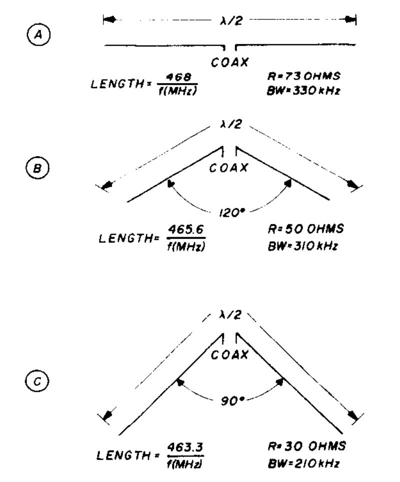

fig. 1. Comparison of feedpoint impedance (R) and bandwidth (BW) for dipole (A) and the two versions of the inverted-V dipole (B and C).

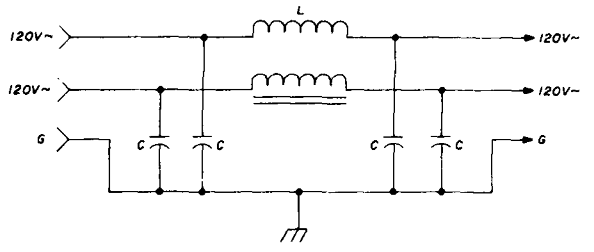

fig. 2. A simple line filter you can make. The dual winding coil (L) is composed of 20 bifilar turns No. 18 insulated wire, wound on a ferrite rod, 1/2-inch diameter. Rod is 61 nickel-zinc material having a permeability of 125 (J.W. Miller FR-500-7 or Amidon R61-050-750). Wires are wound in parallel and ends are held in place with twine and epoxy cement. Capacitors (C) are 0.01-μF ceramic units, rated for continuous operation at 125 Vac and can withstand surges to 1400 volts (Aerovox AC-7, Centralab CI-103 or Sprague 125L-S10). Filter is built on a metal plate bolted within an aluminum chassis which serves as a dust cover. (Filter data from *Interference Handbook*, by Nelson, published by Radio Publications, Inc., Box 149, Wilton, Connecticut 06897).

Thus, the dipole will be 60 feet on a leg, with an included angle of 120 degrees and should cover the complete 80-meter phone region with an SWR of less than 2-to-1.

The antenna can be zeroed-in for minimum SWR by raising or lowering the ends of the dipole. As in the case of any antenna, the presence of nearby metallic objects (power lines, TV antennas, etc.) may alter the performance and SWR a bit.

more about TVI and RFI

TVI and RFI seem to be a sore subject these days. More hams and more entertainment equipment is the prime factor, plus the fact that solid-state circuits, as used in home entertainment equipment, operate at a lower signal level than does the older, tube-style gear. Nevertheless, the Amateur operator should make sure his equipment is clean and a few simple preventive, anti-TVI steps should be taken *even if there is no TVI or RFI*. Better to be safe than sorry!

Cleaning up the exciter: at the very least, an rf line filter should be used with the exciter to prevent rf from finding its way into the primary power line. A simple and effective line filter, such as the J.W. Miller[1] C-508-L, or equivalent, will be satisfactory. In addition, the exciter should be grounded (more about this later).

Cleaning up the linear amplifier: an rf line filter should be used on the linear amplifier. J.W. Miller Co., and others, make suitable filters, or you can build your own. A practical filter is shown in **fig. 2**.

Your antenna system: you'll require a lowpass filter between your transmitter and your antenna. It should go in the 50-ohm coaxial line after all such devices as SWR meters or coaxial switches. That is, there should be nothing between the filter and the antenna except the interconnection line. Several makes of lowpass filters are available; a good one is the Barker & Williamson 425, rated at 1 kW.[2] (The model 424 filter is rated at 100 watts — just the thing for your exciter.) Both these filters are designed for 50-ohm coaxial systems.

Your ground system: the station ground is important, especially from the FCC point of view. If you are ever visited by the FCC or a TVI committee, one of the first questions they will ask is, "Is the transmitting equipment grounded?"

To protect yourself in this instance, you'll need a ground lead from the equipment to the nearest ground point: either a water pipe ground or an external ground rod driven into the soil.

From a legal point of view, this satisfies the requirement. *But I don't* have to tell you that such a ground is worthless as an rf ground. Unfortunately, a good rf ground is hard to get, unless your station is at ground level and the ground wire from the equipment to the ground is only a foot or two long! In most cases, this is an impossible requirement.

In my case, I am on the ground floor of my home. I connected all equipment (receiver, exciter, amplifier) together with flexible No. 10 insulated copper wire. *I did not depend* upon the shields of the coaxial interconnecting wires to do the job. The next step was to drill a small hole in the floor behind the operating table and drive an eight-foot (2.5 m) ground rod down into the earth through this hole, until only an inch of the rod protruded into the room. I then ran a No. 10 flexible wire from the equipment to the ground rod.

This provided a satisfactory ground on all bands except 10 meters. I found that I still had some rf floating around the equipment on that band, even though everything was supposedly at ground potential. I didn't want to drive another ground rod under the house (it was a terrible job), so I drove one into the ground at the point where my coaxial line came from under the house and passed across the yard to the antenna tower. I grounded the shield of the coaxial line to this ground rod and then, spurred on by over-enthusiasm, I *drove a third ground rod* at the base of the tower and tied the coaxial shield and the tower to this rod. In addition, I bypassed all the rotor control wires to the ground rod at the base of the tower.

That seemed to do the job. All equipment was rf-cold on all bands, I used a lowpass TVI filter for the transmitter and all power leads were filtered and bypassed. That should make my equipment TVI-proof. Did it?

cleaning up the TV receiver

The answer to the question, of course, is no. While my transmitting equipment was reasonably clean, both my TV receiver and those of my neighbors were wide open to strong local signals in the ham bands. My receiver (a ten year old RCA XL-100) turned black in the face when I went on the air with the linear amplifier — on any band!

When I removed the back from the set, the reason was apparent: a rat's nest of interconnecting wires running between printed circuit boards and no sign of any filtering or protective circuits. (The TV set was much worse, from a TVI point of view, than my previous one — an old tube model with very good internal shielding).

To clean up this receiver, it was necessary to use a line filter (J.W. Miller C-508-L), plus a good high-pass filter on the antenna ribbon line. One of the best filters is the J.W. Miller C-513-T3. This is a multiple section design enclosed in an aluminum box. It provides more low frequency attenuation than simpler filters.

The combination of the line filter and the high-pass antenna filter did the job. Now I could operate at full power on all bands below 30 MHz with no TVI. Eventually, I got Miller line and high-pass filters for my nearby neighbors and now I am clean on their TV receivers.

what about stereo equipment?

Ham signals can easily get into stereo gear and can cause a lot of problems. Again, the cause is simple. The equipment is mostly solid-state, operates at low signal levels and has no shielding or filtering against strong nearby radio transmissions! The stereo market is very competitive and everything that can be done to save a penny is done, and this includes omission of any RFI suppression circuits.

Filtering and bypassing interconnecting leads usually solves this vexing problem, but the subject is too complex to cover in this short article. A recommended publication tells the whole story and gives you plenty of good data on RFI problems in general.[3]

table 1. List of stations registered for operation on 10.1 and 10.15 MHz.

kHz	mode	call	location	kW	remarks
10,100.0	RTTY	RUZU	Molodezhnaya Base, Antarctica		Meteo
100.5	CW	KNY28	Washington, DC, U.S.A.	1.0	Algerian Embassy
102.0	RTTY	YIF25	Baghdad, Iraq	2.5	PTT
103.0	"	YIE99	" "	2.5	INA
103.3	ISB	WWL20	San Juan, PR, U.S.A.	2.0	Telcom
105.0	RTTY	RKA79	Moscow, U.S.S.R.	20.0	TASS
105.0	"	STL52	Khartoum, Sudan	5.0	SUNA
113.0	"	FJY2	Port-aux-Francais, Kerguelen Is.	1.0	Meteo/TFC
114.7	ISB	TTZ	N'Djamena, Chad	6.0	Telcom/TFC
115.0	CW	8PX	Barbados, Barbados	0.2	TFC
115.0	FAX	BAF4	Beijing, P.R. China		Meteo
116.5	RTTY	5NK33	Kano, Nigeria	3.5	Meteo
118.0	USB	RGI24	Moscow, U.S.S.R.	15.0	R. Moscow Feeder
118.5	RTTY	OEM70	Vienna, Austria	5.0	Meteo
118.7	"	STK	Khartoum, Sudan		Aero
120.0	"	HMR59	Pyongyang, North Korea		KCNA
122.0	"	AWC	Calcutta, India	2.5	Aero
123.1	CW	CSP40	Guarda, Portugal		Air Force
125.0	RTTY	ETD3	Addis Ababa, Ethiopia	2.5	Aero
125.0	"	OLG3	Prague, Czechoslovakia	30.0	TFC
126.0	"	DKZ	Berlin, German D.R.		DP
127.5	"	NGD	McMurdo Base, Antarctica	15.0	USN
128.0	ISB	JBE30	Tokyo, Japan	10.0	TFC
130.0	RTTY	NAA	Colter, ME, U.S.A.	15.0	USN
130.0	"	YIF29	Baghdad, Iraq		INA
130.0	FAX	RBW48	Murmansk, U.S.S.R.	20.0	Meteo
132.0	RTTY	TNL55	Brazzaville, Congo	1.5	Aero
133.0	"	J3R			UNID
135.0	ISB	IRH31	Rome, Italy	10.0	Telcom
136.6	CW/USB	-	Emergency Nets of U.S.A.		USCG
137.0	RTTY	TNL97	Brazzaville, Congo	1.5	Meteo
140.0	RTTY/CW	RUZU	Molodezhnaya Base, Antarctica		Meteo/TFC
140.0	RTTY	UBJ	Baku, U.S.S.R.		Meteo
140.0	CW	UGE2	Bellingshausen Base, Antarctica		TFC
143.0	RTTY	A9C	Bahrain, Bahrain		Aero
144.9	"	HBO20	Geneva, Switzerland	10.0	
145.0	"	JAE30	Japan		
147.0	USB	TUP	Abidjan, Ivory Coast	2.0	Telcom
150.0	RTTY	SUA246	Cairo, Egypt	10.0	MENA

two new, good books for Radio Amateurs

It is always refreshing to find publications of interest to Radio Amateurs. Prentice-Hall publishers (Englewood Cliffs, New Jersey) are entering this field with two new books by Doug DeMaw, W1FB. Doug, as you know, is the Senior Technical Editor of *QST* magazine.

Doug's first book is *Ferromagnetic-Core Design & Application Handbook.*[4] This hardcover, 256-page book covers design and use of inductors using toroids, rods and pot cores for ferrite and powered-iron materials.

Ferromagnetic materials are common today in receiver and transmitter circuits, power supplies, and antenna baluns, but the use and theory of these interesting devices are shroud-

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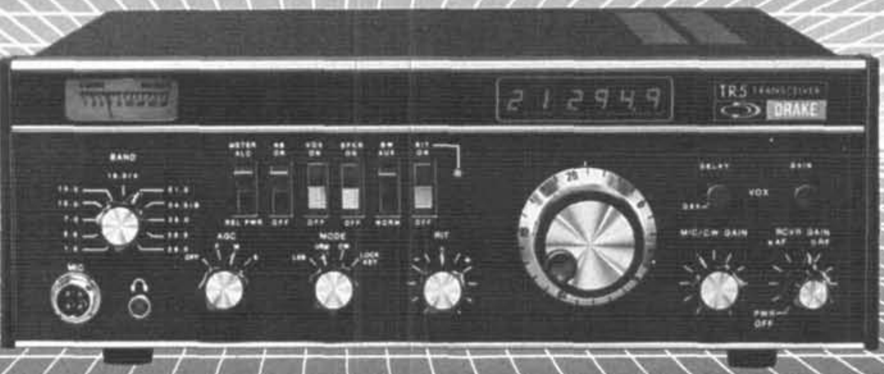

A NEW DIMENSION IN PERFORMANCE

• U.S. Made • Competitive Price • All Solid State • 12V DC • SWR Protected •
• Broadband • No Tune Up • Full Break-in CW • 150 Watts PEP, SSB or CW Input •
• High Dynamic Range • Excellent Sensitivity/Selectivity • Digital Readout •
• 160-10 Meters Plus WARC Bands and MARS Coverage* •

Front panel switching allows independent MODE and optional crystal filter selection.

A passive double balanced mixer is employed in the receiver front end. This stage is preceeded by a low noise high dynamic range bipolar rf amplifier to provide good, strong signal performance and weak signal sensitivity.

Accurate digital readout of operating carrier frequency is displayed to 100 Hz.

A rugged, solid-state PA provides continuous duty in SSB and CW modes. A cooling fan (FA7) is available for more demanding duty cycles, such as SSTV or RTTY. The PA also features very low harmonic and spurious output.

VOX GAIN, VOX DELAY, VOX disable, QSK, selectable AGC time constants, RIT and noise blanker selection are front panel controlled for ease of operation.

The TR5 is designed with modular construction techniques for easy accessibility and service.

GENERAL

Frequency Coverage: 1.8-2.0*, 3.5-4.0, 7.0-7.5, 10.0-10.5, 14.0-14.5, 18.0-18.5*, 21.0-21.5, 24.5-25.0*, 28.0-28.5*, 28.5-29.0, 29.0-29.7* MHz. (*With accessory range crystal).

Modes of Operation: Usb, Lsb, Cw.

Frequency Stability: Less than 1 kHz drift first hour. Less than 150 Hz per hour drift after first hour. Less than 100 Hz change for a ± 10% line voltage change.

Readout Accuracy: ± 10 ppm ± 100 Hz.

Power Requirements: 13.6 V-dc regulated, 2 A. 12 to 16 V-dc unregulated, 0.8 V rms maximum ripple, 15 A.

Dimensions:
Depth: 12.5 in (31.75 cm), excluding knobs and connectors.
Width: 13.6 in. (34.6 cm).
Height: 4.6 in. (11.7 cm) excluding feet.

Weight: 14 lb. (6.35 kg)

TRANSMITTER

Power Input (Nominal): 150 Watts, PEP or Cw.

Load Impedance: 50 ohms.

Spurious and Harmonic Output: Greater than 40 dB down.

Intermodulation Distortion: Greater than 30 dB below PEP.

Carrier Suppression: Greater than 50 dB.

Undesired Sideband Suppression: Greater than 60 dB at 1 kHz.

Duty Cycle:
Ssb, Cw: 100%.
Lock Key (w/o FA7 Fan): 30%, 5 minutes maximum transmit.
Lock Key (w/FA7 Fan): 100%.

Microphone Input: High Impedance.

Cw Keying: Instantaneous full break-in, adjustable delay.

RECEIVER

Sensitivity: Less than 0.5 uV for 10 dB S + N/N except less than 1.0 uV, 1.8-2.0 MHz.

Selectivity: 2.3 kHz minimum at − 6 dB. 4.1 kHz maximum at − 60 dB (1.8:1 shape factor).

Ultimate Selectivity: Greater than − 95 dB.

Agc: Less than 5 dB output variation for 100 dB input signal change, referenced to agc threshold.

Intermodulation: (20 kHz or greater spacing) *Intercept Point:* Greater than 0 dBm. *Two-Tone Dynamic Range:* Greater than 85 dB.

I-f Frequency: 5.645 MHz.

I-f Rejection: 50 dB, minimum.

Image Rejection: 60 dB, minimum below 14 MHz. 50 dB, minimum above 14 MHz.

Audio Output: 2 watts, minimum @ less than 10% THD (4 ohm load).

Spurious Response: Greater than 60 dB down.

ACCESSORIES AVAILABLE

Model 7021 SL300 CW Filter
Model 7022 SL500 CW Filter
Model 7027 SL1000 RTTY Filter
Model 7023 SL1800 RTTY Filter
Model 7026 SL4000 AM Filter
Model 7024 SL6000 AM Filter
Model 1570 PS75 AC Power Supply
Model 1545 RV75 Synthesized Remote VFO
Model 1531 MS7 Speaker
Model 1507 CW75 Keyer
Model 1558 NB5 Noise Blanker
Model 7077 Microphone

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ed in mystery for most Amateurs. Doug's book tells the whole story in simple words and terms and covers circuit design and application from A to Z. The information is invaluable and the book should be in every ham's library. Of great help is the section covering available cores and rods. Now when some article specifies a core with a red dot on it, or Q-2 material, I'll know what the author is talking about!

Doug's second book is *Practical RF Design Manual*,[4] a hardcover book of 246 pages. This is a gold mine of information for the experimenter who designs and builds his own equipment, or for the inquisitive Amateur who wants to know how his gear works. It covers the important circuitry used in today's exciters, receivers and transceivers. It contains in-depth coverage that general-coverage handbooks can't afford to include, mainly because of a restriction on the total number of pages in the publication.

The book has an impressive section on receiver dynamic range, and equally handy sections on frequency control systems, very useful to the home constructor. It also includes more data on small- and large-signal amplifiers than I have ever seen in one publication. Best of all, the book is written in language the average Amateur can understand.

the 10-MHz Amateur band

I have monitored the 10-MHz band almost daily during the past year. Over 50 countries permit Amateur operation on this band and such good DXers as FB8WG and VK9YC operate regularly in the 10-MHz region. By the date this is in print, the band should be open to American Amateurs.

It is interesting to compare those who should be in this region against those who are actually there. **Table 1** shows the official International Telecommunications list of stations registered for operation between 10.1 and 10.15 MHz. Careful monitoring of the band during the summer showed that most of these stations really weren't there, with the exception of NAA's powerful RTTY signal at 10.130 MHz. Most of the rest of the ITU-registered stations were conspicuous by their absence. In their place was a rag-tag group of intruders who have less legal reason for being there than do Radio Amateurs.

the new Radio Handbook

The twenty-second edition of the *Radio Handbook* (Howard W. Sams Co., publisher) has been on the market for a few months.[5] I have edited this book since the fourteenth edition (1956). It is interesting to note the tremendous advance made in Amateur Radio in 26 years!

The new edition is primarily devoted to solid-state equipment, sideband and linear amplifiers — the latter hardly mentioned or known in 1956. And in addition, counters, phase-locked oscillators, fm, satellite communication, moonbounce, slow-scan TV, RTTY, color TV, spread-spectrum transmission, keyboards, keyers, solid-state amplifiers, and low noise reception are covered in the twenty-second edition of the *Radio Handbook*.

ham radio

references

1. A copy of the J.W. Miller catalog can be obtained free by writing to: Bill Courtney, J.W. Miller Division, Bell Industries, Box 5825, Compton, California 90224.
2. A copy of the B&W catalog can be obtained free by writing Elmer Bush, Barker and Williamson, 10 Canal St., Bristol, Pennsylvania 19007.
3. RFI is no problem if you don't have it, but many headaches if you do. Recommended reading on this subject is the *Interference Handbook*, by William Nelson, WA6FQG, former RFI investigator, Southern California Edison Company. The Ham Radio Bookstore has this *Handbook*, or it may be ordered from Radio Publications, Box 149, Wilton, Connecticut 06897.
4. These books are available from the Ham Radio's Bookstore for $28.95 each plus $2.00 shipping and handling.
5. Available from the Ham Radio's Bookstore, Greenville, New Hampshire 03048 for $34.95 plus $2.00 shipping and handling.

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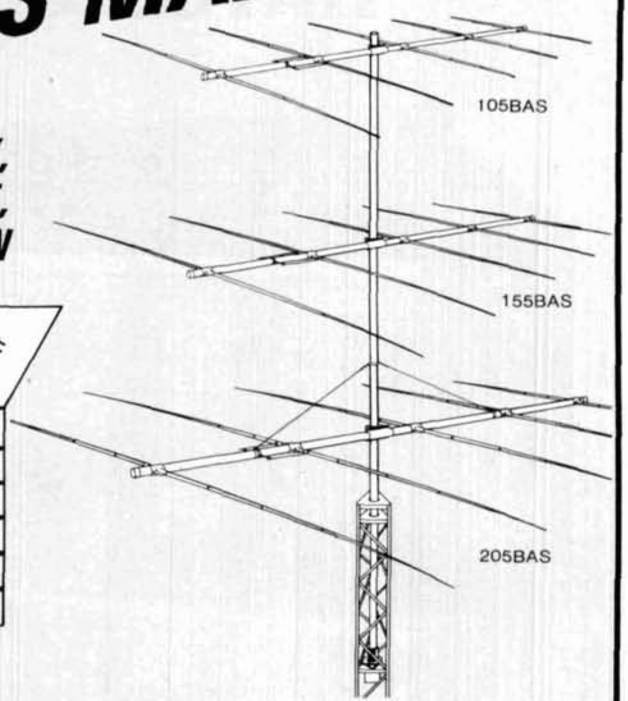
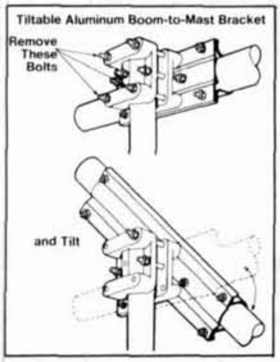


MAX. MECHANICAL INTEGRITY, ELECTRICAL PERFORMANCE, SPACE SAVINGS AND SELECTION

MODEL NO.	AVERAGE GAIN (db)	MAXIMUM F/B RATIO (db)	NO. OF ELEMENTS	LONGEST ELEMENT (ft.)	LONGEST ELEMENT (m)	BOOM LENGTH (ft.)	BOOM LENGTH (m)	TURNING RADIUS (ft.)	TURNING RADIUS (m)	BANDS (Meters)	SHIPPING WEIGHT (lbs.)	SHIPPING WEIGHT (kg)
402BAS	4.9	25	2	45.9	14	16.1	4.9	25	7.6	40	47	21.3
204BAS	10	25	4	36.5	11.1	26	7.9	22.5	6.7	20	55	25
205BAS	11.6	35	5	36.5	11.1	34	10.4	25	7.6	20	77	35
155BAS	12	25	5	24.5	7.5	26	7.9	17.5	5.3	15	42	19
105BAS	12	35	5	18.5	5.6	24	7.3	15	4.6	10	29	13

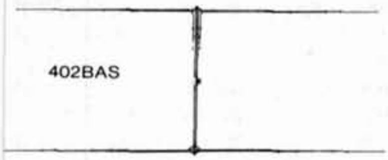
3-Element Monobanders also available.
Optional BN-86 balun recommended for above antennas.

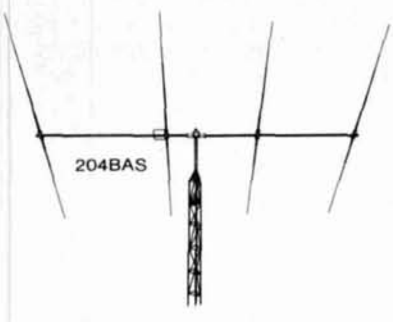


MECHANICALLY Hy-Gain monoband antennas employ the best materials available and are fabricated with accurate tooling for an integral balance so all parts work together. For example, our element-to-mast brackets are the best in the industry and our tiltable mast-to-boom clamps are unique. Stainless steel hardware is chemically passivated to eliminate rust. All tubing and parts are deburred and finished so you don't have to re-manufacture the antenna before installation. *It all adds up to antennas with maximum mechanical integrity that withstand 80 mph (129 km/h) windloads and radial ice.*

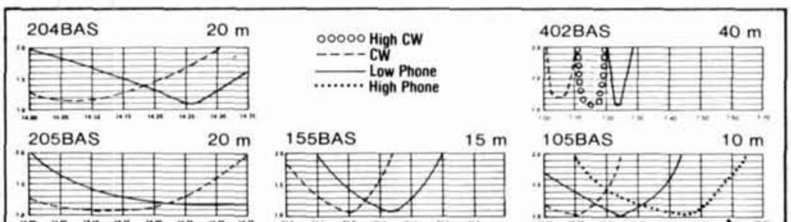
ELECTRICAL *performance is not based on* theoretical calculations alone but is tuned and tested for optimum results on our government approved test range. Hy-Gain's factory tuned 52 ohm Beta Match is exclusive and assures positive dc ground for lightning protection and reduced precipitation static. Though sometimes unconventional, our meticulous element spacing assures maximum F/B ratio and uncompromising power gain. VSWR at resonance *is less than 1.5:1. All Hy-Gain monobanders* handle maximum legal power with a 4:1 safety margin. In short, electrical performance is at maximum by design and requires no re-tuning.

SPACE problems are virtually eliminated. Even our largest monoband antennas fit most residential lots. And thanks to Hy-Gain's careful materials selection and superb mechanical engineering, the weight and windload of antennas is at an absolute minimum to permit stacking on conventional heavy duty towers and rotators. *This gives you maximum DX performance even with limited space.*





MONOBAND BEAMS



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The filtering system, a TEN-TEC exclusive, virtually switches to privacy. It starts with a superb 2.4 kHz 12-pole ladder sideband filter system, standard. It provides variable bandwidth for ssb, great for today's crowded phone bands. A novel pass band tuning circuit allows a received signal to be moved within the pass band to its optimum position with respect to QRM. Optional narrow band filters are available for ssb, cw and RTTY, all switched from the front panel. The ultimate in QRM reduction.

Full cw break-in opens a window on the band while transmitting, turning monologues into conversation. Or, if conditions dictate, just switch to semi-break-in. And no VOX adjustment when changing modes.

A versatile offset tuning system allows the receiver and transmitter to be tuned separately with a ± 1 kHz range for fine tuning or ± 4 kHz for working off frequency. For net operation, both can be moved simultaneously.

Reliability is designed in. The CORSAIR system is so rugged it will operate into infinite SWR. And we guarantee it unconditionally (except for lightning) for one year. The CORSAIR is designed for 100% duty cycle, ideal for RTTY, SSTV and of course, contests.

Beauty is more than skin deep. The contemporary styling with the blackout LED frequency display (last digit in green), the baked-on textured bronze/black finish with aluminum trim will retain its handsome appearance permanently. Beneath its sleek exterior is a carefully crafted chassis packed with performance.

There are many other features, each with superb performance. An effective speech processor, notch filter, adjustable noise blanker, signal spotter, three position AGC, threshold ALC, simplified VOX, all controlled from the front panel. In addition, the CORSAIR has a compression loaded speaker, less than 2% audio distortion, and full accessory connections including remote bandswitch output. It even has a volume equalizing headphone output.

The CORSAIR is a total system of pure operating pleasure—it really must be put through its paces to be fully appreciated. Its smooth controls, comfortable and logically spaced, give it the feel of a superlative transceiver. One that will be a faithful companion for the years ahead.

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Now, you can enjoy over 60 television channels with Lowrance Earth Station/System 7 Receiver.

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With the magic of satellites, you can receive more than 60 channels of television and over 20 channels of stereo directly into your home. Including first-run movies, sports events, special children's shows, religious programs, news, live coverage of Congress, farm reports — and much, much more.*

It all comes from a satellite earth station — consisting of a dish antenna, amplifier and satellite receiver. The station picks up signals from satellites thousands of miles overhead and converts them into television and stereo for you to enjoy. And it's surprisingly affordable. (Systems start as low as $2,900.)

The most advanced receiver on the market today is System 7, made by Lowrance Electronics. We supply the satellite receiver, and our distributors add a dish antenna. Lowrance has been a leader in the electronics industry for more than 25 years now. You may already be familiar with our sportfishing sonar products, acclaimed as the finest in the world. And we're building that same quality and reliability into our satellite receivers.

Right now, you're missing out on worlds of entertainment. For more information on the Lowrance Earth Station/System 7 Receiver, clip the coupon below and mail.

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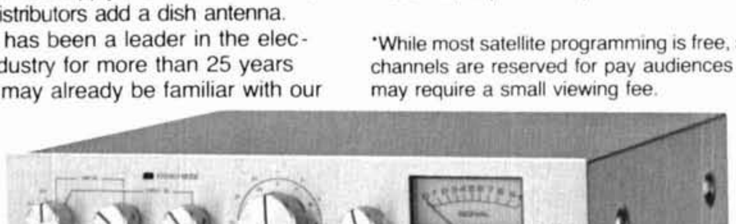

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More Details? CHECK—OFF Page 132

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Measures resistance from 10 milliOhms to 20 Ohms. Now you can measure resistance down to 10 milliOhms with this low cost, easy to use DVM module. Check coil resistance, transformers, relays, chokes, printed circuit board copper paths and ground cables. Special zero balance control nulls out input cable resistance to insure accurate readings. Your DVM has to be set to 2V range during operation.

- Resistance range 10 milliOhms to 20 Ohms
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A fully assembled and tested triple benchtop power supply. Includes fixed 5V @ 1 Amp, 5V to 15V @ 0.5 Amp and −5V to −15V @ 0.5 Amp—all supplies regulated, short proof. Each supply has a power on indicator LED. Complete and ready for use in a durable (8" x 6" x 3½") metal case.

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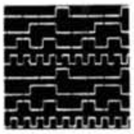

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- 8 TTL compatible input channels (1 TTL load per channel) can drive 50 Ohm scope cable.
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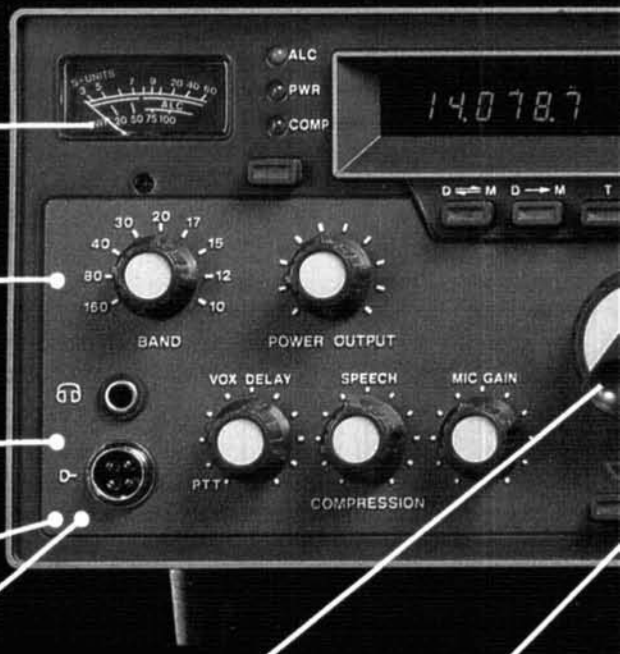

Entirely solid-state, broadbanded in design. Delivers 100 watts out on SSB, CW and RTTY.

Built-in Motorized Bandswitch rotates band selector to the desired setting under remote control.

A *Terminal Interface* offers two-way communication between the Transceiver and an ASCII teletype, video terminal or computer through a rear panel RS-232C I/O port.

Commands are available to select, display and change the band, mode, all 27 memory and operating frequencies, passband shift, plus the band scanning and baud rates.

Also, set and toggle T/R/Tr status on the display, and freely manipulate the three frequencies on each band, with full diagnostic error-prompting.

Main tuning dial has optically-encoded shaft for smooth, linkage-free control and zero backlash.

Pushbutton up & down variable-speed scan traverses the band in 16 selectable rates, with 100 Hz final resolution and ultra-low drift.

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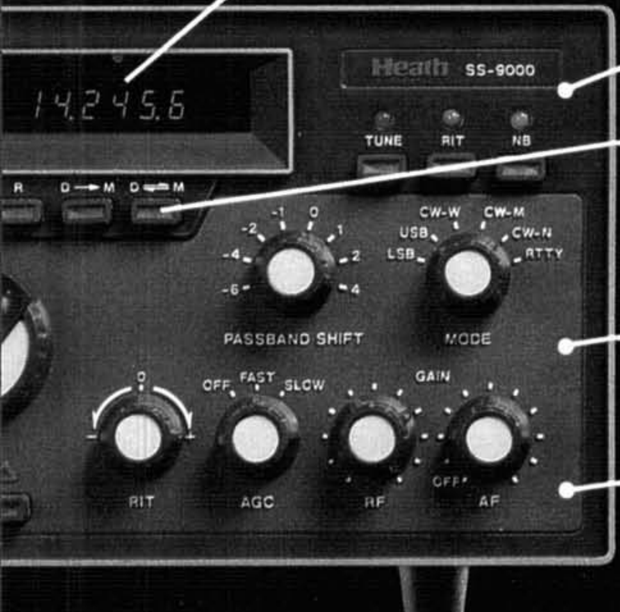
Unique dual digital display gives the smart operator multiplied advantage in frequency-handling speed and agility.

100% synthesized and microprocessor-based. A crystal controlled master oscillator provides exact PLL reference for super stability and repeatability.



Simultaneous readout of working frequencies. Pushbutton exchange with (and copy into) memory or opposite display permits instantaneous QSY.

256 bytes of on-board CMOS Random Access Memory accepts three inputs per band (preserved with battery backup) for a total of 27 frequencies to recall and work at will.

Superior over-current, thermal and high VSWR protection incorporated for safe, worry-free operation.

Assembled and tested in the USA.

The PS-9000 AC Power Supply with Speaker and independent 12/24-hour digital clocks (illustrated below) is a perfectly matched component.

Add the Heathkit SA-1480 Remote Coax Switch. When changing bands, the proper antenna will be selected automatically.

MORE IN THE CATALOG

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See last page for nearest location.

the ham notebook

Ten-Tec 645 ultramatic keyer mods

I run my station on battery 100 percent of the time, and am always looking for a way to trim a few milliamps of drain. I became concerned with the appetite of my Ten-Tec 645 Ultramatic Keyer the first time I put a meter in series and discovered a quiescent drain of over 300 mA. After opening the case and pulling the board, I burned my thumb on the two 68 ohm 2-watt resistors used to drop the 12 Vdc line.

I removed R_{17}, R_{18}, and D_3, a 5.6 volt zener diode. In this same space I mounted an LM340 T-5 three-terminal regulator and a small heatsink. The regulator mounted easily after I drilled a single hole for the middle (ground) wire. I could then put the keyer back in its original shape without a lot of telltale holes in the board.

Because this regulator is some distance from the 12 volt supply, I used an external bypass capacitor of 0.22 μF on the input terminal of the regulator. Mount it as close as possible to the regulator. The 0.1 μF capacitor recommended for the output is provided by C_9 already in place.

Next socket the ICs and substitute some 7400 LS chips for the original 7400s. I did this on a trial and error basis and found it worked for IC-1, IC-2, IC-3 but *not* IC-4 and IC-5. Thus, you need two 74LS00 (IC 1 and 2) and one 74LS10 (IC-3). A check showed 120 mA quiescent, almost a two-thirds reduction! Not enough to fool with if you are using commercial ac, but enough to make a difference for extended battery operation.

Adding an extra key jack in parallel with the output of the 645 keyer allows you to use a straight key. Mount the phono jack on the rear panel and bypass with a 0.01 μF capacitor.

The low speed range of the keyer can be expanded by changing the value of R_1 from 4.7K to 8.2K. Unless you really need 50 WPM, it is much nicer to be able to accurately adjust in the 10-20 WPM range; the top end is still above 40 WPM.

A stereo (three conductor) jack can be added to the rear panel to allow the use of the 645 paddles to feed a memory keyer (such as the Autek MK-1). Use a shorting jack and the paddles return to the 645 when the plug is removed. This saves getting used to new paddles for contest work.

Gil Frey, Jr., K4JST

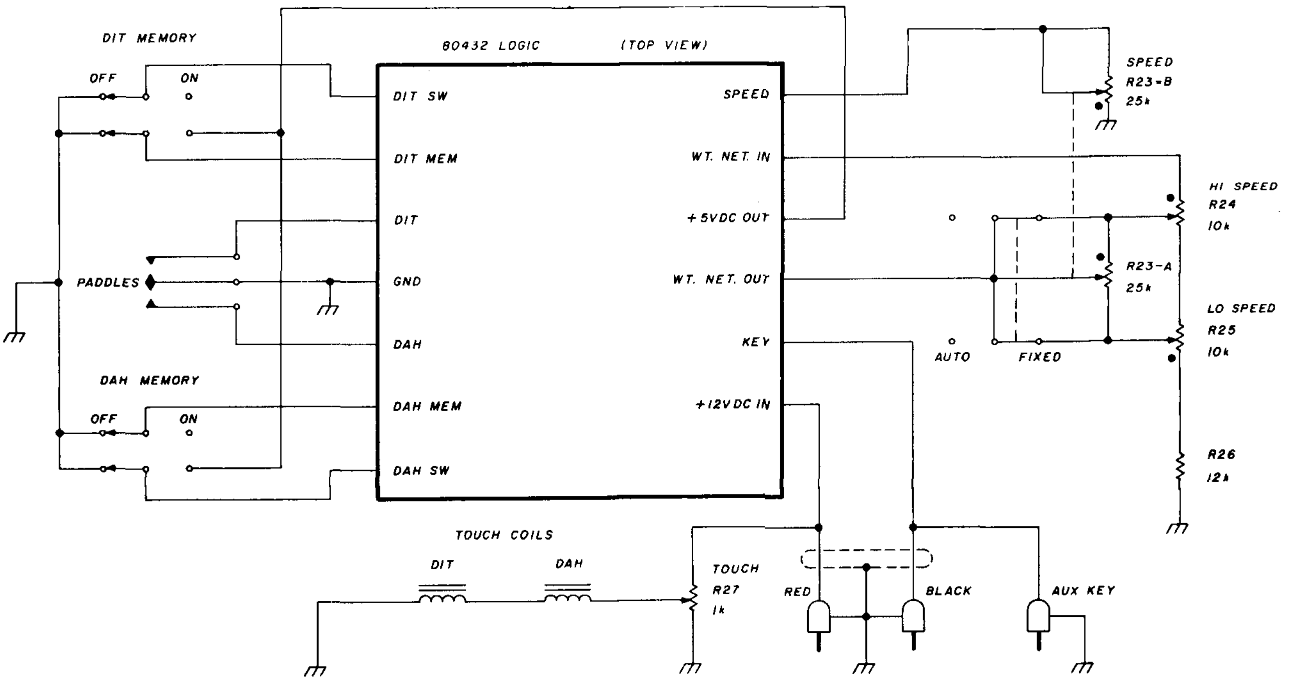

fig. 1. Logic board.

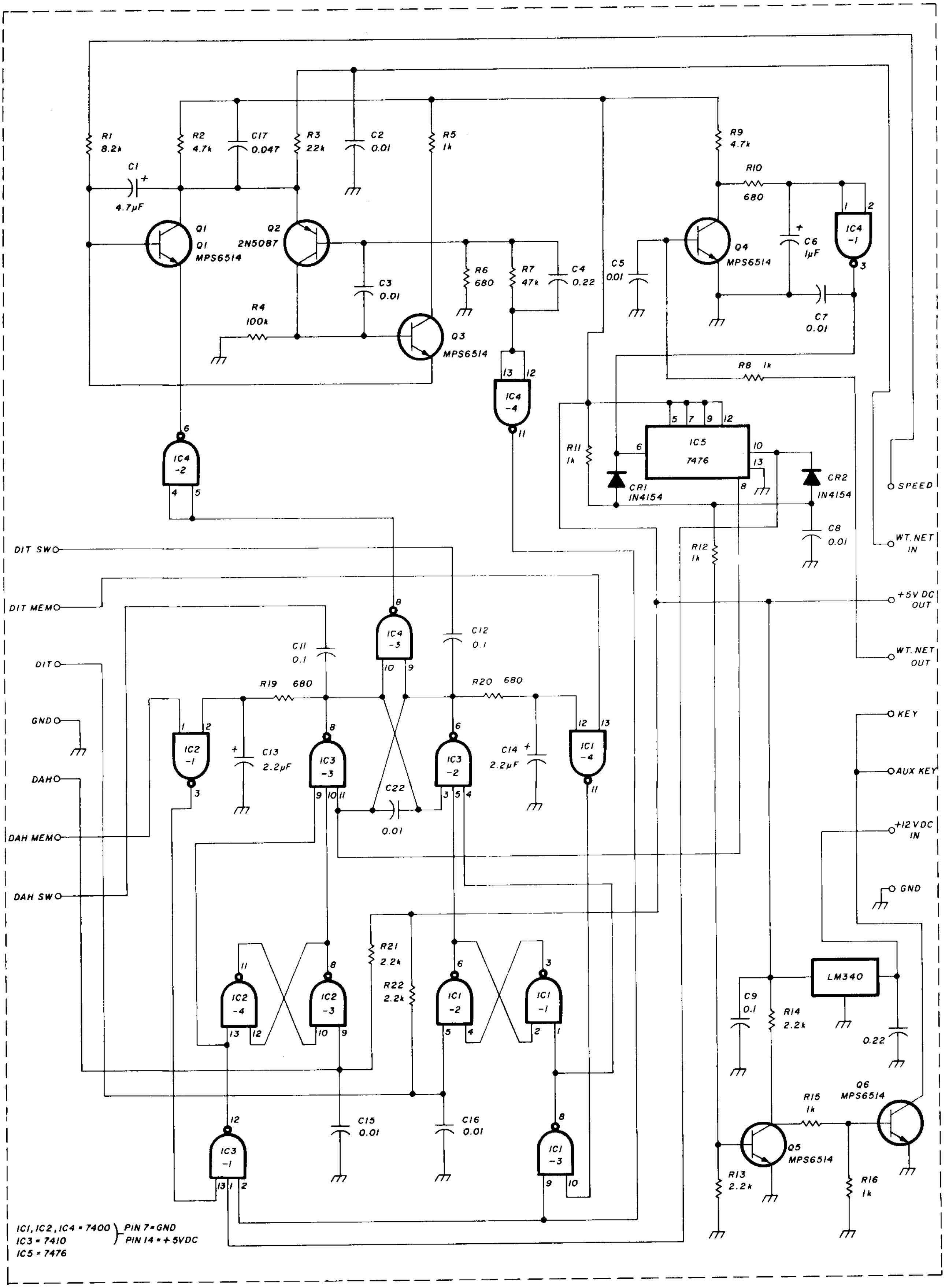

fig. 2. Wiring block diagram.

The ultimate team...the new Drake "Twins"

The TR7A and R7A offer performance and versatility for those who demand the ultimate!

TR7A Transceiver

• **CONTINUOUS FREQUENCY COVERAGE** — 1.5 to 30 MHz full receive coverage. The optional AUX7 provides 0 to 1.5 MHz receive plus transmit coverage of 1.8 to 30 MHz, for future Amateur bands, MARS, Embassy, Government or Commercial frequencies (proper authorization required).

• **Full Passband Tuning (PBT)** enhances use of high rejection 8-pole crystal filters.

New! **Both 2.3 kHz ssb and 500 Hz cw crystal filters, and 9 kHz a-m selectivity are standard,** plus provisions for two additional filters. These 8-pole crystal filters in conjunction with careful mechanical/electrical design result in realizable ultimate rejection in excess of 100 dB.

New! **The very effective NB7 Noise Blanker is now standard.**

New! **Built in lightning protection** avoids damage to solid-state components from lightning induced transients.

New! **Mic audio available** on rear panel to facilitate phone patch connection.

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New! **NB7A Noise Blanker supplied as standard.**

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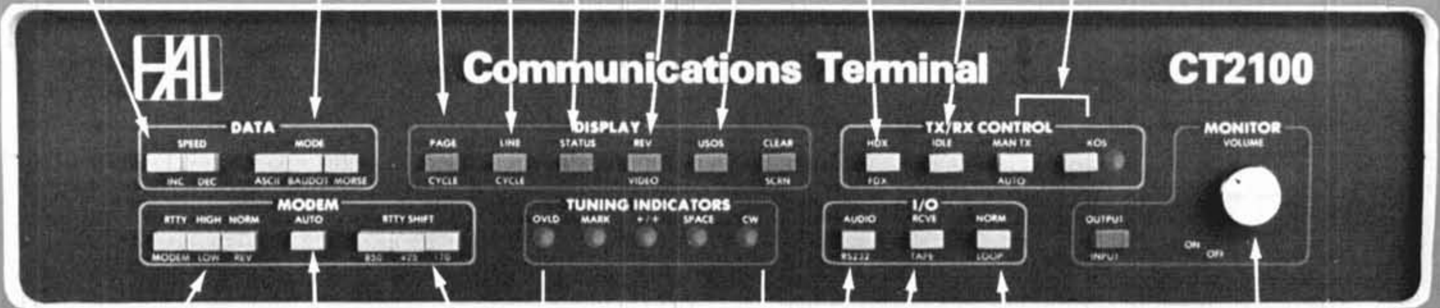

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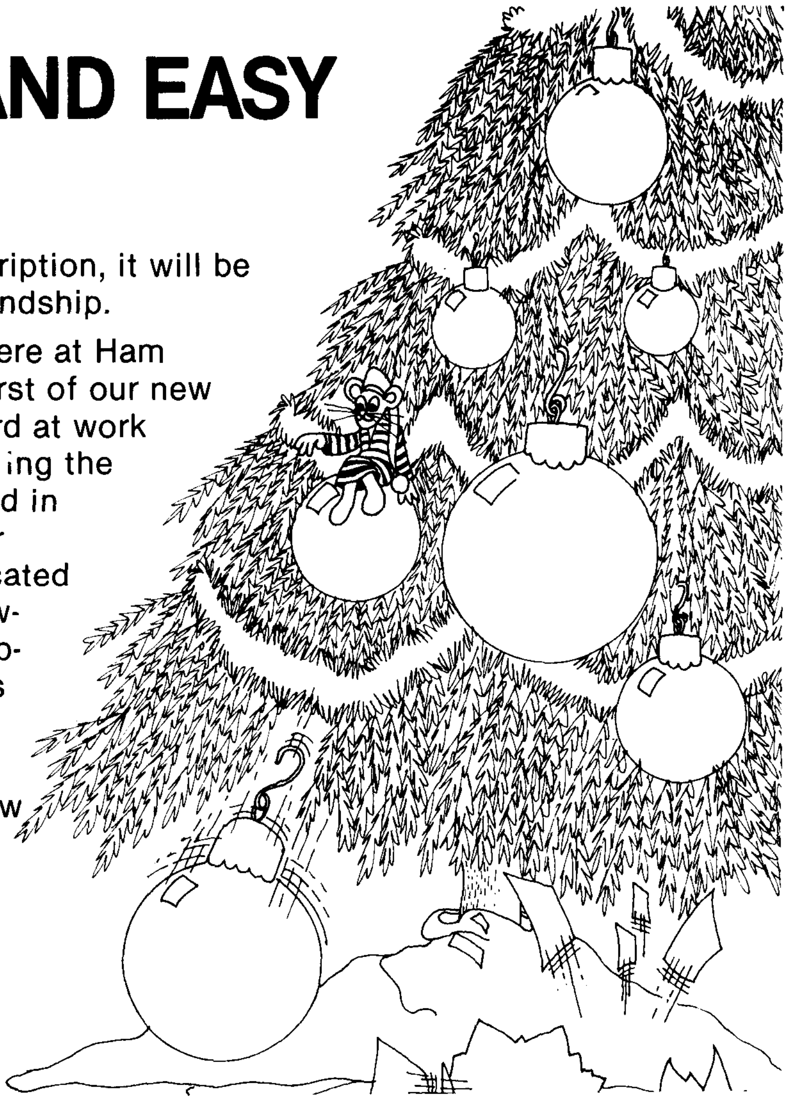

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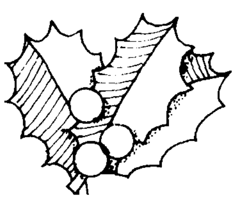

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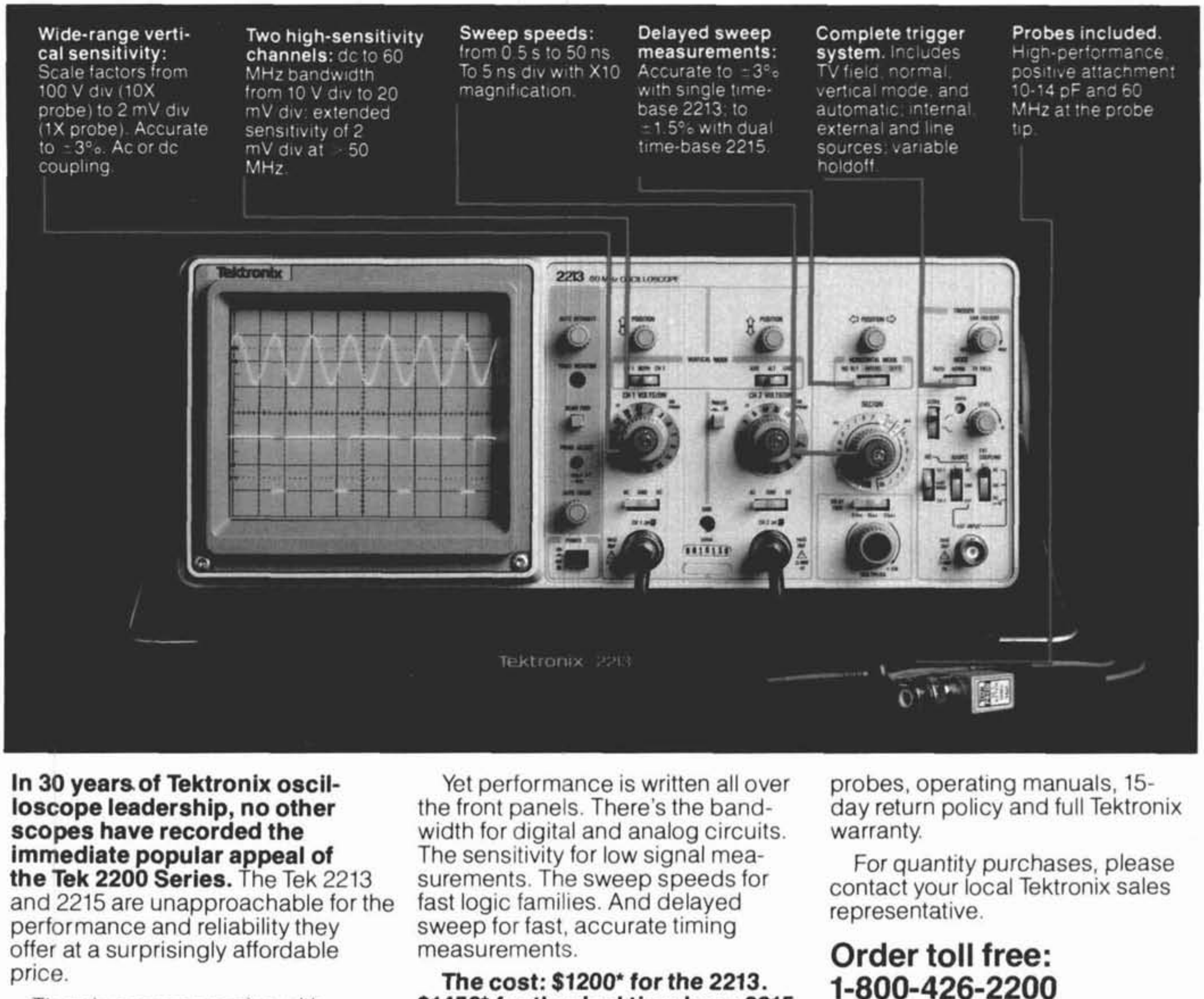

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receiver dynamic range

Defining and deriving a popular and important specification

Today's communications receiver is expected to detect and extract information from signals of varying levels in a crowded spectrum. Earlier designs were concerned primarily with good sensitivity and selectivity. New requirements call for a high degree of rejection of spurious products produced by non-linear interaction of many strong signals, sometimes far removed from the receiving frequency.

One method of determining the quality of receiver performance is to specify both an upper and lower signal-handling power limit, that is, a spurious-free dynamic range. To establish performance criteria requires a knowledge of the receiver's sensitivity (MDS), its third-order intercept point (defined later), system noise figure, and i-f bandwidth. Let's first define dynamic range.

Dynamic range is the power range over which a device such as a radio receiver provides useful operation. The upper limit of the dynamic range (P_u) is limited by the level of two equal input signals that create a third-order intermodulation product, which is equal in amplitude to the Minimum-Detectable-Signal (MDS)* level. The MDS is considered as the lower limit (P_L) of the dynamic range, and is defined as a signal 3 dB greater than the equivalent noise level for a specified i-f bandwidth. The minimum detectable signal can be found through **eq. 1**.

$$P_{L(dBm)} = MDS_{(dBm)} = -171\ dBm^{\dagger} + NF_{(dB)} + 10 \log (BW)_{IF} \qquad \textbf{eq. 1}$$

Where: *MDS* is the low-power limit of dynamic range in dBm.
NF is system noise figure in dB.
BW_{IF} is i-f bandwidth in Hz.
P_L is lower power limit of dynamic range in dBm.

The upper limit of the dynamic range can then be expressed by **eq. 2**.

$$P_{u(dBm)} = 1/3\,(MDS + 2\,IP) = 1/3\,(-171\,(dBm) + NF\,(dB) + 10 \log BW_{IF\,(Hz)}) + 2/3\,IP\,(dBm) \qquad \textbf{eq. 2}$$

Where: P_U is the upper power limit of the dynamic range in dBm.
IP is receiver's third order input intercept point in dBm.

By combining the two equations, we can find **eq. 3** for the total spurious-free dynamic range:

$$\begin{aligned} SFDR\,(dBm) &= P_U\,(dBm) - P_L\,(dBm) \qquad \textbf{eq. 3} \\ &= 1/3\,(MDS + 2\,IP) - MDS \\ &= 2/3\,(IP - MDS) \\ &= 2/3(IP(dBm) - NF(dB) - 10 \log BW_{IF\,(Hz)} + 171\,(dBm)) \end{aligned}$$

*Sometimes referred to as the noise floor.
†$KTB + 3\,dB = -171\,dBm$.

By Cornell Drentea, WB3JZO, 7140 Colorado Avenue, N., Brooklyn Park, Minnesota 55429

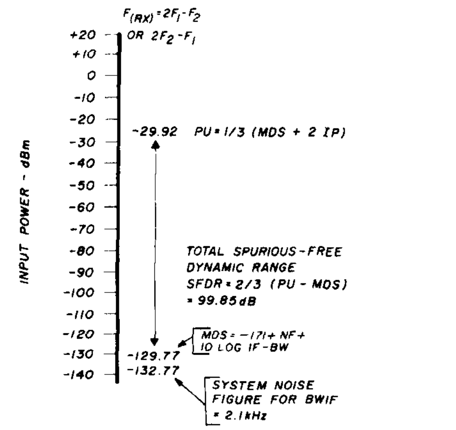

fig. 1. Determining the dynamic range of a receiver with a noise figure of 8 dB, an i-f bandwidth of 2.1 kHz, and an input intercept point of +20 dBm.

Where: *SFDR* is the spurious free dynamic range.

This equation shows that the dynamic range is *directly proportional to the intercept point* (IP) *and* inversely proportional to the noise figure (NF), and i-f bandwidth (BW_{IF}).

We can then say that the dynamic range improves with lower noise figures, narrower i-f bandwidths and higher intercept points.

The following example shows a practical application for the dynamic-range formula. Assume a typical high-performance receiver with a noise figure of 8 dB, an i-f bandwidth of 2.1 kHz and an input intercept point of +20 dBm. Substituting these quantities in **eq. 3** yields:

$$SFDR = 2/3\,(+20\,dBm - 8\,dB - 10\log 2100\,Hz + 171\,dBm) = 99.85\,dB.$$

$$SFDR = 99.85\,dB.$$

The total distribution of this number can best be understood by examining the graph in **fig. 1**. We know that the total spurious-free dynamic range (SFDR) for our receiver is 99.85 dB, but what is not known is where this range fits in the total picture of the receiver's sensitivity, and once this is found, what this range means from a practical performance point of view. We had previously determined that the lower limit of the dynamic range is given by the Minimum Detectable Signal (MDS). If, using **eq. 1** for our example, we find the lower limit of the receiver's dynamic range to be −129.77 dBm.

$$MDS = -171 + 8 + 10\log 2100 = -129.77\,dBm.$$

We can then say that the system's noise level for an i-f bandwidth of 2.1 kHz is 3 dB below this number, or −132.7 dBm (MDS is defined as a signal 3 dB greater than the equivalent noise level for a specified i-f bandwidth).

Knowing the MDS, the IP (20 dBm) and with the help of **eq. 2**, we can determine the upper limit of our 99.85 dB dynamic range:

$$P_u = 1/3\,(-129.77 + 40) = -29.92\,dBm.$$

The same result would be obtained if we added the total dynamic range of 99.85 dB to the MDS:

$$P_u = 99.85 + (-129.77) = -29.92\,dBm.$$

This last procedure could be used to verify the validity of **eq. 2**.

If these numbers are plotted as shown in **fig. 1**, we can conclude that the receiver in our example will perform undisturbed for all input signals varying from approximately −30 dBm to −130 dBm, with the receiver tuned to a third-order intermodulation product produced by two strong signals equal in amplitude and differing in frequency from each other. The amplitude of these signals, as well as the difference frequency (ΔF), were represented in our example by the +20 dBm input-intercept point. In practice, this quantity is a function of the output intercept of all *non-linear elements, such as mixers, amplifiers, etc.,* involved in the design of the receiver, as we will see next.

intercept method

Fig. 2 shows the intercept method, used as an evaluation method for the strong-signal handling capability of a radio receiver. In practice, the dynamic range of a receiver is measured with the setup shown in **figs. 3** and **4**.

First, the MDS is found as shown in **fig. 3**. The MDS is measured as the power necessary at genera-

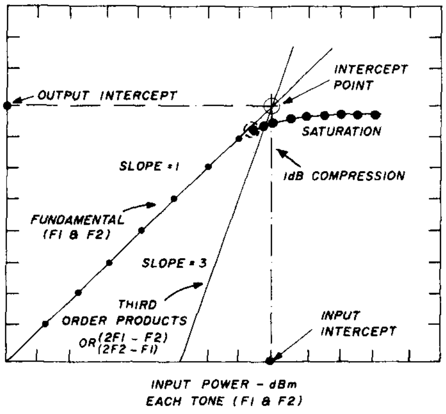

fig. 2. Determining output and input intercepts of a radio receiver.

tor G (expressed in dB), to produce a 3 dB increase in audio output over the noise level of the receiver. The MDS is specified for a given i-f bandwidth. The greatest bandwidth should be used for a worst-case analysis.

Knowing the MDS, the setup in **fig. 4** can be used to actually find the output intercept, and with this information, the input intercept can be plotted as shown in **fig. 2**.

To find the output intercept point, the outputs of the two signal generators (G_1 and G_2) are combined in a hybrid combiner. The output of the combiner (which now contains a two tone signal) is applied through a calibrated step attenuator to the receiver.

The two generators are usually 10 kHz apart, with the receiver tuned to 2F2-F1 or 2F1-F2, a third order product. The attenuator is then varied until the response of the receiver at the frequency of the third-order product is the same as that produced by the MDS found earlier. The performance is specified by measuring and plotting the output intercept as shown.

If the receiver is well designed, the desired output signal and the distortion product curve will intersect as high as possible, as shown in our example. This is the output intercept which describes the intermodulation response of the receiver.

The input intercept can also be plotted from the intercept point. This number can then be used to find the spurious-free dynamic range as previously discussed.

In conclusion, the receiver processes a weak signal in the presence of many adjacent strong signals. Because of the deficiencies in the design of the first mixer and the front end, if a preamplifier is used, the receiver may not be able to copy the weak signal, and it may be completely blocked out. The receiver's ability to perform under such conditions is expressed by the spurious-free dynamic range.

This article was adapted from the book *Radio Communications Receivers* by the author, published by TAB Books Inc. It is available from the Ham Radio Bookstore, Greenville, NH 03048, for $13.95 plus $2.50 shipping and handling.

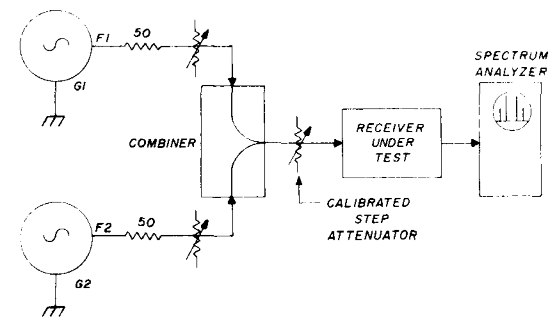

fig. 4. Set-up for measuring output intercept point. Input intercept can then be plotted and used in the dynamic-range formula.

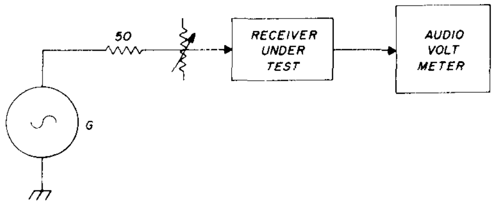

fig. 3. Set-up for measuring MDS.

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ham radio

DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

December is probably the best month for winter DX. The low signal absorption combined with high daytime MUFs result in excellent signals on the higher DX bands (10 and 20 meters). On the other end of the frequency spectrum, the long nights make for excellent DX on 40 through 160 meters.

Expect the 27-day solar maximum just at the end of November and again on the 23rd of December: consequently, the higher DX bands should be active the first week and the last week-and-a-half of the forecast period. The days in between should favor the lower frequency bands. December is traditionally one of the quietest insofar as geomagnetic disturbances are concerned, but the days of highest probability will be around the 9th, 18th, and 28th.

The winter solstice will take place on the 22nd at 0439 UT. A partial eclipse of the sun (74 percent obscured) will occur on the 15th across Europe, extreme northeast Africa, and west Asia, and on the 30th there will be a total eclipse of the moon across North America, Asia, and Australia. Lunar perigee will be on the 2nd at 1100 UT and the 30th at 2200 UT; by coincidence, full moon will be on the 1st and 30th.

The Geminid meteor shower, which reaches its peak on December 13th and 14th provides the richest and most reliable display of the year, with rates of 60 to 70 per hour (determined mainly by radio, because of the poor weather in December). Also, a smaller portion of the shower (15 to 20 per hour) is observed on December 22.

more on the radio-quality index

If you have talked Santa into bringing you a home computer for Christmas, you may want to use it to enhance your ham radio DX operating by programming a radio-quality index into it. A formula was given in the DX Forecaster column in the August, 1982, *ham radio*. Further programming and debugging help is given below.

I have divided the formula into three sections, a term and factors, and given representative values within the ranges of the variables. First is the seasonal term, θ, which is used as the power to which the solar flux, ϕ, is raised. This term is needed to increase quality in the summertime, probably representing increased signal strengths from sporadic-E layer propagation. It varies from 0.7375 in winter to 1 near summer solstice, as in the following table:

day	A 0.49315x	cos²A	θ
1 (January)	0.49315	0.999925	0.7375
80 (March)	39.45200	0.59626	0.8435
172 (June)	84.82180	0.008215	0.9978

Day number x is the day of the year, starting with January 1 as 1. February 1 would be 32, and so on. Use trig identity, $cos^2 A = \frac{1}{2}(1 + cos\,2A)$.

The radio flux factor, $log\,(\sqrt[4]{\phi})^{\theta}$, is the log to base 10 of the fourth root of the radio flux number, right from WWV. The ϕ varies from about 65 to 400, and the value of this factor for three values of ϕ and the θ extremes of 1.0 and 0.7375 are as follows:

ϕ	log ϕ	factor value in June	December
70	1.84510	0.461	0.340
150	2.17609	0.544	0.401
375	2.57403	0.643	0.475

The magnetic factor is $e^{-0.01A}$, where A is the magnetic number (estimate) for the day from WWV. The exponential function e^x is used. A table of representative values is as follows:

A	$-0.01A$	$e^{-0.01A}$
5	−0.05	0.9512
10	−0.10	0.9048
50	−0.50	0.6065
100	−1.00	0.3679

Finally, putting the factors all together with the 10-times factor and the +0.82 term to shift the scale to a 0 to 9 range of numbers, an overall example for March 21, 1982, (day 80) with solar flux of 150 and A of 10 is calculated as follows:

$$Q = 10\ \frac{0.8435}{4}\ (2.17609)\,(0.9048)$$

$$+\ 0.82 = 4.15 + 0.82 = 4.97 \text{ or } 5$$

band-by-band summary

Ten, fifteen, and twenty meters will have DX from most areas of the world during daylight and into the evening almost every day. Long skip and one-long-hop trans-equatorial openings toward evening can be opportunities for new DX locations. Look for them during the few disturbed geomagnetic periods, otherwise watch for high solar flux days for ten and fifteen meter openings.

Forty, eighty, and one-sixty meters are the night DXer's bands. Excellent extended periods of long skip, albeit over shorter distances than on the higher bands, can make a cold winter night enjoyable. Low noise and quiet geomagnetic conditions generally result in pleasant operating this time of year. Happy Holidays, and lots of DX during the coming new year!

ham radio

DECEMBER

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GMT	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	GMT
PST	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	PST
ASIA FAR EAST	10	15	15	15	15	20	20	20	20	—	—	—	—	—	—	—	—	—	—	—	20	15	15	10	N
EUROPE	20	20	20	15	15	15	20	20	20	20	—	—	—	—	—	—	—	—	40	40	20	20	20	20	NE
S. AFRICA	15	15	15*	10	15	15	15	20	—	—	—	—	—	—	20	20	20	20	20	20	15	15	15	15	E
S. AMERICA	15	15*	15*	10	10	15	15	15	20	20	40	—	40	40	40	20	20	20	20	15	15	15	15	15	SE
ANTARCTICA	15	15	15	20	20	—	—	—	—	—	—	40	40	20	20	20	20	20	15	15	15	15	15	15	S
NEW ZEALAND	10	10	10	10	15	15	20	40	—	40	40	40	40	40	20	20	20	20	15	15	15	10	10	10	SW
OCEANIA AUSTRALIA	10	10	15	15	15	15	15	20	—	—	40	40	—	—	20	20	15	15	15	15	10	10	10	10	W
JAPAN	10	10	15	15	20	—	—	—	—	—	—	40	40	40	40	40	20	20	20	20	15	15	15	15	NW

MID USA

MST	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	MST
ASIA FAR EAST	—	—	—	—	20	20	20	20	20	20	20	—	—	—	—	—	—	—	—	—	20	15	15	15	N
EUROPE	20	20	20	15	15	15	15	20	20	20	—	—	—	—	40	40	40	40	40	40	20	20	20	20	NE
S. AFRICA	15	15	15	15	10	10	10	10	15	—	—	—	—	—	—	—	—	20	20	20	20	15	15	15	E
S. AMERICA	15	15	15	10	10	10	10	10	15	15	20	—	40	20	20	40	40	40	20	20	20	15	15	15	SE
ANTARCTICA	15	15	15	—	—	—	—	—	—	—	—	—	—	—	20	20	20	15	15	15	15	15	15	15	S
NEW ZEALAND	15*	10	10	10	15	20	20	—	—	—	—	—	—	—	—	20	20	20	20	20	15	15	15	10	SW
OCEANIA AUSTRALIA	10	10	10	15	15	15	15	20	20	—	—	—	—	—	—	20	20	20	20	15	15	15	15	15	W
JAPAN	15	15*	15*	20	—	—	—	—	—	—	—	—	20	20	20	20	—	—	20	20	20	15	15	15	NW
CST	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	CST

EASTERN USA

EST	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	EST
ASIA FAR EAST	—	—	—	—	—	15	15	15	20	20	—	—	—	—	—	20	20	—	—	—	—	15	15	15	N
EUROPE	15	15	15	10	10	10	10	10	15	—	—	—	—	—	40	40	40	40	40	20	20	20	20	20	NE
S. AFRICA	15	15	10	10	10	10	10	10	10	10	15	—	—	40	40	40	20	20	20	20	20	20	20*	15	E
CARIBBEAN S. AMERICA	15	15	15	10	10	10	10	10	10	15	20	20	40	40	40	40	40	20	20	20	20	20	20	15	SE
ANTARCTICA	15	15	15	15	—	—	—	—	—	—	—	—	—	—	—	20	20	20	15	15	15	15	15	15	S
NEW ZEALAND	10	10	10	15	15	20	20	20	—	—	—	—	—	40	20	20	20	20	20	15	15	15	15	15	SW
OCEANIA AUSTRALIA	10	10	15	15	15	15	15	15	—	—	—	—	—	—	20	20	20	20	20	20	15	15	15	10	W
JAPAN	15	15	20	20	—	—	—	—	—	—	—	—	—	—	—	—	20	20	20	20	20	20	15	15	NW

Look at next **higher** band for possible openings.

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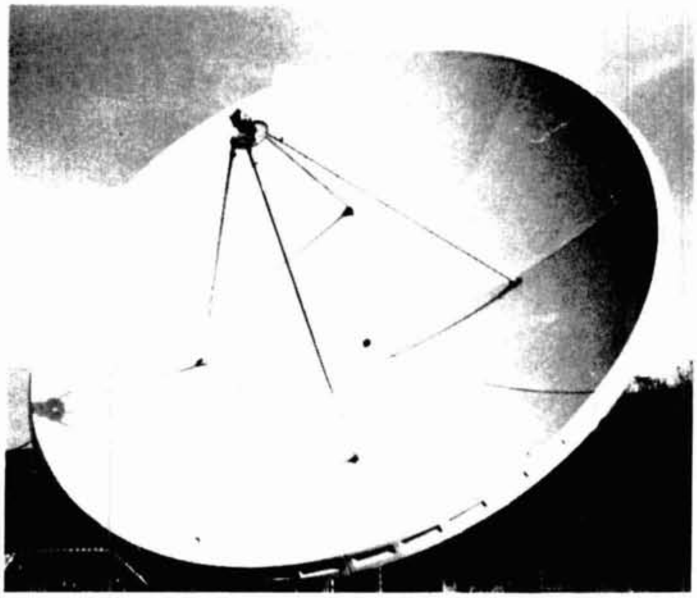

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More Details? CHECK—OFF Page 132

is it stolen?

How to avoid being burnt by more than rf

Willie Hambone earned the name "Bargain Willie" at his local radio club for good reason. He always knew the price of the latest radio equipment, and had a feeling for what a seller would expect when it was offered at a ham flea market. He was, of course, a veteran of the Dayton Hamvention; after Willie had made the pilgrimage to Dayton for several years, his acquaintances wondered what equipment he *didn't* have. But when the annual local hamfest — one of the largest in the state — came, Willie was there.

This time Willie's eagle eye fastened on the latest model Modzilla 870, complete with power supply, Modzilla mike, and 870-RV remote VFO. No manual; but the seller assured Willie that since it was a current model, he would have no trouble getting one from the U.S. distributor for $10, and he'd shave that off the price. Price? Well, the current market price was $1,350 — but since the seller was about to take a job working for an oil exploration company in South America, and needed some cash to pay his wife's hospital bill, he'd take $675 — exactly half price — less the $10 to buy a manual.

Not everybody goes to a hamfest with $665 in his pocket, but Willie always said that cash talks, and his hot little hands soon pulled that bargain price out of his wallet, gave it to the seller, and proceeded to carry his new acquisition to his car. The rest of the hamfest was anti-climactic for Willie; he could hardly wait to get his new gear home and on the air. Since it was a class piece of equipment, he decided he ought to check with another ham in town who had a Modzilla 870; and after his friend had reviewed the tune-up procedure with him over the telephone, Willie plugged it in for the smoke test.

It worked beautifully. The path to Europe was open on 15, and it was no trouble to work Gs and DLs with the barefoot rig, one station after another. During the next few days, Willie checked the rig out on other bands, and found it even brought in QSOs on 160. In short, he was delighted, both with the rig and with his bargain. He was tempted to forget about the instruction manual, lack of which had shaved $10 off the price — but when he thought that *someday* he'd sell the rig for a later model, he wrote a letter to Modzilla's U.S. distributor in La Squinta, California, enclosing $10 for a manual, carefully noting the serial number of the equipment so that he would get the proper edition for his new 870.

Willie's joy seemed unlimited. The heatsink on his 870 hardly had a chance to cool down, so happily did Willie describe his bargain far and wide during the next few weeks. Then, on Saturday afternoon, it happened.

the problem arises

The doorbell rang, and with some disgust, Willie — who was home alone — answered. The caller turned out to be a Deputy Sheriff with a folded sheet of paper in his hand. "Willie Hambone?" he inquired.

"That's me," Willie acknowledged.

"Mr. Hambone," the deputy went on, "I have a search warrant signed by Judge Green of the County Court, authorizing me to search your premises for pieces of stolen radio equipment. They are called a Modzilla Model 870 and an 870-RV; and I have a picture of this type of equipment. If you have it here and want to show it to me, fine; otherwise, my partner and I will have to go through your house, room by room."

Willie felt the floor sinking beneath him. "Look, officer, I have a Modzilla 870, and you're welcome to look at it; but I paid good money for it. I didn't steal it from anybody; I bought it, and it's mine!"

They proceeded to Willie's shack, where Willie announced, "Here it is. These are produced by the

By George H. Goldstone, W8AP, 1010 Burnham Road, Bloomfield Hills, Michigan 48013

thousands. Maybe a few get stolen, but I paid for this one."

"You may have paid for it, Mr. Hambone, but if this equipment carries serial number 89-6634, you are in possession of stolen property. May I look at the serial number on the back?"

Willie already knew the number; his heart sank. His request for an instruction manual, giving the serial number . . . of what was a stolen rig!

It didn't take the deputy long to check the number. But if Willie felt bad about losing $665, he felt even worse after the deputy's next announcement:

"Mr. Hambone, you are under arrest, charged with receiving and concealing stolen property of a value sufficient to constitute a felony. I must advise you that you are not required to make any statement; any statement you make can be used against you in court; you are entitled to counsel; and if you cannot afford counsel, an attorney will be provided for you. You must come with me to the County Jail, where you will be booked, and you will be allowed to call an attorney from there."

Willie's bargain had evaporated. In fact, so had his world.

what happened to Willie

Willie hired a competent lawyer, whose services were not inexpensive. At a preliminary hearing, his lawyer raised the defense that Willie had no knowledge the transceiver was stolen; that such knowledge is an essential element of the crime of receiving stolen property. The judge agreed and dismissed the charge, but his remarks to Willie are worth noting:

"Mr. Hambone, I am dismissing the charge of receiving stolen property, although I hesitate to do so. You are an Amateur Radio operator, and I feel quite sure you knew the true value of this equipment at the time you bought it. Such knowledge of value would permit this court to draw an inference that you sensed the equipment was stolen. Since you have no criminal record, I am dismissing the complaint; but if you are ever again found to have stolen equipment in your possession, the court will take a different attitude."

Some bargain, that transceiver! Willie not only lost the $665 he had paid for the Modzilla 870; he paid his attorney's fee, and in local ham circles, he was now known as "the ham who has been had."

The unhappy situation fictionalized here may well have happened, at least in many details. We all know expensive Amateur Radio equipment is stolen from time to time. The elaborate high-frequency mobile installation is almost a thing of the past. VHF and some HF equipment is now made small enough that the owner can unplug the major component — a transceiver — and carry it in his briefcase.

The development of the ARRL insurance program, to a considerable extent, is the result of growing radio equipment theft. This article is not designed to tell you how to avoid theft of your equipment; it is designed to suggest ways in which you may avoid the purchase of *stolen* equipment.

Traditionally, physical possession is considered one indication of ownership. While it may be an *indication* of ownership, it does not prove your title to the property. So, where do you obtain some proof of title? As to new merchandise — and let us take a typical transceiver purchased from an established dealer — you will receive a paid invoice, identifying the goods by make, model, and serial number. Considering the importance of equipment warranties, every buyer should insist that a serial number be included on his invoice. This invoice is evidence of a contract of sale, and by law, a contract of sale implies a warranty of good title to the merchandise sold, and that the transfer is a rightful one.[1]

At any flea market, the majority of vendors are not merchants regularly dealing in Amateur Radio equipment. More often, they are individuals with usable gear they no longer want or need, which they want to convert into money or other ham gear. We normally do not expect such a casual seller to furnish ownership documentation; it is unusual when he furnishes a receipt for the goods you purchase. If a seller will accept your check in payment, you may note on the back, "In payment for Johnson Invader Serial No. 116628," but this only shows what the check paid for; it does nothing to prove that the seller was the owner.

proof of ownership

It is not too much to ask a seller of any major item of equipment to furnish some evidence the goods are his. Every ham should staple his purchase invoice onto the back of the instruction manual for reference at the time it is sold. There are tactful ways to ask for title evidence; you will not make friends by saying "How do I know it isn't stolen?" but you can easily say, "Do you have an invoice to show where this gear was purchased?"

Not everyone keeps sales invoices. Sometimes we want to forget how much money went into one piece of gear! But there is no reason why a Bill of Sale cannot be given, preferably in a form which will identify both buyer and seller, say where the seller obtained the equipment, state the selling price, contain a warranty of title in all cases, a warranty against liens, and a warranty of condition whenever condition is vital to the sale. A suggested form for a Bill of Sale is shown in **fig. 1**. It can easily be reproduced in quantity to use at hamfests and flea markets; perhaps the club

BILL OF SALE

The Seller, ______________________________
(Name of Seller)

______________________________ *in consideration*
(Address of Seller)

of the price of $ ______________________________ paid to him, receipt of which is

acknowledged, hereby sells to ______________________________
(Name of Purchaser)

____
(Address of Purchaser)

the following equipment:

____________	____________	____________
(Quantity)	(Description)	(Serial No.)

originally purchased from ______________________________

Seller represents and warrants that he is the owner of the equipment sold, and no other person has any interest in it, or lien upon it by way of an unterminated Financing Statement, or otherwise. As to the condition of the equipment, Seller makes the following representations:

(Check one below which applies)

☐ 1. The equipment is in good working condition.

☐ 2. The equipment is sold "as is", and Seller makes no representation as to its performance.

☐ 3. The equipment requires repairs (other than normal alignment) in order to meet the performance specifications of the manufacturer.

Witness:

______________________________ ______________________________
(Signature of Seller)

Date of Sale: ______________________________

fig. 1. Sample Bill of Sale form.

sponsoring the affair can have them printed, and make them available at printing cost.

effect of a Bill of Sale

Between seller and buyer, the Bill of Sale is clear proof that the seller has transferred whatever ownership he had to the buyer. In most cases, possession of a Bill of Sale by the buyer precludes any criminal intent on his part, should the gear prove to be stolen; without criminal intent, you would not end up with a charge of receiving stolen property as suggested in poor Willie's example.

If the seller has valid title to the property, the Bill of Sale effectively transfers it to the purchaser. But if the seller does not have good title to the property, the purchaser acquires no more ownership than the seller had. It is certainly worthwhile to protect yourself against criminal liability by asking for and receiving a Bill of Sale. Would you *want to* make a deal with someone who refuses to give a Bill of Sale?

possible liens

Much new radio equipment is bought on credit. Some radio supply houses reputedly make more money on their credit operations than on the sale of the gear itself, which can occur when a supplier does the financing rather than using Master Charge, VISA, etc. If the gear has been financed by the purchaser, the seller or the financing agency has probably filed what is called a Financing Statement. When a Financing Statement has been recorded, the party extending credit may have rights to the goods after the date of recording which are legally superior to those of the purchaser. If you acquire an expensive piece of relatively new gear from someone who has a reputation for buying everything on credit, you would be wise to check with your County Clerk or Register to see if there is the lien of a Financing Statement recorded against what you plan to buy. A Bill of Sale should include a representation that no such lien exists.

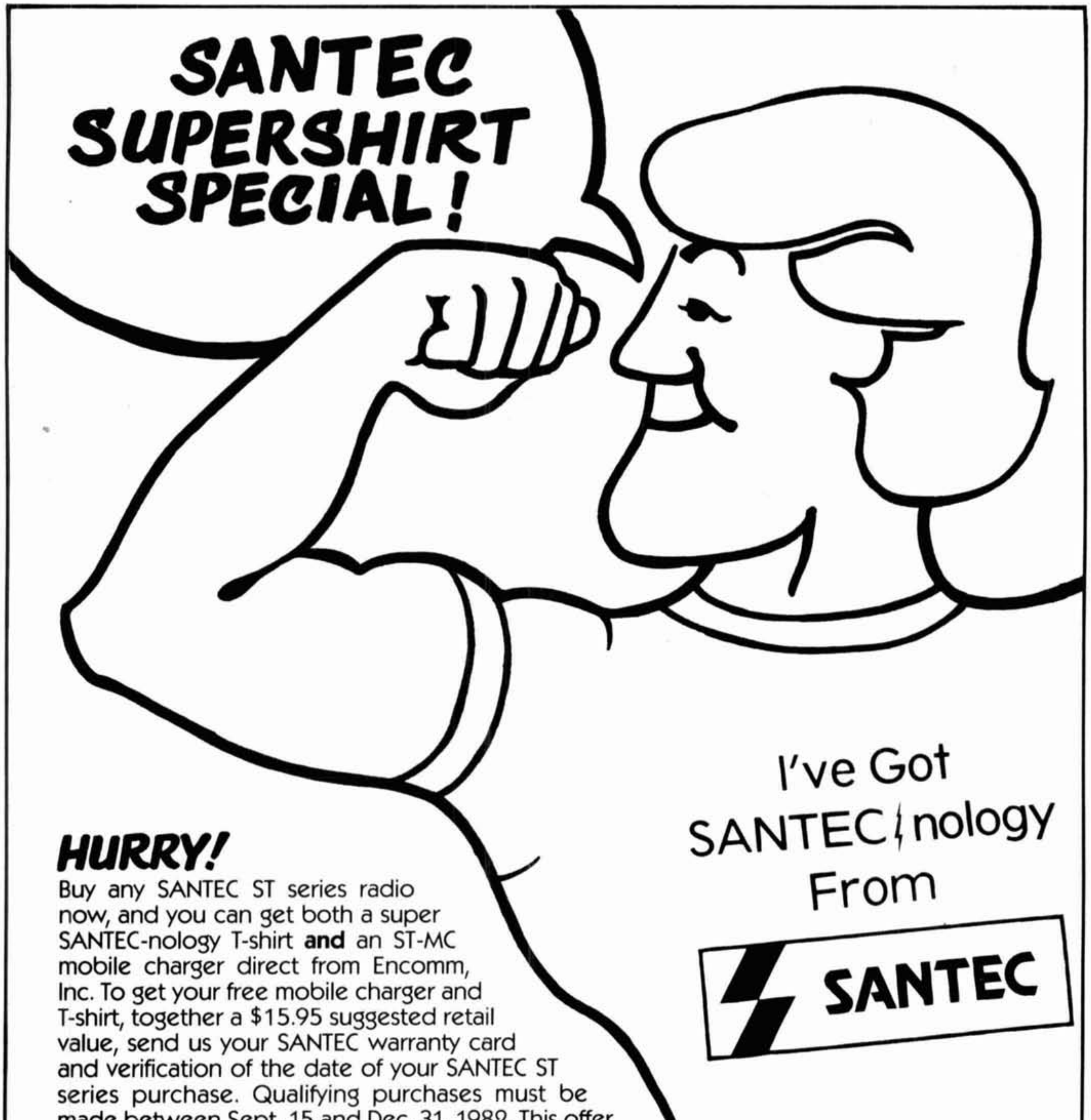
some common-sense conclusions

No one wants his own equipment stolen, nor does anyone want to help thieves of Amateur Radio equipment by furnishing them a market. We can all help shrink the stolen equipment market by retaining our purchase documents, complete with serial numbers. When buying used gear, insist on evidence of ownership; ask for purchase records, but take a Bill of Sale *in any event*. The Bill of Sale, if properly drawn up, will show that you purchased the equipment in good faith, will identify the seller, and can also serve as a warranty of the condition of the equipment. Taking into account the present cost of equipment — either new or good used gear — insisting on a Bill of Sale is a wise precaution!

references

1. *Uniform Commercial Code*, Section 2-312.

ham radio



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More Details? CHECK—OFF Page 132

NEW products

Heil EQ200 mike equalizer

We always thought we had good audio from our transmitter. No one ever complained about garbled speech or hard-to-understand transmission. Granted, we have had people tell us we sound like Demosthenese, the Greek orator who practiced with stones in his mouth . . . that was before Bob Heil sent us his latest product, the EC200 microphone equalizer.

Bob Heil is well-known throughout the audio field as an expert on sound reproduction. Besides being a professional organist, he is in constant demand by music groups from rock bands to Philharmonic orchestras. He knows his audio. In a conversation with Bob, he stated that the most misunderstood and neglected part of any ham station is the microphone/audio circuitry. Sure, there have been compressors, clippers, and whatever. But they do more to compound the problems of poor audio than solve them.

With this in mind, Bob determined to apply his professional expertise to solve the problem. Looking through manufacturers specifications, Bob found most modern transmitters and transceivers have filter networks that limit audio input to the 300-3,000 Hz range. But most *microphones* are designed to cover a much broader range of frequencies, since they are used in services as diversified as stereophonic reproduction to paging services. The broader response of the microphone will be transmitted, and this will unnecessarily broaden your output.

The solution he came up with is the EQ200. The basic circuit is two 741 op amps (cm 1458). One-half of the first IC is used as a preamplifier and a transformer to provide proper impedance matching. The other half of the IC is used as a peaking lowpass active filter. The second IC is used as a shelving highpass filter and a line summing amplifier.

There are three controls on the front panel of the unit. The mike preamp gain may be adjusted from 0 to +20 dB. Heil advises that this be set so the microphone will not overload or clip. The LO control is used as a boost and cut control. Boost refers to increasing the level, cut reduces the level. The boost and cut is ±12 dB. The low filter is centered at 490 Hz. The HI control is also a boost and cut, with the filter centered at 2800 Hz.

As mentioned before, most microphones used today were not designed for ham use; their audio response is usually much greater than is necessary. Since all microphones are different, there is no universal setting. Heil has some recommended settings, but it best to set the processor through a trial-and-error process. Luckily, we have a friend who received an EQ200, so we tested and set our processors together. It was interesting to actually hear how the high and low tones can be emphasized and deemphasized to create a truly pure-sounding signal.

The only problem we found was that we chewed up batteries. That can be remedied easily by installing a 9 Vdc supply or adding a low drain LED to remind you the unit is on. This is more of an inconvenience than a problem. Bob Heil tells us a newer model will incorporate these changes.*

Finally, Bob provides some helpful hints about how to use the microphone properly, such as keeping adequate spacing between mouth and microphone and making sure your operating room is not full of echoes.†

The EQ200 is a nice item to have between your rig and microphone. Price is $49.95 for the basic unit. For more information, contact Heil Sound, Box 26, Marissa, Illinois 62257.

*For those who own EQ200s, changing the input resistors from 10K to 100K should solve the problem of excessive power drain.

†As an added feature, the EQ200 can be modified to work as a two-tone generator for SSB tuning and testing. A parts kit is available from Heil Sound for an additional $7.00.

new high-frequency equipment line

Yaesu Electronics Corporation is pleased to announce the availability of the new FT-102 line of high-frequency equipment. The FT-102 transceiver uses an all-new transmitter section, featuring three 6146B final tubes for extremely low distortion. In addition to VOX and an rf clipping-type speech processor, the FT-102 transmit audio may be adjusted for optimum response to the operator's voice.

The FT-102 receiver uses JFET components in the front end for wide dynamic range. A number of filter options are available, with wide/narrow filter selection independent of the mode switch. Audio peak filtering for CW, audio shaping for all modes, and an i-f notch filter provide intelligence recovery. The noise blanker is highly effective against the Woodpecker and pulse noises.

Equipped for SSB and CW operation, the FT-102 option list includes an a-m/fm module for activating those modes. Other accessories for the FT-102 are the FV-102DM synthesized VFO, the SP-102 speaker with audio filter, the SP-102P speaker/patch, and the FC-102 1.2-kw antenna tuner with optional remote antenna selector.

For further details, contact Yaesu Electronics Corp., P.O. Box 49, Paramount, California 90723.

electronic parts by mail

A new, free catalog lists over 1500 electronic items which can be ordered through the mail. Parts are high quality, no rejects or seconds. Large line of semiconductors, LED displays, lamps, connectors, sockets, headers, jumpers, switches, meters, amplifiers, generators, etc. Some items are available in kit form or assembled. All items can be shipped immediately from stock.

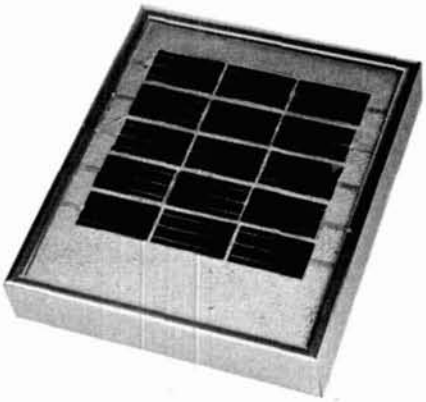
For more information, contact Sintec Company, Drawer Q, Milford, New Jersey 08848; telephone 1-800-526-5960 (New Jersey residents dial 201-996-4093).

photovoltaic battery charger

The Phaeton II Photovoltaic Battery Charger manufactured by International Solar Products Corporation of Durham, North Carolina, produces 4.8 volts of direct current power at 240 milliamps in peak sunlight. Four AA cells, two C cells, and two D cells can be charged with the unit. Batteries are fully recharged in 14 to 16 hours of sunshine.

Phaeton II measures 6 × 7 inches and weighs less than two pounds. It is constructed with anodized gold or silver frame, heavy-duty aluminum battery cradles and the same silicone covering used to protect the solar cells on orbiting communication satellites. The unit contains no plastic parts.

The manufacturer states the average consumer could spend as much as $100 per year on throw-away batteries to power portable radios, tape recorders, toys, games, flashlights,



cameras, and other electronic appliances found in many homes today. At $49.50, the Phaeton II can totally replace this annual cost after it pays for itself in the first 6 to 7 months of use.

The unit is available directly from the manufacturer, International Solar Products Corporation, 1105 W. Chapel Hill St., Durham, North Carolina 27701; telephone 919-489-6224.

frequency counter program

A cassette program that turns the Apple II computer into an audio frequency counter with an accuracy of 30 parts-per-million. You may consider this a rather expensive frequency counter, especially when it doesn't cover rf at all. However, it is aimed primarily at those experimenters who already have an Apple II computer.

This counter has a twist to it. Unlike most frequency counters, it does not gate the unknown for a fixed reference period. Rather it counts an approximately equal number of clock pulses over an exact (but arbitrary) multiple of whole cycles of the unknown. Then it calculates the frequency from this average, much as a period counter would. The result is that the full stated accuracy is achievable in less than two seconds, over the entire audio range. This means that in less than two seconds you can find out the frequency of your subaudible tone encoder to within 0.01 Hz. The counter can achieve even

NEW products

greater accuracy if you have a little patience. It also keeps a running average of the last N (default is 50) samples. If fewer than N have been taken, it will average them. The result is accuracy approaching 1 PPM.

Although the Apple's time base (which is the reference for this program) isn't calibrated or compensated, it is crystal controlled and therefore relatively stable over short periods once it has temperature stabilized. Included is a procedure (need only your cassette recorder, microphone, and a color TV) to calibrate it in software, using the 15734.26 Hz horizontal oscillator frequency of a color TV receiver. This signal is of course locked to the station it is receiving, which, if a network program is being viewed, is in turn locked to a cesium 3.579545 MHz reference at the network.

A copy of the cassette costs $15. For more information and dealer prices, contact Wilton Helm, WA6GQO, 827 Vinton Court, Thousand Oaks, California 91360.

220 MHz H.T. amplifier

Mirage Communications Equipment, Inc., announces the release of its new 220-MHz amplifier. The C22 solid-state all-mode 220 to 255 MHz amplifier has the same famous five-year warranty (one year on rf power transistors) as all Mirage products.

The C22 has many features, including bias as a linear amplifier IE: fm, SSB, CW; it can be keyed with as little as 300 mW; 2 watts in with 20 watts out; and dc power 13.6 Vdc at 3 amps (full output).

For additional information, contact Mirage Communications Equipment, Inc., P.O. Box 1393, Gilroy, California 95020; telephone 408-847-1857.

micro computer pollution control

Power-line electrical noise, hash, and spikes often cause erratic computer operation. In addition, severe spikes from lightning or heavy machinery may damage expensive hardware. Many systems create their own pollution. Disks and printers often create enough electrical interference to disrupt an entire program. Nearby electronic equipment is affected as well.

Electronic Specialists' recently-announced Magnum Isolator Model ISO-17 is designed to control severe electrical pollution. Incorporating heavy duty spike/surge suppression, the Magnum Isolator features four individually quad-Pi filtered ac sockets. Equipment interactions are eliminated and disruptive/damaging power line pollution is controlled. The Magnum Isolator will control pollution for an 1875-watt load. Each socket can handle a 1000-watt load. Price, $181.95.

For more information, contact Electronic Specialists, Inc., 171 South Main Street, P.O. Box 389, Natick, Massachusetts 01760; telephone 617-655-1532.

300-watt antenna tuner

Palomar Engineers introduces the new PT-407 antenna tuner. The PT-407 is a general-purpose tuner for 1.8-30 MHz, for matching antennas

fed with coaxial or open wire lines, single wire, or mobile antennas. The 300-watt power rating makes it just right for most transceivers. The PT-

407 is an efficient tuner with a large, airwound coil, a large balun for open-wire feed, and with ceramic insulation throughout. It is housed in an 8 × 4 × 7-inch aluminum cabinet with brushed aluminum control panel and black vinyl cover. All controls are on the front panel. Coaxial connectors are SO-239. Porcelain feedthrough insulators are used for balanced line and single wire inputs.

The PT-407 Antenna Tuner sells for $149.95. For further information write to Palomar Engineers, 1924-F W. Mission Road, Escondido, California 92025; telephone 714-747-3343.

regulated dc power supply

The precision-regulated dc power supply from Tripp-Lite converts 120 Vac into 13.8 Vdc. It allows users to operate dc mobile equipment on ac

home power, and it saves money, as this unit is inexpensive and eliminates the need for buying ac equipment.

Features include solid-state integrated circuits for precise regulation; filter insuring low noise operation; current limiting electronic foldback for automatic overcurrent protection; heavy duty power transformer for complete line isolation; ripple voltage from 0 to full load is only 0.1 volts maximum; on/off indicator light and on/off switch on face-plate; UL listed ac cord and plug type SPT-2.

For more information, contact Tripp-Lite, 500 N. Orleans, Chicago, Illinois 60610.

Hamtronics® kits

The R76 VHF fm receiver kit is a new version of the R75 receiver for 10 meters, 6 meters, 2 meters, 220 MHz, or the adjacent commercial bands. It features a very low noise front end, pump-resistant squelch with hysteresis to lock onto fading signals, on-board volume and squelch controls for easy wiring, and fixed i-f filters for easy alignment. It has also been reduced in size — now only 3¼ × 4 inches (8.25 × 10.16 cm). It is available in two selectivity options, starting at $84.95.

The model R451 UHF receiver kit includes the features in the R76 kit as well as automatic frequency control to lock onto drifting transmit signals. Kits are available with various options starting at $94.95.

Hamtronics® new line of low-noise amplifiers resembles the popular P30 and P432 receiver preamps, but the circuit is new. The LNA 28, LNA 50, LNA 144, LNA 220, and LNA 432 units are optimized for lowest noise figure at the ham bands, but they can also be used on adjacent commercial bands. The LNA 432 also provides very good gain and noise figures for UHF TV signals and the new 800 MHz commercial band: 0.5 dB at 28 and 50 MHz, 0.6 dB at 144 MHz, 0.7 dB at 220 MHz, and 0.95 dB at 432 MHz. Gain runs from 33 dB at 28 and 50 MHz to 17 dB at 432 MHz. The price is $39.95 for the VHF units and $44.95 for the UHF unit.

The Shuttle receiver kit, a special version of the Hamtronics R110-450 UHF a-m aircraft receiver to listen to the space shuttle, is now available off the shelf for $94.95.

For further information, contact Hamtronics, Inc., 65-V Moul Road, Hilton, New York 14468-9535; telephone 716-392-9430.

5/8 antenna for handhelds

Centurion has added a new model to their line of heavy-duty telescoping antennas. It is a full-length 5/8-wave

NEW products

radiator providing increased efficiency and range for handheld radios.

Designated Style F, the new antenna for VHF frequency bands from 118-174 MHz is fitted with a BNC connector.

For more information, contact Centurion International, P.O. Box 82846, Lincoln, Nebraska 68501-2846; telephone 402-467-4491.

special keyboard

Pipo Communications has just announced a specially designed keyboard compatible with the Collins KWM-380 high-frequency radio. The new sixteen-button keyboard is color-coordinated and has the fourth row buttons marked to indicate their function. This will facilitate ease of operation by eliminating the need to memorize what the buttons do. The keyboard sells for $20 and has a frame available for $3.

For more information or to order, please contact Pipo Communications, P.O. Box 3435, Hollywood, California 90028; telephone 213-852-1515.

6-meter transceiver

ICOM has announced the IC-505, a fully synthesized multimode transceiver covering 50 to 54 MHz (option), USB, LSB, and CW on fm. It uses an internal battery pack (9 C-size batteries), and puts out three watts of rf power when run on its batteries, or ten watts when connected to an external 13.6 volt dc source. Low power is 0.5 watts.

Features include an LCD frequency display for low battery consumption, provision for internal memory back-up, dual VFOs, five memories plus a call channel, memory scan, program scan, sideband squelch, LCD annunciators for VFO, scan, memory channel, call and split, and split frequency operation.

For more information, contact ICOM America, Inc., 2112 116th Avenue, N.E., Bellevue, Washington 98004; telephone 206-454-8155.

GaAs FET VHF/UHF amplifiers

Lunar Electronics announces a line of narrow-band tuned receiving preamplifiers for the VHF and UHF communities. Typical specifications exceed previously available receiving preamplifiers by up to ten times in performance. Exhibiting very high gain at VHF, typically 22-24 dB, moderate gain at UHF, typically 16 dB, plus a very low noise figure, typically 0.3-0.4 dB at VHF and 0.5-0.6 dB at UHF land mobile frequencies, these units are also well suited to high rf environments, exhibiting 1 dB compression power levels of +10 dBm or more. The good gain, coupled with very low noise figure, effectively reduces a typical repeater receiver sensitivity to that of ambient limitations. Improvements in receiver performance have been consistently reported by users at 6-10 dB in a typical repeater installation between the duplexer and receiver input.

Units are built to customer's specified frequency, but do exhibit a typical bandwidth of 5 percent CF with little degradation in performance. Dc input is well filtered and regulated, which allows accepting any dc voltage between 12 and 28 volts, drain approximately 35 mA. VHF connector options include BNC, SMA, N in and out; UHF connector options are SMA, N in and out, with SMA in BNC out the standard option. SMA to RG-58 connectors are included as option for UHF units. Frequencies are available from as low as 15 MHz to the 800 MHz land mobile bands.

For more information, contact Lunar Electronics, 2775 Kurtz Street, Suite 11, San Diego, California 92110; telephone 714-299-9740.

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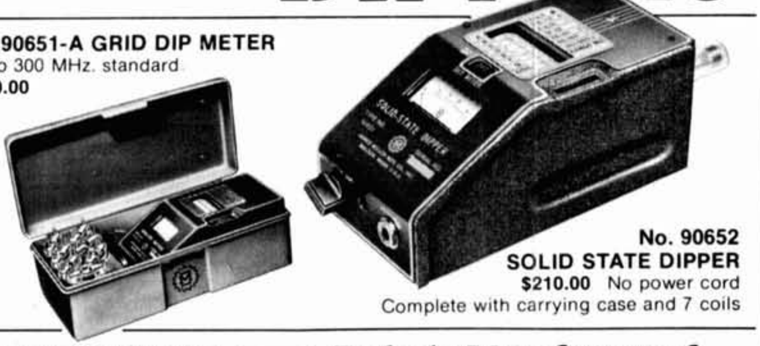

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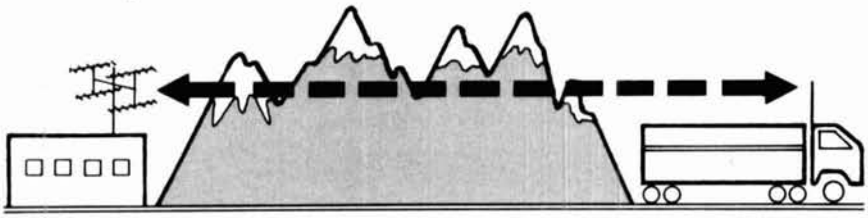

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HAM-AD-FEST — Next 6 issues $2.00. WA4OSR's Rigs & Stuff, Box 973-H, Mobile, AL 36601.

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WANTED: Micor and Mstr II Base Stations 406-420 and 450-470 MHz. Also 2 and 6 GHz solid state microwave equipment. AK7B, 4 Ajax Place, Berkeley, CA 94708.

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WANTED: Schematics-Rider, Sams or other early publications. Scaramella, P.O. Box 1, Woonsocket, RI 02895-0001.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-2, HT-8, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

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ILLINOIS: Wheaton Community Radio Amateurs Hamfest will be held February 6, 1983 at Arlington Park Race Track EXPO Center, Arlington Heights, Illinois. Free Flea Market tables and plenty of floor space. Large commercial area including computer section. For general info call W9JTO at 311-231-9524. Clear paved parking.

Awards. Tickets $3.00 at entrance, $2.50 in advance. Send SASE to WCRA, P.O. Box QSL, Wheaton, IL 60187. Talk-in on 146.01/61 and 146.94. Doors open 8 AM. Be There! — KA9KDC.

INDIANA — SOUTH BEND: Hamfest Swap & Shop, January 2, 1982, first Sunday after New Year's Day at Century Center downtown on U.S. 33 Oneway North between St. Joseph Bank Building and river. Industrial History Museum in same building. Carpeted half acre room. Tables $3 each. Four lane highways to door from all directions. Talk-in freq: 52-52, 99-39, 93-33, 78-18, 69-09, 145.43, 145.29.

MINNESOTA: The annual Handi-Ham Winter Hamfest, Saturday, December 4, at the Eagles Club, Faribault. Registration at 9 AM. Handi-Ham equipment auction, noon dinner, program and prize drawing. Talk-in on 19/79. For more information: Don Franz, WØFIT, 1114 Frank Avenue, Albert Lea, Minnesota 56007.

VIRGINIA: Richmond Frostfest '83. The annual winter Ham Radio and Computer Show will be held Sunday, January 16 at the State Fairgrounds, Richmond. General admission: $4.00. All indoor flea market and commercial exhibits. Major prizes in HF and VHF equipment and a minicomputer. Sponsored by the Richmond Amateur Telecommunications Society, P.O. Box 1070, Richmond, VA 23208.

WOULDN'T IT BE GREAT? To pick a winner for "Amateur of the Year" at the Dayton Hamvention and get Free Tickets too. Write for details: Hamvention, P.O. Box 44, Dayton, Ohio 45401, attention awards. Do it now!

OPERATING EVENTS

"Things to do..."

DECEMBER 4: The Everglades ARC will operate W4SVI, 1300 UTC, December 4 and 2200 UTC December 5 to celebrate the 35th anniversary of the dedication of Everglades National Park. Frequencies: 10 kHz up from lower edges of 40 to 10 meter General phone bands and 146.52 MHz. Certificates for QSL and large SASE to: W4SVI, c/o Dick Dowst, Everglades ARC, 14511 S.W. 287th Street, Leisure City, FL 33033.

DECEMBER 17: The Switzerland of Ohio ARES will operate a Christmas special event station at Jerusalem, Ohio, under the call N8DLJ, December 17, 18, 19 from 1600 to 2200Z each day. Frequencies: First 10 kHz of General phone portion of each band and the first 10 kHz of the Novice bands as propagation permits.

DECEMBER 7: KCØFW plans to operate from St. Kitts (VP2K) December 7 to 13. All bands 160-10 phone and CW. Special attention to working Europeans and JA's.

DECEMBER 1-31: The BBC is celebrating the 50th anniversary of the official start of the Empire Service (now renamed the External Service). To commemorate this, the Ariel Radio Group has obtained special call signs. Stations will be GB2BBC, GB3BBC, GB8BBC, Central London; G3BBC, West London and GB4BBC, Caversham near Reading. Also other BBC Club Stations will participate. 80m to 2m with maximum activity around December 19. Main operating mode SSB on HF.

DECEMBER: The Borealis ARC will present the Worked All North Pole Certificate to anyone working a minimum of three BARC members. Operating time 0400-0900Z, 30 kc up from lower edge of Novice and General bands. For certificate send call signs, dates worked and $2.00 to: Borealis ARC, c/o Wendell Keller, SR Box 80343, Fairbanks, AK 99701.

DECEMBER 9: The Triple States Radio Amateur Club will operate from Bethlehem, West Virginia, December 9 - December 12 from 1400 to 2300 UTC daily. Frequencies: for WD8DDL/8 will be 7.275, 14.325, 21.415 and 28.550 MHz on SSB and 7.110, 14.075, 21.110 and 28.110 MHz on CW. For a special holiday certificate for contacts SASE to TSRAC, 26 Maple Lane, Bethlehem, Wheeling, WV 26003.

DECEMBER 18: The Sandy River ARC, Farmington, Maine, will operate KA1CNG, Saturday, December 18, 1500Z to Sunday, December 19, 2100Z to celebrate Chester Greenwood Day. Also mobile from the Chester Greenwood Day Parade and related activities Tuesday, December 21, 1400Z to 2100Z. Frequencies: 5 to 10 kHz from bottom of General band edges and 3940 kHz. Certificate for your QSL card and two first-class stamps to KA1CNG, 5 Franklin Ave., Farmington, Maine 04938.

DECEMBER 4: The Argonne Amateur Radio Club plans to operate the club's memorial station, W9QVE, to commemorate the 40th anniversary of the first controlled nuclear chain reaction experiment conducted at Alonzo Stagg field on the University of Chicago campus, from 1500 GMT through 2400 GMT December 5. Frequencies: 20 kHz up from lower edge of General portion of bands 80 to 10m, phone and CW.

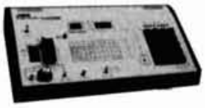
More Details? CHECK—OFF Page 132

2708,2716,2732 & 2764 EPROM Programmer

JE664 EPROM PROGRAMMER

8K TO 64K EPROMS — 24 AND 28 PIN PACKAGES

Self-Contained — Requires No Additional Systems for Operation



• Programs, validates, and checks for properly erased EPROMs • Emulates PROMs or EPROMs • RS232C Computer Interface for editing/program loading • Loads data into RAM by keyboard • Changes data in RAM by keyboard • Loads RAM from an EPROM • Compares EPROMs for content differences • Copies EPROMs • Power Input: 115VAC, 60Hz, 10W power consumption • Enclosure: Color-coordinated, light tan panels w/molded mocha brown end pieces • Size: 15-5/8"L x 8¾"D x 3¼"H • Wt.: 5¾ lbs.

JE664-A EPROM Programmer **$995.00**
Assembled & Tested (Includes JM16A Module)

JE665 — RS232C INTERFACE OPTION — The JE665 RS232C Interface Option implements computer access to the JE664's RAM. Sample software written in BASIC provided for TRS-80® Model I, Level II Computer. Baud rate: 9600. Word Lgth: 8 bits - odd parity. Stop bits: 2. Option may be adapted to other computers.

JE664-ARS EPROM Prog. w/JE665 Option **$1195.00**
Assembled and Tested (Includes JM16A Module)

EPROM JUMPER MODULES — The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets JE664 for proper programming pulses to the EPROM & configures EPROM socket connections for that particular EPROM.

Part No.	EPROM	EPROM MANUFACTURER	PRICE
JM08A	2708	AMD, Motorola, National, Intel, TI	$14.95
JM16A	2716, TMS2516	Intel, Motorola, National, NEC, TI	$14.95
JM16B	TMS2716	Motorola, TI (+5,-12, +12)	$14.95
JM32A	TMS2532	Motorola, TI	$14.95
JM32B	2732	AMD, Fujitsu, NEC, Hitachi, Intel	$14.95
JM64A	MCM68764, MCM68L764	Motorola	$14.95
JM64B	2764	Intel	$14.95
JM64C	TMS2564	TI	$14.95

CONSUMER PRODUCTS

SECURITY ALARM SYSTEMS

Home Alarm System

• Self-Installation • Presettable w/individual 3-digit code — no key nec. • Instant or 10-sec. delayed warning system • Alarm system incl. window & door contacts • One 9V battery required (not incl.) Low power consumption (0.01mA) • Loud audible alarm (90db) • Delayed exit feature • System complete w/one control station with built-in siren and test button; 4 magnetic contact sets & connecting wires for entire system.

ST-05 Home Alarm System **$59.95**

Door Security System

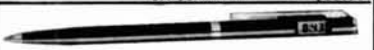
• Coded door alarm • Instant or 7-second delay system • Alarm activated as door is opened • Can be de-activated by pressing personal code • Power: One 9V battery (not incl.) • System includes one personal coded keyboard and one magnetic sensor.

ES-07 Door Alarm **$29.95**

Anti-Theft Auto Alarm System

• Audible horn is activated when door or trunk is opened • Alarm sounds for 3 min. — unless turned off by secret 3-digit code. • Wire cutting will not deactivate alarm. • Code set by owner. • Uses only 0.01mA power. • System complete w/one black-box control unit; one personal coded keyboard; 2 sets of sensors; one audible horn; & wiring (incl. one 10A fuse).

CA-06 Auto Alarm **$59.95**



DIGITAL QUARTZ TIME PEN

• 5-Function: Hours, Minutes, Seconds, Month, Day • Liquid Crystal Display • 1/8" digits • Battery included • Uses standard Parker ink refills • Ultra-slim design (5½" x ⅜")

77ILK	Black/Gold Trim	$9.95 each
77ISG	Stainless Steel/Gold Trim	$9.95 each
77ILR	Red/Gold Trim	$9.95 each

STICK-ON CLOCK

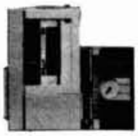
5-Function LCD Quartz Digital

• Hours • Minutes • Seconds • Month • Day • Flashing Colon • Ideal for car, kitchen, bathroom, office, etc. • 1/4" digits • Runs 2 years on 1 battery (incl.) • Size: 1-3/8" Round. Specify color: Red/ST-001R; White/ST-001W; Black/ST-001B

#ST-001____ (Specify letter) .... **$4.95 each or 2/$8.95**

Stereo Cassette Player

with FM Stereo Tuner Pack



- Lightweight Headphones
- Cr02/Metal/Normal Tape Selector
- Anti-Rolling Mechanism

FEATURES: • Blue carrying case, shoulder strap, belt strap, lightweight headphones, FM stereo tuner pack & instruction manual • Talkline • Tone selector • Cr02/Metal/Normal tape selector • LED operation indicator • Built-in microphone • Stop/eject, play, rewind/review, fast forward/cue, tape/radio selector functions • Vol. control • Ext. power input jack • Headphone jack • Auto-stop mechanism (shuts off player when tape ends) • Anti-rolling mechanism (prevents sound from quivering when walking, jogging, etc.) • Weight: 13 oz. • Requires 4 AA batteries (not included) • Size: 6"L x 4"W x 1-1/8"H

Model TWF-802 .... **$69.95**
AM3-4 AA Alkaline Batteries .... **4/$3.95**

UTIC

Mini Stereo AM/FM Receiver

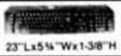
WITH HEADPHONES
For Joggers, Cyclists, Skaters & Sports Events

FEATURES: Lightweight headphones. Left/right balance control. Full fidelity stereo sound. Additional black soft carrying case and shoulder strap. Belt clip (hands free). Operates on 3 AA cell batteries (not incl. - see below). Compact size: 3-1/8"H x 4-7/8"L x 1"D. Wt. 6 oz.

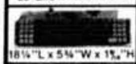
Model 2830 .... **$29.95**
AM3-3 AA Alkaline Batteries .... **3/$2.95**

KEYBOARDS — POWER SUPPLIES

MICRO SWITCH 69-KEY KEYBOARD
Data Entry Keyboard. Encoded Output: 8-bit Parallel EBC DIC. Switching: Hall Effect. 24-pin Edge Card Connection. Complete w/Pin Connection. Can easily be modified to ASCII code.
Part No. KB69SD12-2 (Fits into DTE-20 Enclosure) .... **$19.95 each**



MICRO SWITCH 85-KEY KEYBOARD
Word Processing Keyboard. 26 Pin Edge Card Connection. Supply Voltage +5VDC. Main Keyboard is QWERTY. Additional Key Pads for Cursor and word processing functions.
Part No. 85SD18-1 .... **$29.95 each**



MICRO SWITCH 88-KEY KEYBOARD (PARALLEL)
Data Entry Keyboard used in a Diablo 1640 Terminal. Supply Voltage: +5V, -12V. Switching: Hall Effect — 10-pin Edge Card Connection. Schematic included. Uses 8048 Encoder Chip.
Part No. 88SD22 (Fits into DTE-20 Enclosure) .... **$69.95 each**

POWER SUPPLY +5VDC @ 1 AMP REGULATED *Transaction Tech*
Output +5VDC @ 1A (also +30VDC) reg. Input 115VAC 60Hz. 2-tone (black/beige) self-enclosed case. 6 ft., 3 cond. black power cord. 6⅛"W x 7"D x 2⅝"H. Wt. 3 lbs. Data sheet incl.
Part No. PS51194 .... **$19.95 each**

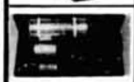
POWER SUPPLY +5VDC @ 1 AMP REGULATED *B Industries*
Output +5VDC @ 1 amp, +36-42VDC adj. 400mA or less, 30VAC (isol.) @ 1.5 amp. Input 115VAC 60Hz. Circ. brkr, re-set button. Blk. self-encl. case w/4 rubber feet. 6 ft., 3 cond. blk. pow. cord. On/off switch. 5⅜"W x 7⅝"D x 3-7/8"H - wt. 7 lbs. Data sheet included.
Part No. PS407D .... **$24.95 each**

POWER SUPPLY +5VDC @ 3 AMP REGULATED *Deltron*
Input: 115VAC, 47-440Hz. Output: 5VDC Adjustable @ 3 amp, 6VDC @ 2.5 amp. Adjustable current limit. Ripple & Noise: 1MV rms, 5MV p-p — 2 mounting surfaces. UL recognized. Size: 4"W x 4⅞"L x 2-7/16"H - wt. 2 lbs. Data sheet included.
Part No. OPS-1 .... **$29.95 each**

MULTI-VOLTAGE POWER SUPPLY +5, +12, −12VDC REGULATED
Input: 105-125VAC, 47-63Hz / 205-250VAC, 47-63Hz. Output: +5VDC @ 2 amps Adj., 5VDC @ 50mA Fixed, +12VDC @ 1 amp Adj., −12V @ 2 amp adj. Overvoltage protection. Size: 12⅞"L x 4-7/8"W x 3⅛"D. Data sheet included.
Part No. RA0250 .... **$39.95 each**

POWER SUPPLY +5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING
Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.5 amp. Fan volt./power supply select switches (115/230VAC). Output: 5VDC @ 7.5 amp, 12VDC @ 1.5 amp. 8 ft. blk. pow. cord. 11⅛"W x 13⅛"D x 3⅝"H. Wt. 6 lbs.
Part No. PS94VO .... **$49.95 each**

POWER SUPPLY 4-Channel Switching Power Supply
Microprocessor, mini-computer, terminal, medical equipment and process control applications. Input: 90-130VAC 47-440Hz. Output: +5VDC @ 5A, -5VDC @ 1A; +12VDC @ 1A, -12VDC @ 1A. Line reg.: ±0.2%. Ripple: 30mV p-p. Load reg.: ±1%. Overcurrent protection. Adj. 5V main output ±10%. 6-3/8"L x 1-7/8"W x 4-15/16"H. Wt. 1½ lbs.
Part No. FCS-604A .... **$69.95 each**



POWER SUPPLY Adjustable Switching 4-24VDC to 5 Amps
Adj. 4-24VDC; 5VDC @ 5A, 6VDC @ 4.6A, 9VDC @ 4.1A, 12VDC @ 3.3A, 18VDC @ 1.9A, 24VDC @ .5A. Overvoltage Protection. Input: 115VAC 50/60Hz. Output variations within 20mV. 6.25"L x 4.25"W x 2.25"H. Wt. 3.25 lbs.
JE224 Kit .... **$79.95 each**
JE224A Assembled & Tested .... **$99.95 each**

SOC 2-6 (Pictured)

SORENSEN Regulated Power Supplies

Sorensen's open construction (SOC) power supplies are series-regulated solid-state systems, designed to provide reg. DC voltages at 6 levels (2-28 v/range). These units are open-framed on sturdy black anodized aluminum for excellent mounting.

FEATURES: 115/208/230VAC Input @ 50-63Hz. Low Ripple: 1.5mVrms, 5mV P-P maximum. Adjustable current limit. Voltage adjustment control. All schematics and specifications supplied with unit. Series A,B,C,E have three mounting surfaces (Series F, bottom mounting only).

Part No.	Series	Output Voltage Adjustment Range min.	max.	Output Current amps (Adc) @40°C	@50°C	@60°C	Size (Inches)	Weight	Price
SOC 2-6	B	1.9	2.1	6.0	4.9	3.8	5.62 x 4.88 x 2.50	4.3 lbs.	$19.95
SOC 2-25	F	1.9	2.1	25.0	21.5	17.5	16.00 x 4.88 x 4.88	18 lbs.	29.95
SOC 5-18	E	4.25	5.25	18.0	15.0	12.0	14.00 x 4.88 x 2.75	12 lbs.	39.95
SOC 5-25	F	4.25	5.25	25.0	21.5	17.5	16.00 x 4.88 x 4.88	18 lbs.	49.95
SOC 12-11	E	11.4	12.6	11.0	9.2	6.8	14.00 x 4.88 x 1.62	12 lbs.	44.95
SOC15-5	C	14.25	15.75	5.0	4.2	3.5	7.00 x 4.88 x 3.37	6.6 lbs.	39.95
SOC 15-8.5	E	14.25	15.75	8.5	7.6	5.8	14.00 x 4.88 x 1.62	12 lbs.	44.95
SOC 15-13	F	14.25	15.75	13.0	10.5	8.0	16.00 x 4.88 x 4.88	18 lbs.	49.95
SOC 28-0.8	A	26.6	29.4	0.8	.64	.45	4.00 x 4.88 x 1.62	2 lbs.	24.95

BUG BOX™ — 30 individual compartments • Stores 60 8-pin or 30 14- or 16-pin DIPs • Heavy duty injection molded plastic • Clear plastic cover slides & locks • Cover marked w/numbers 1-30 • Compartment size: 1" x 3.75" x .5" deep • Box size: 4.9" x 3.3" x .6" • Weight: 1.75 oz.

BUG BOX™

Please specify color code: (B) Blue, (R) Red, (W) White, (Y) Yellow

Part No./Color Code	QTY	PRICE
BGX-001-( )	1	$ 2.29
BGX-010-( )	10	19.99
ANTI-STATIC		
BGX-001-( )AS	1	$ 3.29
BGX-010-( )AS	10	28.89

BUG CAGE™ — 12 locations store Bug Boxes, Big Bug Boxes or Bug Trays • Modular and interlocking • Heavy duty injection molded plastic • Each cage has 6 slip-on locations • 2 cages per pkg. • Cage size: 5-1/8" x 5" x 3-7/8" • 4 colors available — please specify color code: (B) Blue, (R) Red, (W) White, (Y) Yellow

Part No./Color Code	Price
BGC-001-( ) 2 Cages (6 loc. ea.)	$11.95/pkg.

BUG TRAY™ — Stores in Bug Cage • Molded plastic • Three styles: Open (1 compartment 3.05" x 4.6" x .6"); Vertical (5 compartments .5" x 4.6" x .6"); and Horizontal (8 compartments .4" x 3.95" x .6") • Ideal for tools, hardware, components, etc. • Tray size: 3.55" x 5.05" x .6" • Black color only

PART NO.	DESCRIPTION	PRICE
BTH-001	Horizontal Bug Tray	$1.95
BTV-001	Vertical Bug Tray	1.95
BTO-001	Open Bug Tray	1.95
BTX-003	1 of each Bug Tray (3)	4.98

BUG BOX™ STORAGE SYSTEMS

BUG CAGE™ (BGC-001-____) with Bug Boxes

LSI BIG BUG BOX™ — Designed to store large IC's, Resistors, Capacitors and Diodes • Divided into three compartments measuring 1" x 4.15" x .5" deep • Three vertical and three horizontal dividers included • Heavy duty injection molded plastic • Box size: 4.9" x 3.3" x .6" • Weight: 1.75 oz.

LSI BIG BUG BOX™

Please specify color code: (B) Blue, (R) Red, (W) White, (Y) Yellow

PART NO./COLOR CODE	QTY	PRICE
BLX-001-( )	1	$ 3.29
BLX-010-( )	10	28.79
ANTI-STATIC		
BLX-001-( )AS	1	$ 4.29
BLX-010-( )AS	10	37.89

BACK PACK™ — Self-adhesive labels for the back of ICs • Shows exact internal logic in relation to IC pins • 532 labels in each package (including several blank labels) • Each package for 8, 14, 16, 24, 28 and 40-pin ICs • Combo package includes 1,068 labels for TTL and CMOS ICs • Microprocessor package contains 744 labels.

Part No.	Description	Price
BPT-012	TTL	$7.95
BPC-012	CMOS	8.95
BPM-012	Combo	14.95
BPU-012	Microprocessor	9.95

Custom Jumpers!

JUMPER AND CABLE ASSEMBLIES

Custom Cables!

STANDARD DIP JUMPERS

All jumpers use low profile dip plugs with heavy duty pins for repeated disconnect applications.

JAMECO Part No.	AP Cross Reference	No. Pins	Description	Wire Length	Price
DJ14-1	924102-12	14	single end	12"	$1.79
DJ14-2	924102-24	14	single end	24"	2.05
DJ14-3	924102-36	14	single end	36"	2.35
DJ14-1-14	924106-12	14	double end	12"	2.95
DJ14-2-14	924106-24	14	double end	24"	3.19
DJ14-3-14	924106-36	14	double end	36"	3.49
DJ16-1	924112-12	16	single end	12"	1.89
DJ16-2	924112-24	16	single end	24"	2.19
DJ16-3	924112-36	16	single end	36"	2.59
DJ16-1-16	924116-12	16	double end	12"	2.95
DJ16-2-16	924116-24	16	double end	24"	3.29
DJ16-3-16	924116-36	16	double end	36"	3.59
DJ24-1	924122-12	24	single end	12"	2.69
DJ24-2	924122-24	24	single end	24"	3.19
DJ24-3	924122-36	24	single end	36"	3.59
DJ24-1-24	924126-12	24	double end	12"	4.49
DJ24-2-24	924126-24	24	double end	24"	4.95
DJ24-3-24	924126-36	24	double end	36"	5.39
DJ40-1	924132-12	40	single end	12"	5.39
DJ40-2	924132-24	40	single end	24"	6.19
DJ40-3	924132-36	40	single end	36"	6.89
DJ40-1-40	924136-12	40	double end	12"	9.49
DJ40-2-40	924136-24	40	double end	24"	10.29
DJ40-3-40	924136-36	40	double end	36"	10.95

STANDARD DB25 SERIES CABLES

Now you can order DB25 P or S connectors with the cable necessary to fit your application. Choose from our standard flat cable in 4-foot lengths. **Call today.**

STANDARD CABLES

Part No.	Cable Length	Connectors	Price
DB25P-4	4 feet	1 DB25P	$7.95
DB25S-4	4 feet	1 DB25S	8.49
DB25P-4-P	4 feet	2 DB25P	13.49
DB25P-4-S	4 feet	1 DB25P/1 DB25S	13.75
DB25S-4-S	4 feet	2 DB25S	13.95

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6½% Sales Tax
Postage — Add 5% plus $1.50 Insurance
Send S.A.S.E. for Monthly Sales Flyer!

Spec Sheets — 30¢ each
Send $1.00 Postage for your *FREE 1983 JAMECO CATALOG*
Prices Subject to Change

Call for Quantity Discounts

Mail Order Electronics • Worldwide

Jameco ELECTRONICS®

NEW! Telex Number Telex 176043

1355 SHOREWAY ROAD, BELMONT, CA 94002
PHONE ORDERS WELCOME — (415) 592-8097

12/82

5¼" Mini-Floppy Disc Drive

FOR TRS-80 MODEL I (Industry Standard) — **Pertec Computer Corp.**

Features single or double density. Recording mode: FM single, MFM double density. Power: +12VDC (±0.6V) 1.6 amps max., +5VDC (±0.25V) 0.8 amps max. Unit as pictured at left (does not incl. case, power supply or cables). 30-page data book included. Weighs 3½ pounds. Size: 5¾"W x 8"D x 3⅛"H

Part No. *Limited Quantity!* Price
FD200 .... **$179.95**
Single-sided, 40 tracks, 250K bytes capacity
FD250 .... **$199.95**
Double-sided, 35 tracks, 438K bytes capacity

EXPAND YOUR TRS-80

to 16K, 32K, or 48K

**Model 1 =	From 4K to 16K Requires (1) One Kit
Model 3 =	From 4K to 48K Requires (3) Three Kits
Color =	From 4K to 16K Requires (1) One Kit

**Model 1 equipped with Expansion Board up to 48K Two Kits Required — One Kit Required for each 16K of Expansion —

TRS-80 16K Conversion Kit

Kit comes complete with 8 each MM5290 (UPD416/4116) 16K Dynamic RAM (*ns) and documentation for conversion.

TRS-16K2 *150ns	$14.95
TRS-16K3 *200ns	$12.95
TRS-16K4 *250ns	$10.95

TRS-80 Color 32K or 64K Conversion Kit

Kit comes complete with 8 ea. 4164-2 (200ns). 64K Dyn. RAMs & conversion documentation. Converts TRS-80 color computers from 4K-32K Memory or 16K-64K Memory.

TRS-64K2 (200ns) **$54.95**

Universal Computer Keyboard Enclosure

"DTE" Blank Desk-Top Enclosures are designed for easy modification. High strength epoxy molded end pieces in mocha brown finish. Sliding rear/bottom panel for service/component access. Top/bott. panels .080" thick alum. alodine type 1200 finish (gold tint color) for best paint adhesion after modification. Vented top & bottom panels for cooling efficiency.

DTE-20 Panel width 20" **$34.95**

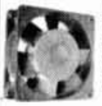
Sprite-style Fan

- 36cfm free air delivery
- 3.125" sq. x 1.665" depth
- 10 yrs. cont. duty at 20°C
- 115V 50/60Hz
- For Apple users

*Metal Frame

PWS2107U	Cleaned & tested (used)	$ 9.95 ea.
*PWS2107F	New	$14.95 ea.

Muffin-style Fan



- 105cfm free air delivery
- 4.68" sq. x 1.50" depth
- 10 yrs. cont. duty at 20°C
- Impedance protected, ambients to 70°C
- 115V 50/60Hz 14W Wt. 17 oz.

*Metal Frame

MU2A1-U	Cleaned & tested (used)	$9.95 ea.
*MU2A-1N	New	$14.95 ea.

JOYSTICKS

JS-5K (Pictured)

JS-5K	5K Linear Taper Pots	$5.25
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AC250 (Pictured)

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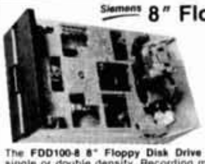

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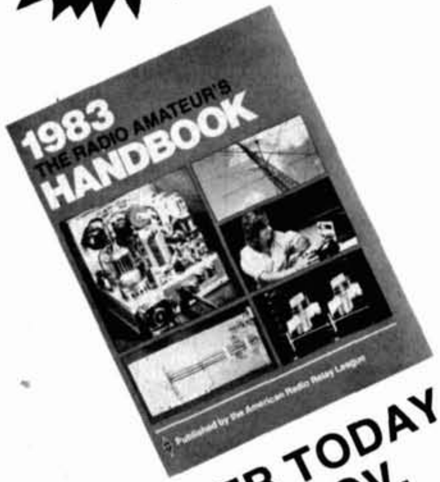

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2N6082	11.50	CA2418 (TRW)	25.00	MA47651	25.50

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GaAs, TUNNEL DIODES, ETC.

PART	PRICE	PART	PRICE	PART	PRICE
MA47100	$ 3.05	MRF503	$ 6.00	PT4186B	$ POR
MA47202	30.80	MRF504	7.00	PT4209	POR
MA47771	POR	MRF509	5.00	PT4209C	POR
MA47852	POR	MRF511	8.65	PT4566	POR
MA49558	POR	MRF605	20.00	PT4570	POR
MB4021	POR	MRF629	3.47	PT4571	POR
MBD101	1.00	MRF644	23.00	PT4571A	POR
MD0513	POR	MRF816	15.00	PT4577	POR
MHW1171	42.50	MRF823	20.00	PT4590	POR
MHW1182	48.60	MRF901	3.00	PT4612	POR
MHW4171	49.35	MRF8004	2.10	PT4628	POR
MHW4172	51.90	MS261F	POR	PT4640	POR
MHW4342	68.75	MT4150 Fair.	POR	PT4642	POR
MLP102	25.00	MT5126 Fair.	POR	PT5632	POR
MM1500	32.32	MT5481 Fair.	POR	PT5749	POR
MM1550	POR	MT5482 Fair.	POR	PT6612	POR
MM1552	50.00	MT5483 Fair.	POR	PT6626	POR
MM1553	50.00	MT5596 Fair.	POR	PT6709	POR
MM1614	10.00	MT5764 Fair.	POR	PT6720	POR
MM2608	5.00	MT8762 Fair.	POR	PT8510	POR
MM3375A	11.50	MV109	.77	PT8524	POR
MM4429	10.00	MV1401	8.75	PT8609	POR
MM8000	1.15	MV1624	1.42	PT8633	POR
MM8006	2.30	MV1805	15.00	PT8639	POR
MO277L	POR	MV1808	10.00	PT8659	POR
MO283L	POR	MV1817B	10.00	PT8679	POR
MO3757	POR	MV1863B	10.00	PT8708	POR
MP102	POR	MV1864A	10.00	PT8709	POR
MPN3202	10.00	MV1864B	10.00	PT8727	POR
MPN3401	.52	MV1864D	10.00	PT8731	POR
MPN3412	1.00	MV1868D	10.00	PT8742	POR
MPSU31	1.01	MV2101	.90	PT8787	POR
MRA2023-1.5 TRW	42.50	MV2111	.90	PT9790	41.70
MRF212/208	16.10	MV2115	1.55	PT31962	POR
MRF223	13.25	MV2201	.53	PT31963	POR
MRF224	15.50	MV2203	.53	PT31983	POR
MRF237	3.15	MV2209	2.00	PTX6680	POR
MRF238	12.65	MV2215	2.00	RAY-3	24.99
MRF243	25.00	MWA110	7.45	40081	POR
MRF245	34.50	MWA120	7.80	40281	POR
MRF247	34.50	MWA130	8.25	40282	POR
MRF304	43.45	MWA210	7.80	40290	POR
MRF315	23.00	MWA220	8.25	RF110	25.00
MRF420	20.00	MWA230	8.65	SCA3522	POR
MRF421	36.80	MWA310	8.25	SCA3523	POR
MRF422	41.40	MWA320	8.65	SD1065	POR
MRF427	16.10	MWA330	9.50	SS43	POR
MRF428	46.00	NEC57835	5.30	TP1014	POR
MRF450/A	13.80	ON382	5.00	TP1028	POR
MRF453/A	17.25	PPT515-20-3	POR	TRW-3	POR
MRF454/A	19.90	PRT8637	POR	UT0504 Avantek	70.00
MRF455/A	16.00	PSCQ2-160	POR	UT0511 Avantek	75.00
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MRF463	25.00	PT3194	POR	V33B	4.00
MRF472	1.00	PT3195	POR	V100B	4.00
MRF475	2.90	PT3537	POR	VAB801EC	25.00
MRF477	11.50	PT4166E	POR	VAB804EC	25.00
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RECALL PHONE MEMORY TELEPHONE WITH 24 NUMBER AUTO DIALER

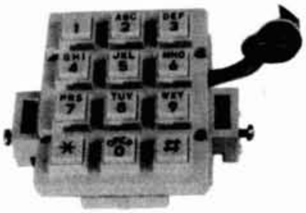
The Recall Phone Telephone employs the latest state of art communications technology. It is a combination telephone and automatic dialer that uses premium-quality, solid-state circuitry to assure high-reliability performance in personal or business applications. $49.99

ARON ALPHA RAPID BONDING GLUE

Super Glue #CE-486 high strength rapid bonding adhesive. Alpha Cyanoacrylate. Set-Time 20 to 40 sec., 0.7fl.oz. (20gm.)
$2.00

TOUCH TONE PAD

This pad contains all the electronics to produce standard touch-tone tones. New with data.



$9.99 or 10/$89.99

MITSUMI UHF/VHF VARACTOR TUNER MODEL UVE1A

Perfect for those unscrambler projects. New with data.

$19.99 or 10/$149.99

INTEGRATED CIRCUIT.

		1 to 10	11up
MC1372P	Color TV Video Modulator Circuit.	$ 4.42	$2.95
MC1358P	IF Amp., Limiter, FM Detector, Audio Driver, Electronic Attenuator.	5.00	4.00
MC1350P	IF Amplifier	1.50	1.25
MC1330A1P	Low Level Video Detector	1.50	1.15
MC1310P	FM Stereo Demodulator	4.29	3.30
MC1496P	Balanced Modulator/Demodulator	1.50	1.25
LM565N	Phase Locked Loop	2.50	2.00
LM380N14	2Watt Audio Power Amplifier	1.56	1.25
LM1889N	TV Video Modulator	5.00	4.00
NE564N	Phase Locked Loop	10.00	8.00
NE561N	Phase Locked Loop	10.00	8.00

FERRANTI ELECTRONICS AM RADIO RECEIVER MODEL ZN414 INTEGRATED CIRCUIT.

Features:
1.2 to 1.6 volt operating range., Less than 0.5ma current consumption. 150KHz to 3MHz Frequency range., Easy to assemble, no alignment necessary. Effective and variable AGC action., Will drive an earphone direct. Excellent audio quality., Typical power gain of 72dB., TO-18 package. With data. $2.99 or 10 For $24.99

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AA Battery Pack of 6 These are Factory New. $5.00

SUB C Pack of 10 2.5Amp/Hr. $10.00

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12vdc at 2.5Amp/Hr. $11.99
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TYPE	PRICE	TYPE	PRICE	TYPE	PRICE
2E26	$ 5.69	KT88	$ 20.00	6562/6974A	$ 50.00
2K28	100.00	DX362	50.00	6832	22.00
2X1000A	300.00	DX415	50.00	6883/8032A/8552	7.00
3B22	19.75	572B/T160L	49.00	6897	110.00
3B28/866A	7.50	592/3-200A3	144.00	6907A	75.00
3-500Z	102.00	807	7.50	6939	15.00
3-1000Z	400.00	811	10.00	7094	125.00
3CX1000A/8283	428.00	811A	15.00	7117	17.00
3CX1500A7/887	533.00	812A	35.00	7211	60.00
3X2500A3	200.00	813	50.00	7289/3CX100A5	34.00
3CX3000A7	490.00	829B	38.00	7360	11.00
4-65A/8165	45.00	832A	28.00	7377	67.00
4-125A/4D21	58.00	4624	310.00	7408	4.00
4-250A/5D22	75.00	4662	80.00	7650	250.00
4-400A/8432	90.00	4665	585.00	7695	8.00
4-400C/6775	95.00	5675/A	25.00	7843	58.00
4-1000A/8166	300.00	5721	200.00	7854	83.00
4B32	22.00	5768	85.00	7868	5.00
4E27A/5-125B	155.00	5836	100.00	7894	12.00
4CS250R	146.00	5837	100.00	8072	65.00
4X150A/7034	30.00	5861/EC55	110.00	8117A	130.00
4X150D/7035	40.00	5876A	25.00	8121	60.00
4X150G/8172	100.00	5881/6L6W	6.00	8122	100.00
4X250B	30.00	5893	45.00	8236	30.00
4CX250B/7203	45.00	5894/A	50.00	8295/PL172	506.00
4CX250F/G/8621	55.00	5894/B	60.00	8462	100.00
4CX250K/8245	100.00	5946	258.00	8505A	73.50
4CX250R/7580W	69.00	6080	10.00	8533W	92.00
4CX300A/8167	140.00	6083/AX9909	89.00	8560/A	65.00
4CX350A/8321	83.00	6098/6AK6	14.00	8560AS	90.00
4CX350F/J/8904	95.00	6115/A	110.00	8608	34.00
4X500A	282.00	6146	7.00	8637	38.00
4CX600J/8809	607.00	6146A	7.50	8643	100.00
4CW800F	625.00	6146B/8298A	8.50	8647	123.00
4CX1000A/8168	340.00	6146W	14.00	8737/5894B	60.00
4CX1500B/8660	397.00	6156	66.00	8873	260.00
4CX5000A/8170	932.00	6159	15.00	8874	260.00
4CX10000D/8171	990.00	6161	233.00	8875	260.00
4CX15000A/8281	1260.00	6291	125.00	8877	533.00
4PR60A	100.00	6293	12.00	8908	12.00
4PR60B/8252	175.00	6360	5.00	8930/651Z	71.00
4PR400A/8188	192.00	6524	53.00	8950	12.00
5CX1500A	569.00	6550	10.00		

6BK4C	6.00	6JM6	6.00	6LQ6 (Sylvania)	7.50
6DQ5	5.00	6JN6	6.00	6LU8	6.00
6FW5	6.00	6JS6B	6.00	6LX6	6.00
6GE5	6.00	6KG6/EL505	6.00	6ME6	6.00
6GJ5	6.00	6KM6	6.00	12BY7A	4.00
6HS5	6.00	6KN6	6.00	12JB6A	6.00
6JB5/6HE5	6.00	6LF6	6.00	6KD6	6.00
6JB6A	6.00	6LQ6 (GE)	6.00	6JT6A	6.00
				6KD6	6.00

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"TVRO BOARD LIST"

70 MHZ IF BOARD: This circuit provides about 43dB gain with 50 ohm input and output impedance. It is designed to drive the Demodulator. The on-board bypass filter can be tuned to bandwidths between 20 and 35 MHz with a passband ripple of less than ½ dB. Hybrid IC's are used for the gain stages.

SINGLE AUDIO BOARD: This circuit recovers the audio signals from the 6.8 MHz frequency. The Miller 9051 coils are tuned to pass the 6.8MHz subcarrier and the 9052 coil tunes for recovery of the audio.

DUAL AUDIO BOARD: Duplicate of the single audio but also covers the 6.2 range.

DC CONTROL BOARD: No description.

DUAL AUDIO BOARD		PRICE EACH
	Printed Circuit Board	$ 25.00
2	3pf sm	1.00
2	12pf sm	1.00
2	50pf sm	1.00
2	68pf sm	1.00
4	91pf sm	1.00
5	.001mfd	.35
6	.01mfd	.35
2	.047mfd	.35
1	.47mfd 25vdc	.35
2	1mfd 10vdc	.59
4	4.7mfd 35vdc	.59
1	470mfd 25vdc	1.29
2	220K 1/4w	.15
2	150K 1/4w	.15
2	6.8K 1/4w	.15
2	3.3K 1/4w	.15
2	2.2K 1/4w	.15
4	1K 1/4w	.15
2	10 ohm 1/4w	.15
2	50K pots	1.00
1	5K pot	1.00
2	CA3065	2.16
1	LM380	1.56
1	7812 Voltage Reg.	1.17
5	2N2222	.50
4	Miller 9051	5.99
2	Miller 9052	5.99
	TOTAL KIT PRICE	97.62

DC CONTROL BOARD		
	Printed Circuit Board	15.00
2	470mfd 25vdc	1.29
2	4.7mfd 25vdc	.59
1	1meg 1/4w	.15
3	10K 1/4w	.15
1	3.3K 1/4w	.15
3	2.2K 1/4w	.15
1	1K 1/4w	.15
2	5K 10 turn trimpot	1.00
4	10K 10 turn trimpot	1.00
1	10K 10 turn with dial	10.00
1	7815 Voltage Reg.	1.17
1	LM324	2.50
1	5 pole rotary switch	2.50
1	SPDT switch	1.00
1	DPDT swich	1.00
1	0-1ma meter	5.00
1	18 to 24vdc at 1 amp power supply	24.99
	TOTAL KIT PRICE	74.27

DEMODULATOR BOARD		PRICE EACH
	Printed Circuit Board	$ 40.00
1	1mfd 35vdc	.59
13	.01mfd 50vdc disc	.35
1	470mfd 25vdc	1.29
2	100mfd 16vdc	.69
2	22mfd 35vdc	.59
3	4.7mfd 35vdc	.59
1	4300pf sm	2.00
1	330pf sm	1.00
1	100pf sm	1.00
1	91pf sm	1.00
2	3pf sm	1.00
1	2 to 8pf ceramic trimmer	1.00
1	100uh choke	1.50
1	4.7uh choke	1.50
1	2.7uh choke	1.50
4	100K 1/4w	.15
1	51 ohm 1/4w	.15
1	27K 1/4w	.15
5	10K 1/4w	.15
1	8.2K 1/4w	.15
2	4.7K 1/4w	.15
1	2.2K 1/4w	.15
1	1.2K 1/4w	.15
3	1K 1/4w	.15
3	560 ohm 1/4w	.15
1	470 ohm 1/4w	.15
1	390 ohm 1/4w	.15
1	300 ohm 1/4w	.15
1	270 ohm 1/4w	.15
1	150 ohm 1/4w	.15
1	41 ohm 1/4w	.15
1	10K pot	1.00
1	NE592/LM733N	2.50
1	NE564	5.00
1	MWA120 (Motorola)	7.80
1	7812 Voltage Reg.	1.17
1	7815 Voltage Reg.	1.17
3	2N2222	.50
2	1N34/38	.50
1	HP5082-2800	2.20
1	5 to 7 volt Zenner	1.00
	TOTAL KIT PRICE	92.25

COMPLETE KIT WITH DUAL AUDIO $923.23
COMPLETE KIT WITH SINGLE AUDIO 880.77

LESS 10% ON ALL COMPLETE KIT ORDERS

BOARDS AND PARTS MAY BE PURCHASED SEPERATELY AT THE PRICES LISTED ABOVE.

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TVRO BOARD DESCRIPTION AND PARTS LIST

DUAL CONVERSION BOARD: This board provides conversion from the 3.7-4.2 band first to 900 MHz where gain and bandpass filtering are provided and, second, to 70 MHz. The board contains both local oscillators, one fixed and the other variable, and the second mixer. Construction is greatly simplified by the use of Hybrid IC amplifiers for the gain stages.

DEMODULATOR BOARD: This circuit takes the 70 MHz center frequency satellite TV signal in the 10 to 200 millivolt range, detects them using a phase lock loop, de-emphasizes and filters the result to produce standard NTSC video. Other outputs include the audio subcarrier, a DC voltage proportional to the strength of the 70 MHz signal, and AFC voltage centered at about 2 volts DC.

DUAL CONVERSION BOARD		PRICE EACH
	Printed Circuit Board	$ 25.00
6	47pf chip caps	1.00
2	4.7mfd 35vdc	.59
2	.01mfd 50vdc disc cap	.35
4	1.5 to 8pf piston trimmer cap	5.99
2	470 ohm 1/4w	.15
2	MWA320 (Motorola)	8.65
1	7815 Voltage Reg.	1.17
1	VT08090	150.00
1	VT08240	156.25
2	1N4005	.39
1	DBM500/1100 (Varil)	125.00
1	MLP102 (Engleman)	25.00
8	SMA Male Connector	5.00
	TOTAL KIT PRICE	572.64

70 MHZ IF BOARD		
	Printed Circuit Board	25.00
3	MWA120	7.80
7	.01mfd 50vdc	.35
2	4.7mfd 35vdc	.59
1	10pf sm	1.00
5	22pf sm	1.00
1	18pf sm	1.00
1	33pf sm	1.00
2	330 ohm 1/4w	.15
5	J.W. Miller 4500-4	4.99
1	7815 Voltage Reg.	1.17
	TOTAL KIT PRICE	86.45

SINGLE AUDIO BOARD		PRICE EACH
	Printed Circuit Board	$ 15.00
1	3pf sm	1.00
1	12pf sm	1.00
1	50pf sm	1.00
1	68pf sm	1.00
2	91pf sm	1.00
3	.001mfd	.35
3	.01mfd	.35
1	.047mfd	.35
1	.47mfd	.35
1	1mfd 10vdc	.59
3	4.7mfd 35vdc	.59
1	470mfd 25vdc	1.29
1	220K 1/4w	.15
1	150K 1/4w	.15
1	6.8K 1/4w	.15
1	3.3K 1/4w	.15
1	2.2K 1/4w	.15
3	1K 1/4w	.15
1	10 ohm 1/4w	.15
1	50K pot	1.00
1	5K pot	1.00
1	CA3065/MC1358P	2.16
1	LM380	1.56
1	7812 Voltage Reg.	1.17
3	2N2222	.50
2	Miller 9051	5.99
1	Miller 9052	5.99
	TOTAL KIT PRICE	55.16

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"CHIPS"

FAIRCHILD VHF AND UHF PRESCALER CHIPS

		PRICE
95H90DC	350MC Prescaler divide by 10/11	$ 8.50
95H91DC	350MC Prescaler divide by 5/6	8.50
11C90DC	650MC Prescaler divide by 10/11	15.50
11C91DC	650MC Prescaler divide by 5/6	15.50
11C06DC	UHF Prescaler 750MC D Type Flip Flop	12.30
11C05DC	1GHz Counter Divide by 4 (Regular price $75.00)	50.00
11C01FC	High Speed Dual 5/4 Input NO/NOR Gate	15.40
82S90	Presettable High Speed Decade/Binary Counter used with the 11C90/91 or the 95H90/91 Prescaler can divide by 100. (Signetics)	5.00
11C24DC	This chip is the same as a Motorola MC4024/4324 Dual TTL Voltage Control Multivibrator.	3.37
11C44DC	This chip is the same as a Motorola MC4044/4344 Phase Frequency Detector.	3.37

GENERAL ELECTRIC CO. GUNN DIODE MODEL Y-2167

Freq. Gap (GHZ) 12 to 18, Output (Min.) 100mW, Duty (%) CW, Typ. Bias (Vdc) 8.0, Type. Oper. (MAdc) 550, Max. Thres. (mAdc) 1000, Max. Bias (Vdc) 10.0. **$39.99**

VARIAN GALLIUM ARSENIDE GUNN DIODES MODEL VSX-9201S5

Freq. Coverage 8 to 12.4GHz, Output (Min.) 100mW, Bias Voltage (Max.) 14vdc, Bias current (mAdc) Operating 550 Typ. 750 Max., Threshold 850 Tup. 1000 Max. **$39.99**

VARI-L Co. Inc. MODEL SS-43 AM MODULATOR

Freq. Range 60 10 150MC, Insertion Loss 13dB Nominal, Signal Port Imp. 50ohms Nominal, Signal Port RF Power + 10dBm Max., Modulation Port BW DC to 1KHZ, Modulation Port Bias 1ma. Nominal. **$24.99**

AVANTEK CASCADABLE MODULAR AMPLIFIERS

	Model UTO-504	UTO-511
Frequency Range	5 to 500 MHz	5 to 500 MHz
Gain	6dB	15dB
Noise Figure	11dB	2.3dB to 3dB
Power Output	+ 17dB	- 2dB to - 3dB
Gain Flatness	1dB	1dB
Input Power Vdc	+ 24	+ 15
mA	100	10
PRICE	$70.00	$75.00

HEWLETT PACKARD MIXERS MODELS

	10514A	10514B
Frequency Range	2MHz to 500MC	2MHz to 500MC
Input/Output Frequency L & R	200KHz to 500MC	200KHz to 500MC
X	DC to 500MC	DC to 500MC
Mixer Conversion Loss (A)	7dB	7dB
(B)	9dB	9dB
Noise Performance (SSB) (A)	7dB	7dB
(B)	9dB	9dB
PRICE	$49.99	$39.99

FREQUENCY SOURCES, INC MODEL MS-74X MICROWAVE SIGNAL SOURCE

MS-74X: Mechanically Tunable Frequency Range (MHz) 10630 to 11230 (10.63 to 11.23GHz) Minimum Output Power (mW) 10, Overall Multiplier Ratio 108, Internal Crystal Oscillator Frequency Range (MHz) 98.4 to 104 0, Maximum Input Current (mA) 400.

The signal source are designed for applications where high stability and low noise are of prime concern. these sources utilize fundamental transistor oscillators with high Q coaxial cavities, followed by broadband stable step recovery diode multipliers. This design allows single screw mechanical adjustment of frequency over standard communications bands. Broadband sampling circuits are used to phase lock the oscillator to a high stability reference which may be either an internal self-contained crystal oscillator, external primary standard or VHF synthesizer. This unique technique allows for optimization of both FM noise and long term stability. List Price is $1158 00 (THESE ARE NEW) **Our Price—$289.**

HEWLETT PACKARD 1N5712 MICROWAVE DIODE

This diode will replace the MBD101, 1N5711, 5082-2800, 5082-2835 ect. This will work like a champ in all those Down Converter projects. **$1.50 or 10/$10.00**

MOTOROLA MHW1172R LOW DISTORTION WIDEBAND AMPLIFIER MODULE.

Frequency Range 40 to 300 MHz., Power Gain at 50MHz 16.6min. to 17.4max., Gain Flatness ± 0.1 Typ. ± 0.2 Max. dB., DC Supply Voltage - 28vdc, RF Voltage Input + 70dBmV **PRICE $29.99**

GENERAL ELECTRIC AA NICADS

Model #41B905HD11-G1

Pack of 6 for $5.00 or 60 Cells, 10 Packs for $45.00

These may be broken down to individual cells.

ORDERING INSTRUCTIONS

DEFECTIVE MATERIAL: All claims for defective material must be made within sixty (60) days after receipt of parcel. All claims must include the defective material (for testing purposes), our invoice number, and the date of purchase. All returns must be packed properly or it will void all warranties

DELIVERY: Orders are normally shipped within 48 hours after receipt of customer's order. If a part has to be backordered the customer is notified. Our normal shipping method is via First Class Mail or UPS depending on size and weight of the package. On test equipment it is by *Air only. FOB shipping point*

FOREIGN ORDERS: All foreign orders must be prepaid with cashier's check or money order made out in U.S. Funds. We are sorry but C.O.D. is not available to foreign countries and Letters of Credit are not an acceptable form of payment either. Further information is available on request

HOURS: *Monday thru Saturday* 8:30 a.m. to 5:00 p.m

INSURANCE: Please include 25¢ for each additional $100.00 over $100.00. United Parcel only

ORDER FORMS: New order forms are included with each order for your convenience. Additional forms are available on request.

POSTAGE: *Minimum shipping* and handling in the US. Canada. and Mexico is $2.50 all other countries is $5.00 On foreign orders include 20% shipping and handling

PREPAID ORDERS: Order must be accompanied by a check

PRICES: Prices are subject to change without notice.

RESTOCK CHARGE: *If parts are returned* to MHZ Electronics due to customer error. customer will be held responsible for all extra fees, will be charged a 15% restocking fee, with the remainder in credit only. All returns must have approval.

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ham radio cumulative index

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general

high-frequency antennas

vhf antennas

matching and tuning

towers and rotators

transmission lines

audio

commercial equipment

More Details? CHECK — OFF Page 132

construction techniques

digital techniques

features and fiction

More Details? CHECK—OFF Page 132

fm and repeaters

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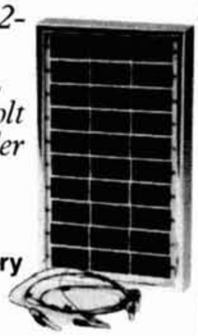

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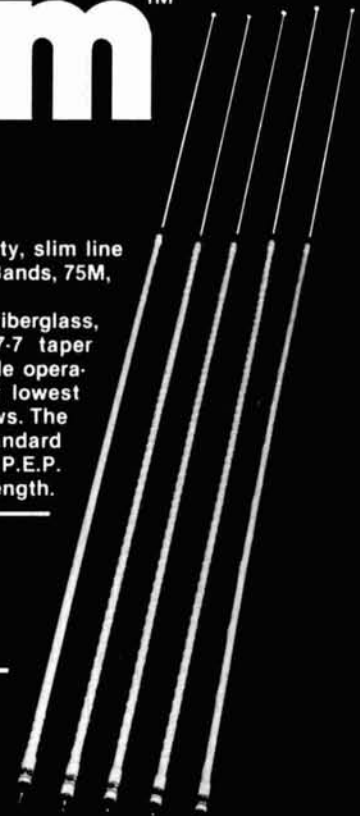

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Caywood ___ 053
Ceco ___ 054
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Ferritronics ___ 041
Fox-Tango ___ 657
Galaxy ___ 026
Goldsmith Scientific ___ 042
Grand Systems ___ 027
Hal Comm. ___ 057
Hallward ___ 043
Hal-Tronix ___ 254
H. R. B. ___ 150
H. R. Magazine *
Ham Shack ___ 879
Hamtronics, N.Y. ___ 246
Harrison Radio ___ 044
Heath ___ 060
Heil Sound ___ 013
Wilton Helm ___ 068
Hoosier ___ 977
Icom *
Ind. Crystal ___ 005
Int. Crystal ___ 066
Int. Solar ___ 028
JWL ___ 058
Jameco ___ 333
Jensen ___ 293
Kantronics ___ 605
Kenwood *
Lockwood ___ 059
Lowrance ___ 065
Long's ___ 468
Lunar ___ 577
MFJ ___ 082
MHz Elec. ___ 415
Madison ___ 431
Mirage ___ 760
National Satellite ___ 046
Nemal ___ 968
P.C. *
Palomar Eng. *
Panasonic ___ 683
Peterson Elec. ___ 047
Photowatt ___ 070
Pipo ___ 481
Polar Research ___ 008
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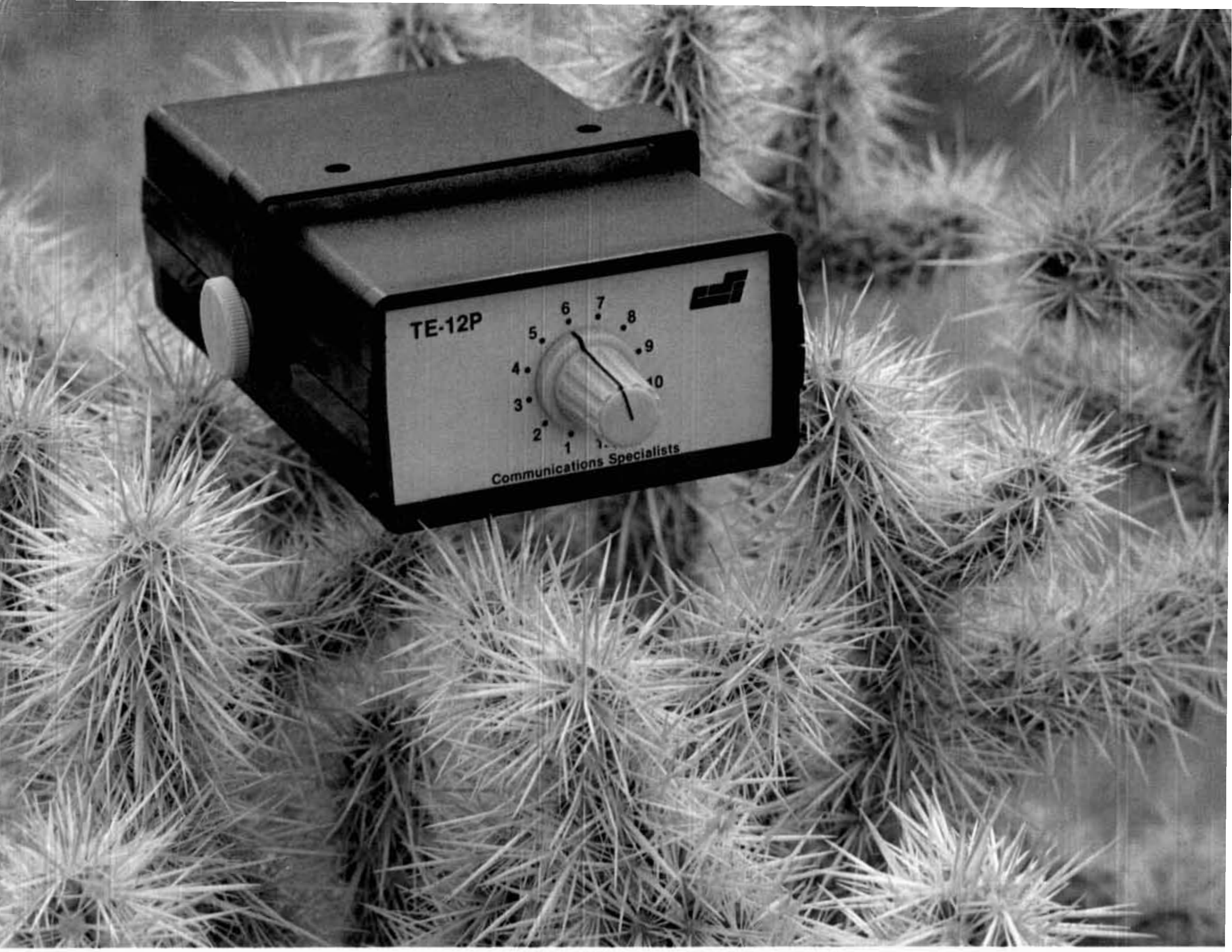

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IF Monitor Circuit
For easy adjustment of the RF Speech Processor or for recording both sides of a conversation, an IF monitor circuit is provided in the transmiter section. When the optional AM/FM unit is installed, the IF monitor may be used for proper setting of the FM deviation and AM mic gain.

WARC Bands Factory Installed
The FT-102 is factory equipped for operation on all present and proposed Amateur bands, so you won't have to worry about retrofitting capability on your transceiver. An extra AUX band position is available on the bandswitch for special applications.

Full Line Of Accessories
For maximum operating flexibility, see your Authorized Dealer for details of the complete line of FT-102 accessories. Coming soon are the FV-102DM Synthesized VFO, SP-102 Speaker/Audio Filter, a full line of optional filters and microphones, and the AM/FM Unit.

Price And Specifications Subject To Change Without Notice Or Obligation

YAESU
The radio.

YAESU ELECTRONICS CORP., 6851 Walthall Way, Paramount, CA 90723 ● (213) 633-4007
YAESU Eastern Service Ctr., 9812 Princeton-Glendale Rd., Cincinnati, OH 45246 ● (513) 874-3100

NEW

Digital DX-terity...

General coverage, Superior dynamic range, 2 VFO's, 8 memories, Scan, Notch...COMPACT!

TS-430S

The TS-430S combines the ultimate in compact styling with advanced circuit design and performance. An all solid-state SSB, CW, and AM transceiver, with FM optional, covering the 160-10 meter Amateur bands, it also incorporates a 150 kHz-30 MHz general coverage receiver having a superior dynamic range, dual digital VFO's, 8 memories, memory scan, programmable band scan, IF shift, notch filter, all-mode squelch, and built-in speech processor.

TS-430S FEATURES:

- **160-10 meter operation, with general coverage receiver**
  With 160-10 meter Amateur band coverage, including WARC 30, 17, and 12 meter bands, it also features a 150 kHz-30 MHz general coverage receiver. Innovative UP-conversion digital PLL circuit, for superior frequency stability and accuracy. UP/DOWN band switches for Amateur bands or 1-MHz steps across entire 150 kHz-30 MHz range. Two digital VFO's continuously tuneable from band to band. Band information output on rear panel.
- **USB, LSB, CW, AM, with optional FM**
  Operates on USB, LSB, CW, and AM, with optional FM, internally installed. AGC time constant automatically selected by mode.
- **Compact, lightweight design**
  Measures only 10-5/8 (270) W x 3-3/4 (96) H x 10-7/8 (275) D, inches (mm), weighs only 14.3 lbs. (6.5 kg.).
- **Superior receiver dynamic range**
  Use of 2SK125 junction-type FET's in the Dyna-Mix high sensitivity, balanced, direct mixer circuit provides superior dynamic range.
- **10-Hz step dual digital VFO's**
  10-Hz step dual digital VFO's operate independently, include band and mode information. Different band and mode cross operation possible. Dial torque adjustable. STEP switch for tuning in 10-Hz or 100-Hz steps. A=B switch quickly shifts "B" VFO to the same frequency and mode as "A" VFO, or vice-versa. VFO LOCK switch provided. RIT control tunes VFO or memory. UP/DOWN manual scan possible using optional microphone.
- **Eight memories store frequency, mode, and band data**
  Memories store frequency, mode, and band data. Eighth memory stores receive and transmit frequencies independently. M.CH switch for operation of memory as independent VFO, or fixed frequency.
- **Lithium battery memory back-up**
  Estimated five-year life.
- **Memory scan**
  Scans memories in which data is stored.
- **Programmable automatic band scan**
  Scans programmed band width. Scan speed adjustable. HOLD switch interrupts band or memory scan.
- **IF shift circuit for minimum QRM.**
  IF passband may be moved to place interfering signals outside the passband, for best interference rejection.
- **Tuneable notch filter built-in**
  Deep, sharp, tuneable, audio notch filter.
- **Narrow-wide filter selection**
  NAR-WIDE switch for IF filter selection on SSB, CW, or AM, when optional filters are installed. (2.4 kHz IF filter built-in.)
- **Speech processor built-in**
  Improves intelligibility, increases average "talk-power."
- **Fluorescent tube digital display**
  Indicates frequency to 100 Hz (10 Hz modifiable).
- **All solid-state technology**
  Input rated 250 W PEP on SSB, 200 W DC on CW, 120 W on FM (optional), 60 W on AM. Built-in cooling fan, multi-circuit final protection. Operates on 12 VDC, or 120 VAC, or 220/240 VAC with optional PS-430 AC power supply.
- **All-mode squelch circuit, built-in**
- **Noise blanker, built-in**
- **RF attenuator (20 dB)**
- **Vox circuit, plus semi break-in with side-tone**

Optional accessories:

- PS-430 compact AC power supply.
- PS-30 or KPS-21 AC power supplies.
- SP-430 external speaker.
- MB-430 mobile mounting bracket.
- AT-130 compact antenna tuner, 80-10 m incl. WARC.
- AT-230 base antenna tuner, 160-10 m incl. WARC.
- FM-430 FM unit.
- YK-88C (500 Hz) or YK-88CN (270 Hz) CW filters.
- YK-88SN (1.8 kHz) narrow SSB filter.
- YK-88A (6 kHz) AM filter.
- MC-42S UP/DOWN hand microphone.
- MC-60A deluxe desk microphone, UP/DOWN switch.

More information on the TS-430S is available from all authorized dealers of Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220.

KENWOOD

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