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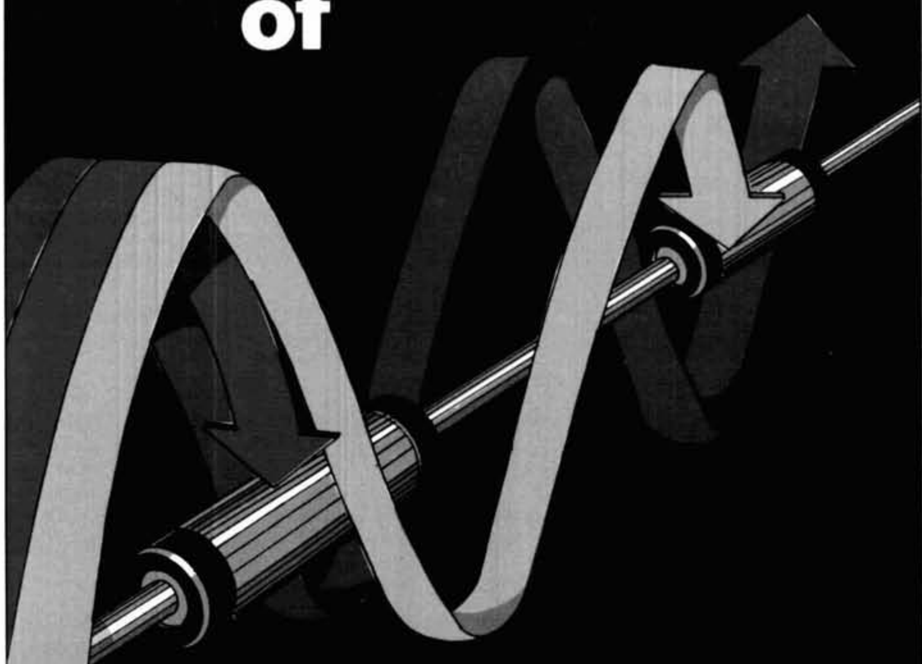
The Mysteries of Trapped Antennas



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contents

Observation & Opinion

From time to time I tune across the Novice bands just to see what's going on and to learn how the beginners are developing their operating skills. I sometimes fire up my rig and work a few Novices. In most cases the Novices appreciate a more experienced CW operator invading their territory, especially if the latter is patient and understanding. I recommend that all experienced CW operators take the time to work a few Novices. It's a welcome change from fighting the pile-ups and gives a sense of accomplishment, especially if you've helped a Novice improve his code proficiency and operating procedures.

Listening on the Novice frequencies can be an interesting experience. The Novice portion of the 40-meter band is a good example. Here you'll find some operators who are pretty good — their sending, although not fast, is clear and clean, and their operating techniques are on a par with those of many General-class operators. A few have electronic keyers or keyboards, but most plod along with a straight key. At the other end of the scale, you'll find Novices who just can't seem to break bad operating habits. This is where an experienced CW operator can really help, but it takes a lot of patience and, above all, tact.

Many Novices don't know what to do after they've called CQ. The over evening I heard a station sending CQ continuously at a rapid rate for three minutes, followed by his call sign, which was sent only once. After a pause of a few seconds, the CQing started again. This was repeated for another three or four minutes — still no response. Then I tuned up the band a few kilohertz, and there was another Novice calling CQ. The same pattern was again repeated — no response. All in all, I heard perhaps ten stations across the Novice portion of the band calling CQ. One wonders if they had their receivers turned on.

Then I tuned back to the first station and there he was, still at it. When he signed this time I gave him a call, being particularly careful to match my sending speed to his. I signed over — nothing. Then, "QRZ? QRZ?" I sent my call again at his speed. Again, "QRZ?" This went on for a few minutes, then I reduced speed to about half and the Novice finally answered. We had a pleasant contact for a while, with the Novice sending at a considerably slower rate than before, complete with all the punctuation marks.

I mentioned earlier that many Novices don't know what to do after calling CQ. I find that many Novices, after returning to the receive mode, don't tune around their transmitting frequency. Apparently they expect the replying station to be exactly on their transmitting frequency, which is unlikely in many cases. If the Novice is using a sharp CW filter in the receiver, the answering signal could be outside the receiver i-f passband and will never be heard.

The best answer to the CQ problem is don't. Old-timers will recall a filler cartoon that used to run in *QST* years ago. It showed a mama cat walking along the top of a fence, followed by three kittens. The caption was, "If you wanna get results, you gotta make calls!" Not only did it mean CQ calls but also calls to other stations.

Another recollection of bygone days is the series of pieces in *QST* by T.O.M. (The Old Man). T.O.M. loved to write about "Rotten Radio." His poignant prose was directed to everything from rotten spark sets to rotten operating. I think we could use more of T.O.M.'s scathing criticism. Although he wrote in a humorous vein, there was a lot of truth in his observations. I'll bet if T.O.M. were alive today, he would endorse my sentiments about the operating practices of some of our Novices. I feel it's the responsibility of the higher-class operators to give a little of themselves to assist those Novices that need help.

Alf Wilson, W6NIF
editor

comments

filter design

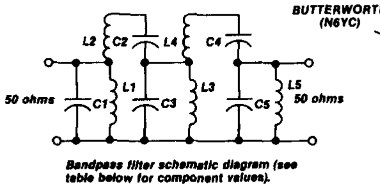
Dear HR:

I am writing to tell you that I enjoyed reading the "Rf Power Meter" article by Ralph Fowler, N6YC, that appeared in the June issue. I was particularly interested in Mr. Fowler's discussion of the directional bridge and its associated accessories. I noted that several of Mr. Fowler's accessories were lowpass and bandpass filters, and he referred the reader to the ARRL *Handbook* for lowpass filter construction information. In my opinion, there are more useful references than the ARRL *Handbook* for the design of the seven-pole LC lowpass filters used by Mr. Fowler, and I wish to bring these references to the attention of Mr. Fowler and the readers of *ham radio*.

Since 1972, I have had many articles published on passive LC filter design (references 1 through 8) in which tables of pre-calculated designs required only standard-value capacitors to simplify construction. The most recent article[5] on this design aid was published in the January 7, 1981, issue of *EDN*. I recommend this last reference to Mr. Fowler and your readers for the expeditious design and construction of the seven-element lowpass filters mentioned in the article. (**Table 2** of the reference is probably more useful for Amateur Radio applications than is **table 1**).

For example, on page 59 of his article, Mr. Fowler states he uses "seven-pole LC lowpass filters with cutoffs at 5.8, 9.6, 15.7, 23.1, and 30.4 MHz" to attenuate the harmonic amplitudes of his signal generator. These designs can be conveniently selected from my **table 2** and only standard-value capacitors are needed. Also, all of the messy calculations are eliminated. For the previously listed cutoff frequencies used by Mr. Fowler, I suggest Filter Designs #207, 232, 138, 162, and 173, respectively. These designs have reflection coefficients of less than 9.2 percent, and they should perform satisfactorily in this application. I will be happy to provide anyone with a copy of my article if they send me a stamped, self-addressed envelope.

To further demonstrate how standard-value capacitors can simplify filter design and construction, I have made minor modifications to Mr. Fowler's 5.3-MHz Butterworth bandpass filter (**fig. 9**, page 61 of his article). The Butterworth design was modified into a Chebyshev design that is easier to construct, and the passband and stopband performance of the two designs is very similar (see my **fig. 1** of bandpass filter responses). (The Chebyshev design was based on my tabulation of pre-calculated five-element lowpass filters that was published in June, 1978 — see reference 6.) Note that the inductor values of the two different de-



Bandpass filter schematic diagram (see table below for component values).

Five-resonator bandpass filter designs by N6YC and W3NQN.

Type	3-dB BW	F_c (MHz)	C1,5 (pF)	C2,4 (pF)	C3 (pF)	L1,5 (μH)	L2,4 (μH)	L3 (μH)
Butterworth	—	5.3	1970	70	6370	0.46	12.9	0.14
Chebyshev RC = 5.0%	1.16	5.42	2700	75	5600	0.319	11.5	0.154

Note: The W3NQN Chebyshev BPF design has been optimized to use only standard-value capacitors.

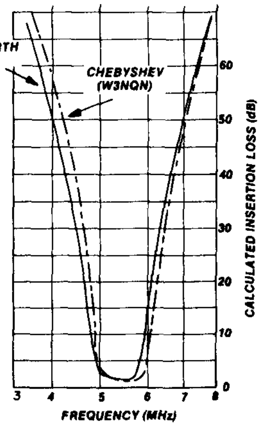


fig. 1. Calculated bandpass filter responses based on an inductor Q of 100 at 5.3 MHz.

signs are very similar, and therefore the inductors of the Chebyshev design should be just as feasible to obtain as the Butterworth designs. If the bandwidth of the filter is made too small, the ratio of inductance values (L2 to L1,5) will become too large, thus making it difficult to get good inductor Q and proper filter performance. The filter bandwidth selected by Mr. Fowler seems reasonable from a construction and performance viewpoint. Capacitor values C2 are similar (70 pF compared with 75 pF) but C1,5 and C3 are quite different. This difference is a consequence of changing the Butterworth design into a Chebyshev design. Mr. Fowler's center frequency of 5.3 MHz was slightly increased to 5.42 MHz to make C2,4 come out to a standard capacitor value (75).

Mr. Fowler was correct in his concluding sentence that "improvements doubtless can be made," and this I have attempted to demonstrate as far as the passive LC filter design aspect is concerned. I am grateful to Mr. Fowler for taking the time and effort to write his articles, and I thank *ham radio* for publishing them. I hope to read many more similar articles which will assist me and others in improving our technical expertise.

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Ed Wetherhold, W3NQN

presstop

FCC'S STAFF REPORT was finally issued July 16, and the 92-page document contains a number of inferences and suggestions that should cause concern in the Amateur community. Although the report cites CB radio as the greatest single source of RFI complaints, Amateur Radio is almost invariably mentioned along with CB in discussions of problems and solutions. "The problems created by radio frequency interference (RFI) are serious and getting worse," the report's chapter on recommendations begins, and then in the very next paragraph it states, "A significant part of the RFI problem is TV receiver overload caused by CB radio (and to a lesser extent amateur radio)."

Among The Proposed Solutions (to TV set overload by CB radio) are mandatory or voluntary TV receiver standards and TV receiver labeling (as to performance). Another option would be to set a combined transmitter/receiver limited liability, which could (for the transmitter operator) include adding filters, limiting antenna height (or direction), quiet hours, or even compensating the person interfered with! Another option, even more onerous, would place all burden for TVI resolution on the transmitter operator.

This Last Interference "Remedy" comes up several times in the Commission's staff report, and would certainly be very objectionable to the Amateur service. With it an Amateur could be forced to reduce power, move or modify antennas, avoid certain bands, or even give up operating entirely in order to resolve an interference problem. This alternative remedy does seem to have some support, however, as it comes within the present authority of the FCC. The alternative remedy, regulation to require better interference rejection by home entertainment devices, is one that would require new legislation, such as Senator Goldwater's bill, S929.

A Further Notice Of Inquiry on the RFI question, General Docket 78-369, was issued along with the staff report. Reply Comments are due on November 16.

SIGNIFICANT RULES RELAXATIONS have been suggested for the Amateur Service in an FCC working paper, "Deregulating Personal and Amateur Radio." The recently released 80-page document, more a "brainstorming session" of the possible directions Amateur and CB deregulation might take than hard and fast proposals, was prepared by the Commission's Office of Plans and Policy.

Repeater Rules Are Discussed in the paper, which suggests reducing the responsibility control operators have for repeater control or eliminating it completely, and changing the prohibitions on repeaters below 29.5 MHz. Some restrictions on third-party traffic could also be relaxed; the working paper is very strong on "deregulation or liberalization of restrictions that may inhibit new technology," and suggests that the rules now restrict or even prohibit Amateur experimentation with packet radio, spread spectrum, and other new communications developments.

A Code-Free VHF License "for technically qualified applicants" might strengthen Amateur Radio's technological orientation it further suggests, along with improving utilization of the 28-MHz band by giving Technicians some phone privileges there. It also considers the possible benefits of allowing "some Amateur operations on 27 and 900 MHz Personal Radio Service (CB) frequencies."

The Personal Radio Service and how it can best use the new 900-MHz band occupies the bulk of the working paper. The adoption of various new communications techniques and the expansion of personal radio into landmobile business communications, mobile and rural radiotelephone, and even marine radio are subjects which receive even more attention than the Amateur Service does in the paper.

Though The Deregulation Ideas presented in the working paper are simply ideas at this time, they deserve consideration, as they represent some recent FCC thinking. A very few copies of the paper were available from the Commission; reproductions are also offered by Fair Press Services, (202) 463-7323, and the Downtown Copy Center, (202) 452-1422, at about $8.00 a copy.

Amateurs With Comments on the working paper can contact Alex Felker, Office of Plans and Policy, FCC, Washington, D.C. 20554.

ARRL HAS BEEN SUED FOR $50,000 by three members of the Indiana Radio Club Council, who allege in their complaint that "the defendant (ARRL) refuses to hold a recall vote" in the Central Division. League General Manager Dick Baldwin had acknowledged receipt of the Council's recall petition in a July 29 letter, in which he stated the petition had been put on the September 9 Executive Committee meeting agenda.

The First Hearing on the suit was set for September 25, in the U.S. District Court in Indianapolis.

A NEW WORLD LAND SPEED RECORD will be attempted starting on September 28 at the Bonneville Salt Flats in Utah. A special-event station with SSTV pictures of the attempt, being made by Thrust Cars Ltd. from England, will be active October 3, 4, 10, 11, 17, 18, and 24 starting at 1500Z. Frequencies will be 14240 and 21340 for SSTV, and 14290 and 21370 for SSB QSOs. Operating as WA7MTF, the Amateurs will also provide ATV along the 11-mile strip for crowd control.

trapping the mysteries of trapped antennas

A quantitative treatment of antenna trap design and construction

Much information is available pertaining to antenna design and construction. Most of this information is written for a technically competent audience and addresses the problem of antenna performance under nearly ideal conditions. With 17 years in Amateur Radio, I have yet to live in a location where compromises are not required. One very popular compromise is the use of traps to achieve multiband operation with a single antenna.

The use of traps in commercial designs, such as verticals and triband beams, has been an accepted technique for many years. Although design guidelines are available, a quantitative definition of what is required and acceptable does not seem to exist. I was puzzled about trap designs and asked why a compromise in performance should be costly. Owning a transceiver that covers 160 through 10 meters, I wanted to use as many of the bands as possible. Separate antennas for each band were out of the question because of limited space. Having no previous experience with trapped antennas, I decided it was the right time to gain some.

what is required?

I began reading assorted handbooks and college texts. I reviewed back issues of magazines and queried colleagues. I was surprised to discover how little information is available about traps, much less their use in antennas. The following information was derived from my research:

1. Traps are parallel-resonant tuned circuits that provide an effective open circuit at their resonant frequency.

2. Traps become a series inductance at frequencies below resonance, electrically lengthening the antenna. This implies that the physical length of the antenna is shorter at lower frequencies because of the inductance provided by the coil component of the trap.

3. Traps must have a high Q.

4. High-Q capacitors must be used.

5. Large-diameter coils are recommended.

6. Capacitors and inductors providing 200 to 300 ohms of reactance at resonance provide good results.

7. Traps must be resonant very near the center of the band for which they are designed.

I needed answers to some basic questions to determine the requirements of a trap:

1. What is an effective open circuit?

By Gary E. O'Neil, N3GO, 13 Holiday Hill Road, Endicott, New York 13760

2. How high is high Q?

3. How large is a large-diameter coil?

4. How close to the desired frequency must a trap be resonant?

5. What effects do traps cause at the band edges?

6. How much do traps shorten an antenna?

7. How do I tune an antenna with traps?

I'd be dishonest if I claimed that I asked all these questions at once and that my initial results were where this story ends. Actually, I went through two designs before developing the trap described here and evaluated one commercially manufactured design for comparison of performance. As I progressed, I found I had questions not answered by colleagues or reference books. Some crude testing was in order.

high Q or high impedance?

I needed to know what an effective open circuit was, and my test for this was quite simple. I built a 20-meter dipole as my reference antenna and assumed that adding a high-value resistor in series with the length of wire on the end would be like adding a high-Q trap and wire for a lower band when operating on 20 meters. I assumed a quarter wavelength on 20 meters to provide a worst-case mismatch of the antenna. I cut some wire to 16.5 feet (5 meters) in length and spliced a resistor to one end; then I connected this wire onto one end of my dipole at the opposite side of the resistor and measured the VSWR. The following results were obtained:

resistor value (kilohms)	VSWR
2.7	2.8 to 1
3.9	2.6 to 1
6.8	2.2 to 1
10.0	1.7 to 1

The VSWR of the antenna before this test was less than 1.2 to 1. I conducted the test where the antenna was best matched to get a feel for the contribution to overall VSWR.

It appears that an impedance greater than 7 kilohms must be maintained to ensure a 2:1 VSWR. A lower trap impedance can be used and compensated for by adjusting antenna lengths; but in this case the loading effect would have caused an interaction and tuning for resonance on all bands would be a frustrating experience.

While studying my impedance data and considering Q, I became a bit perplexed. As losses approach zero, Q approaches infinity and bandwidth approaches zero. If this were true, the trap would be useful at one frequency only. Zero bandwidth was not my problem. Given bandwidth and center frequency, I can calculate Q, as illustrated by this example:

Given: $F_c = 14.175\,MHz$ (center of 20 meters)

$3\,dB\,BW = 0.35\,MHz$ (width of 20-meter band)

Therefore:

$$Q = \frac{F_c}{3\text{-}dB\,BW} = \frac{14.175}{0.35} = 40.5$$

It follows that high Q is 40.5 on 20 meters and is valid if, at F_c, the impedance is equal to 14 kilohms. The impedance at the band edges in this case would be 7 kilohms, which is sufficient for a 2:1 match and assumes that the antenna and traps are tuned to 14.175 MHz exactly.

A Q of 40.5 and an impedance of 14 kilohms at resonance can be achieved with a wide variety of LC combinations and assorted types of capacitors.

Now assume Q remains constant but impedance increases at F_c. The effect is a higher impedance across the band. If the impedance at F_c remains constant and Q gets larger, the impedance at the band edges is reduced. This implies a problem, since my crude measurements indicate a need to maintain greater than 7 kilohms across the band.

My point is, *high Q may not be desirable in antenna traps*. It's important to understand that the property of the trap providing isolation is its *impedance*. It is this impedance that must be kept large. Anything larger than 7 kilohms improves isolation and is therefore desirable.

A little experience will clarify the fact that, as Q increases, the impedance at F_c increases. This is perhaps the reason why high-Q traps are considered a must for good performance. I intend to show this is not true and attempt to explain the contribution of Q to losses and bandwidth rather than to impedance at resonance.

questions answered

The most helpful reference I could find for an answer to my original question suggests that high Q is approximately 100, and a Q of 50 would be considered medium. Aside from answering my original question, this information served no useful purpose. The same is true for high-Q capacitors. Strictly speaking, Q refers to losses *in this case* rather than bandwidth. And if capacitors are used, the higher the Q, the better should be your guide. High-voltage capacitors are popular but are generally expensive and difficult to find.

Large-diameter coils seem to imply 2-3 inches (5-7.5 cm), although most triband beam manufacturers do well with smaller diameters. This information, along with the recommended 200-300 ohms of reactance at resonance, have worked well in the past; and experiments with trap designs of the more conventional type tend to support these recommendations. For this reason, I will not oppose the theories on which they are based.

I attempted a number of trap designs, looking for a low-cost, easily manufactured capacitor. Gary Myers, K9CZB,[1] used coaxial cable for the capacitor in his 7-MHz trap. My tests revealed an impedance of 50 kilohms at F_c for a 15-meter version using an HP-4815A Vector Impedance Meter. Its Q was high (approximately 126); and to ensure 7 kilohms at the band edges, the center frequency had to be accurate and stable. With a bit of persistence, careful thought, and some RG-58/U, I was able to develop the trap described here.

theory

The single-element trap simultaneously uses three physical properties that can be realized with a section of coaxial cable. Using the properties of capacitance, inductance, and coupling reduces the complexity of LC networks to an appropriately configured length of coax in the form of a coil. Models have been built, tested, and evaluated in the 3.5- to 30-MHz range and calculations verified to 150 MHz with a reasonable accuracy.

A properly designed and manufactured coaxial cable has a uniform capacitance per unit length, which is predictable, between the center conductor and shield. This capacitance can be employed in an LC network such as a tank circuit, which presents a high impedance at resonance.

A second property is that coax can be coiled. The forming of a conductor (the coax shield in this case) into a coil produces an inductance greater than that of the wire alone, due to coupling between turns. This is predictable and can serve as the inductive component in an LC network. It should be noted that only the shield is considered to be coiled and is the significant contributor to the inductive component of the trap.

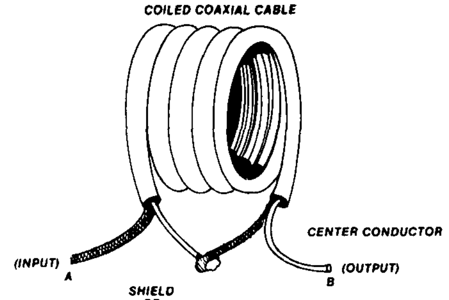


fig. 1. Single-element trap wiring detail.

Since the center conductor is shielded, the effects of coiling the cable do not influence the center conductor, which maintains a given inductance per unit length of the wire alone. Although this property has negligible effect on the operation of the trap to be described and was omitted from the calculations, one should be aware of it for applications at or near microwave frequencies. The important point is that the capacitance per unit length remains unchanged by coiling the cable due to the shielding properties of the outer conductor.

configuration

With the source of capacitance and inductance defined, the task of wiring the device remains. **Fig. 1** illustrates this requirement and shows the cable coiled as described. It is shown without a form for support as an illustrative aid. If flexible cable such as RG-58/U is used, a rigid form such as PVC plumbing stock would be required.

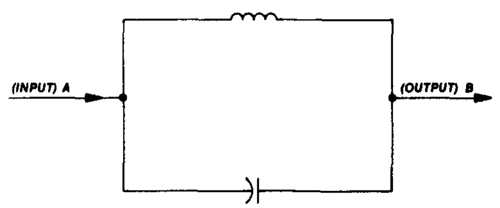


fig. 2. Electrical schematic of an antenna trap.

Fig. 2 is the schematic representation of a parallel LC network with external connections designated **A** and **B**. Notice that a dc path must be provided between terminals **A** and **B**. Also, each plate of the capacitor connects to opposite ends of the inductor. A casual look at **fig. 1** may cause some confusion since it appears that, with the center conductor connected to the shield, the cable's capacitance is short circuited. This is valid only at dc as is the case in the circuit shown in **fig. 2**. An analysis of the phase relationships required at resonance will reveal why this connection is not only valid but is also required.

The third property of the coaxial cable is the coupling between the center conductor and shield due to magnetic induction. This property (the basis of transformers) is clearly seen if viewed as a straight length of cable. **Fig. 3** shows this schematically as two parallel conductors revealing the necessary components of a 1 to 1 transformer, or more aptly, a coupler. Current injected into the primary from some source induces a secondary current in the opposite direction as indicated by the arrows. Connecting the top of the secondary to the bottom of the primary causes primary and secondary currents to oppose each other. These currents, being equal and opposite, aid the opposition of the network to current flow. At resonance, the trap has a high circulating current enhancing the coupling properties, which further improves this opposition.

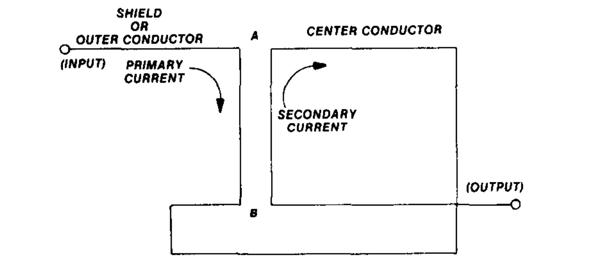


fig. 3. Electrical schematic of single-element trap as a 1:1 transformer or coupler.

With the cable configured as shown in **fig. 1** and referring to the schematic in **fig. 2**, one might assume that the input and output connections should be at the ends of the shield. This provides the tank circuit function using only the properties of inductance and capacitance. Magnetic induction is not employed when one end of the secondary remains open circuited. The connections indicated provide the return path for secondary current, and an analysis of phase relationships at resonance will validate this connection.

The inductance of the center conductor now included causes a slight shift downward in resonant frequency and was observed to be about 2.5 percent in a 15-meter trap. The significant result of this connection is the gain in impedance produced by the opposing primary and secondary currents with no detectable change in *Q* relative to the 3-dB bandwidth of the device. Test data provided at the end of this article illustrates the significance of this impedance gain.

Tests of traps using conventional LC configurations indicate this trap has much lower *Q* (wider bandwidth) but provides a comparable impedance at resonance, implying similar loss characteristics. High impedance and relatively low *Q* make this design superior, since the accuracy to which it is tuned and its physical stability become less critical. *The result is a trap that does not need tuning.*

In addition to these profound advantages, the cost is near zero. If you are considering erecting an antenna, you will likely have coax as your feedline. A local plumbing contractor may be a good source for discarded PVC stock sufficient for these traps.

Q versus loss

Does the low *Q* of the single element trap imply that it is lossy? This must be answered with another question. What is low loss? **Fig. 2** represents a tank as a capacitor in parallel with an inductor. If this were an exact representation, the impedance at resonance would be infinite. Mother nature plays her role and introduces loss represented by a resistor in parallel with the tank.

At resonance, the impedance is infinity in parallel with the resistor representing the losses, or approximately the value of the resistor alone. To determine actual losses, it's necessary to apply a voltage across the tank and solve for the power dissipated in the resistor. The power dissipated as heat in this resistor is the loss presented by the tank. It should be clear that the losses encountered are inversely proportional to the tank's impedance. If this impedance is high, the loss will be low. If *Q* can be reduced without decreasing the value of the resistor representing the losses, the performance in multiband antenna applications will be enhanced.

This results from using the single-element trap described and is supported by data collected on four 15-meter traps. Trap A was a commercially manufactured unit; B is the single-element trap built as I have described; C, similar to trap A, is my first attempt at a compact, low-cost design; D was a K9CZB[1]-style trap. The data as measured on an HP-4815A:

trap style	inductor	capacitor	impedance at resonance (kilohms)	*Q*
A	1.7 inch (4.3 cm) dia. 14 AWG (1.6 mm) wire	concentric tubing	40	142
B	1.7 inch (4.3 cm) dia. RG-58U	RG-58/U coax cable	41	56
C	1.7 inch (4.3 cm) dia. 14 AWG (1.6 mm) wire	concentric tubing	27.5	75
D	1.7 inch (4.3 cm) dia. 14 AWG (1.6 mm) wire	RG-8/U coax stub	54	126

When compared with the commercial design, the single-element trap has approximately the same impedance at resonance (equal losses) but nearly three times the bandwidth. This means the accuracy and stability can be three times worse and still achieve equal results. The traps I use were built in a hurry and are resonant out of band. There was no detectable interaction during adjustment, and the performance of the antenna has been excellent on all bands.

pros and cons

A brief review of the relative advantages and disadvantages of trap antennas compared with separate antennas per band is offered here:

advantages:

1. Multiband operation achieved with a good match on all bands.

2. Automatic bandswitching.

3. Antenna length reduced.

4. No compromise operation on highest band(s) since a full-size antenna is employed there.

5. Lower cost than separate antennas.

disadvantages:

1. Lower radiation efficiency due to trap losses on lower bands.

2. Narrowing of bandwidth due to the inductive loading presented by the traps.

3. Loss of second-harmonic rejection if bands are so related.

The first two disadvantages, though not severe, are the compromise that is made in any trapped antenna design. This is also true of the third, but this compromise deserves more comment. Single-band antennas provide second-harmonic rejection due to mismatch losses, and in a simple test nearly 20 dB of rejection was achieved. This compromise affects all of us, not just the user of the antenna, and to keep interference minimal, antenna matching systems are recommended. If a matching system is not used, careful tuning of the transmitter, and application of U.S. Regulations Part 97.67b[2] will go a long way in maintaining peace and friendship within the Amateur fraternity and among other services as well.

construction

Table 1 provides the dimensions for traps below 30 MHz. These dimensions assume RG-58/U and 1.25 inches (3.2 cm) PVC stock are the materials used. Form lengths given permit 1 inch (2.5 cm) to extend beyond each side of the coiled coax. This facilitates using the form as a support for each antenna section and can be adjusted to suit personal preferences. All traps must be close wound and should be as tight as possible to ensure mechanical stability. The coax lengths permit 3 inches (7.6 cm) to extend beyond each side of the coil, permitting antenna-section splicing and the wiring of the trap itself.

With the form and coax cut as indicated in **table 1**, assembly can begin. An 0.2-inch (0.5-cm) drill was selected to allow a snug fit for the coax.

1. Begin construction of the trap by drilling one hole approximately 1 inch (2.5 cm) from the end of the form.

2. Strip 3 inches (7.6 cm) of insulation off one end of the coax, and separate the shield and center conductor.

3. Strip 2 inches (5 cm) of insulation off the center conductor. Insert this end of the coax into the hole drilled in the PVC form until the coax jacket extends into the inside of the form no more than 0.25 inch (0.6 cm).

4. Very tightly wrap the coax around the form the specified number of turns and locate the point where the coiled coax should end. Mark this spot.

5. Move the coax end away, and drill a second hole at the marked location as near as possible to the next turn of the coil without cutting the jacket.

6. Tightly rewrap the coil to take up the slack that may have been introduced, and mark the end of the coax 0.25 inch (0.6 cm) beyond the hole just drilled.

7. With a sharp knife cut approximately half way through the jacket material only, then completely around the coax at this location.

8. In a similar fashion make a cut lengthwise along the cable from the first cut to the end of the coax. Do not remove the jacket material at this point. Again, tightly rewind the coil and insert the prepared end of the coax through the second hole.

9. Pull the coax from the inside of the form until it lies flat at both ends. (Some massaging of the end of the coax where it passes into the form may be required.) The jacket may be easily removed from the coax at this point and shield and center conductor separated.

10. Remove all but about 1 inch (2.5 cm) of insulation from the center conductor. Twist together the center conductor of one side and the shield of the opposite side. This connection should be internal to the coil form and tightly twisted to keep the leads as short as possible.

11. Cut off all but 0.5 inch (1.3 cm) and solder this connection.

12. Drill a hole 0.5 inch (1.3 cm) from each end and on the same side of the form. These holes are used to support the elements when used in a dipole or wire vertical.

13. Wrap a turn or two of the remaining end of the center conductor through the hole on its end of the form, and do likewise with the remaining end of the shield through the opposite hole.

table 1. Dimensions for constructing traps for frequencies between 3.75 and 29 MHz.

F_c (MHz)	form length (inches)	form length (cm)	coax length (inches)	coax length (cm)	number of turns	effective length (inches)	effective length (cm)
3.750	6.0	15.2	123.06	312.6	19.79	120	305
7.150	4.2	10.7	70.70	179.6	10.94	65	165
10.075	3.6	9.1	53.70	136.4	8.06	48	122
14.175	3.2	8.1	41.47	105.3	6.00	36	92
18.118	3.0	7.6	34.80	88.4	4.87	29	74
21.225	2.8	7.1	31.24	79.3	4.27	26	66
24.940	2.8	7.1	28.09	71.3	3.74	22	56
28.850	2.6	6.6	25.61	65.0	3.32	20	51

The trap is now complete and ready for installation in an antenna. A silicone-base caulk may be used to seal the traps against weather. I chose not to seal mine and they have been in service for more than a year without degradation in performance.

tuning an antenna

The last column in **table 1** provides the effective length of wire in the trap used. This length should be subtracted on all bands where the trap looks like an inductor to provide a reasonable starting length before tuning.

Start with the highest band used and construct a halfwave dipole using the traps for that band as end insulators. Tune the antenna as desired with the traps connected before going any further. Once tuned, any lower band can be added by connecting more wire to the opposite sides of the traps and extending the antenna from this point. Calculate the length of a quarterwave section on the desired lower band, subtract half the length of the dipole just built, and finally subtract the trap's effective length provided in **table 1**. The result is the length of wire required on the opposite ends of the traps.

Adjust the added sections only to tune the antenna so as not to affect the higher-band antenna that you have already tuned. Traps may be used as the end insulators for this new lower band, and another band (lower still) can be added using the same procedure. When completed, recheck VSWR on all bands. There should be little or no difference from where they were initially tuned.

test data

Fig. 4A is the antenna configuration I chose and is a combination of horizontal trapped dipoles. This provides five-band coverage with optimum bandwidth while remaining a simple construction task. A slight interaction was detected on 10 meters when 15 meters was added (the 10-meter center increased about 200 kHz). This was caused by the connection of the combined dipoles; not by the traps. **Fig. 5** shows the VSWR curves of this antenna. The VSWR of an antenna built as shown in **fig. 4B** is plotted in dashed lines to illustrate the loss of bandwidth by using this approach.

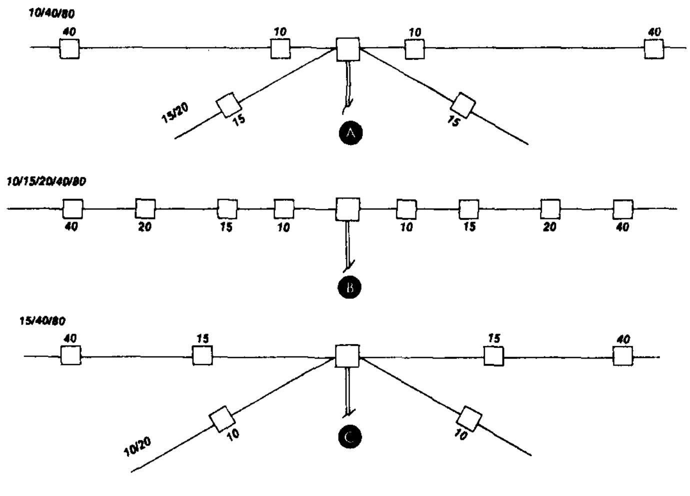


fig. 4. Trap antenna designs. Configuration in use by the author is a combination of horizontal trapped dipoles (A). Single dipole trapped antenna has narrow bandwidth (B). Recommended optimum multiband dipole is shown in C.

Fig. 4C is an alternative approach that has not been verified but is included as an improvement suggestion to reduce the VSWR observed on 15 meters. My assumption here is that the 40-meter and 15-meter dipoles are at or near resonance on 15 meters, thus reducing the feedline impedance by a factor of 2; hence a 2:1 VSWR. I will have verified this assumption as this article goes into print, so watch the letters to the editor for a report of my findings.

Fig. 6 illustrates the impedance bandwidth gained by the wiring technique described, which uses the coupling properties of the coaxial cable.

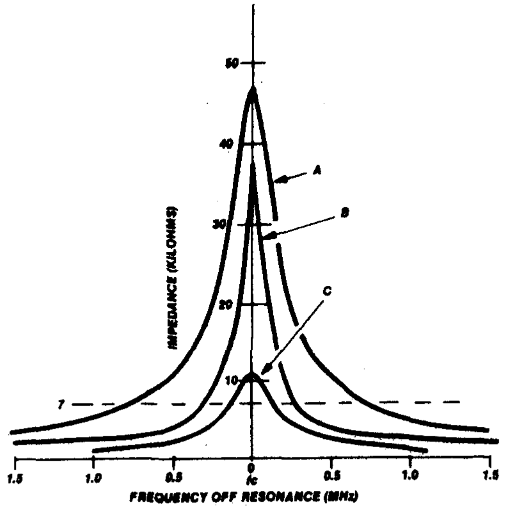


fig. 6. Comparison of relative rejection of 15-meter traps. A represents the single-element trap connected as described in the text. B represents the commercial trap of conventional design that was evaluated by the author. C represents the single-element trap's rejection if improperly connected as discussed in the text. Note the 7 kilohm bandwidth improvement over the conventional design. The rejection is plotted versus frequency away from resonance (f_c).

calculator program

In the interest of expanding the single-element trap applications into areas other than antennas, and accommodating those who have suitable materials other than those that have been described, I can provide a TI-58/59 calculator program that computes the number of tight-wound turns required for a given resonant frequency when the physical properties of the desired materials are specified. In addition, I have described in detail the mathematical derivation of the trap and have provided a step-by-step procedure for building and tuning the antennas described in this article. For copies, send an SASE to the author with a check or money order for $1.50 to cover photo-copy fees. TI-59 owners providing a blank magnetic card will receive a recorded copy of the program.

conclusion

The purpose of, requirements for, and effects of using traps have been explored and supported by comparative test data. In addition, a trap design has been presented that is extremely simple to build (a pair of traps can be built in less than half an hour), costs less than half a dollar per band, and by design requires no tuning. With nothing more than an SWR meter and your transmitter for test equipment, you can have an antenna performing on 80 through 10 meters in a single afternoon.

I hope I have been successful in my attempt to unveil the secrets of antenna traps and instill confidence in those who heretofore have been hesitant, puzzled, or otherwise afraid to pursue trap antenna designs.

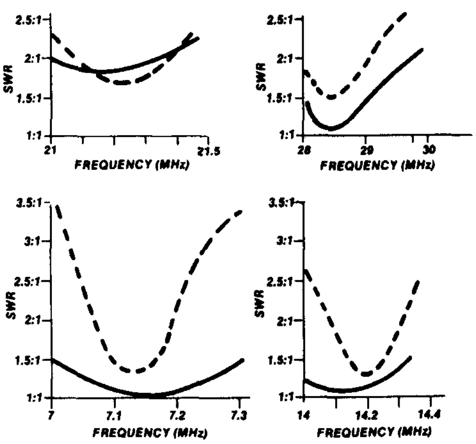


fig. 5. SWR plots of antennas in figs. 4A and 4B (dashed lines) illustrating effects of traps on antenna bandwidth.

acknowledgments

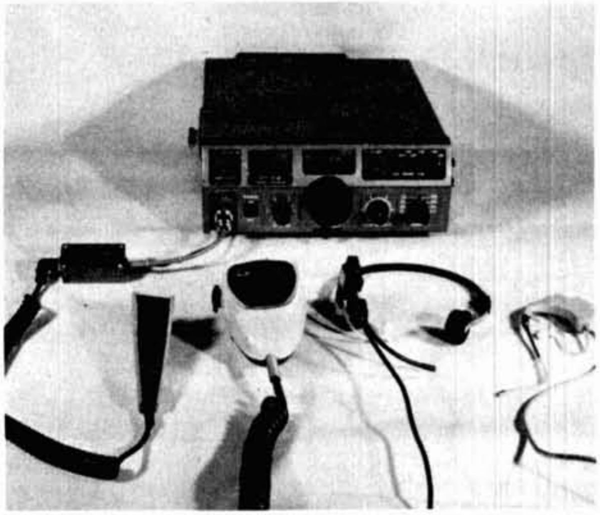
At this point I would like to thank Joe Williams, N2GU, for his editorial and moral support, and Ray Avery, WA2RRS, for the use of his grid-dip oscillator and his support during testing and evaluation of my trap antennas for harmonic radiation. I would also like to thank Ed Lancki, N2BHD, for the use of his commercial antenna traps in my evaluation.

references

1. Gary E. Myers, "A Two-Band Half Sloper Antenna," *QST*, June, 1980, page 32.
2. *The Radio Amateur's License Manual*, 71st edition, ARRL, April, 1974, page 98.

ham radio

More Details? CHECK—OFF Page 94



Current-source adapter allows Amateur transceivers to use simulated-carbon microphones such as (left to right) Telex aircraft microphone, Motorola mobile microphone, Pacific Plantronics MS-50 and *StarSet* headsets.

using simulated carbon microphones with Amateur transmitters

Simulated carbon microphones have several advantages over carbon microphones — all you need is an adapter

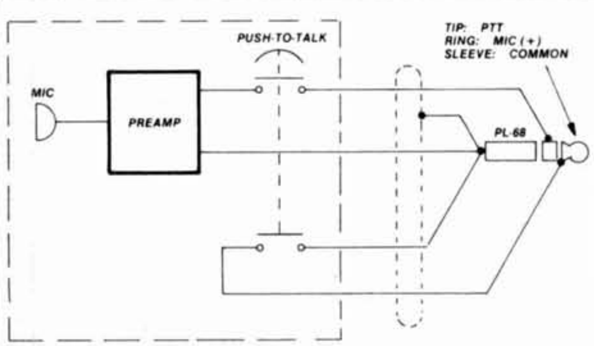


fig. 1. Simulated carbon aircraft microphone schematic showing standard plug connections. Most aircraft microphones have DPST push-to-talk switches, so that multiple microphones can be connected without mutual interference.

Carbon microphones, previously standard in aircraft (**fig. 1**) and many other mobile radios, have been largely replaced by improved types that simulate the electrical characteristics of carbon microphones. Hamfests abound with bargains on high-quality "simulated-carbon" microphones that are sturdily constructed and often include noise-cancelling features. They don't work with most commercially made Amateur equipment, but the required adapter is very simple. (Do not confuse simulated-carbon microphones with the "power microphones" used by CBers.)

The carbon microphone is a variable resistor that changes resistance when sound energy compacts the carbon particles inside it. Unlike dynamic and crystal microphones, which generate their own tiny voltages in response to sound, carbon microphones must be connected to an external source of current to produce an electrical signal. Carbon microphones are rugged, inexpensive, and produce high-level audio signals, but they are no longer popular because of their poor audio-reproduction qualities.

The simulated-carbon microphone contains a dynamic or electret element plus a preamplifier,

By Frank S. Reid, W9MKV, 3243 N. Louden Road, Bloomington, Indiana 47401

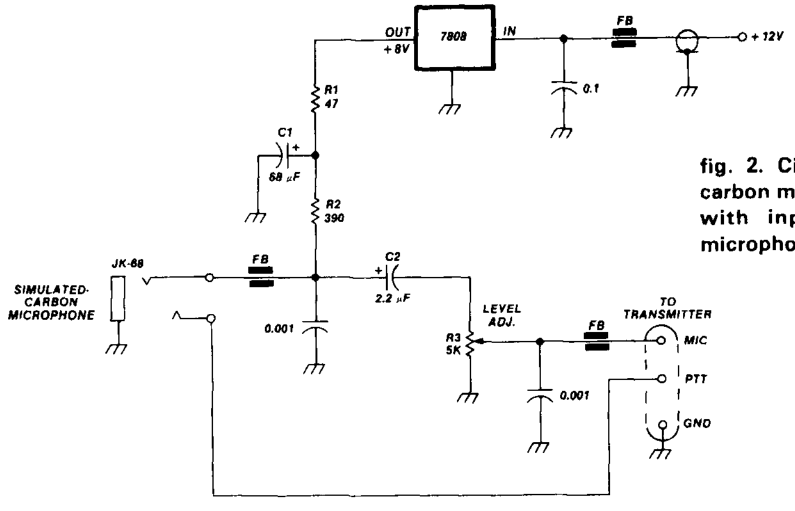


fig. 2. Circuit to supply bias current to simulated-carbon microphones, and couple audio to transmitters with inputs designed for dynamic or crystal microphones.

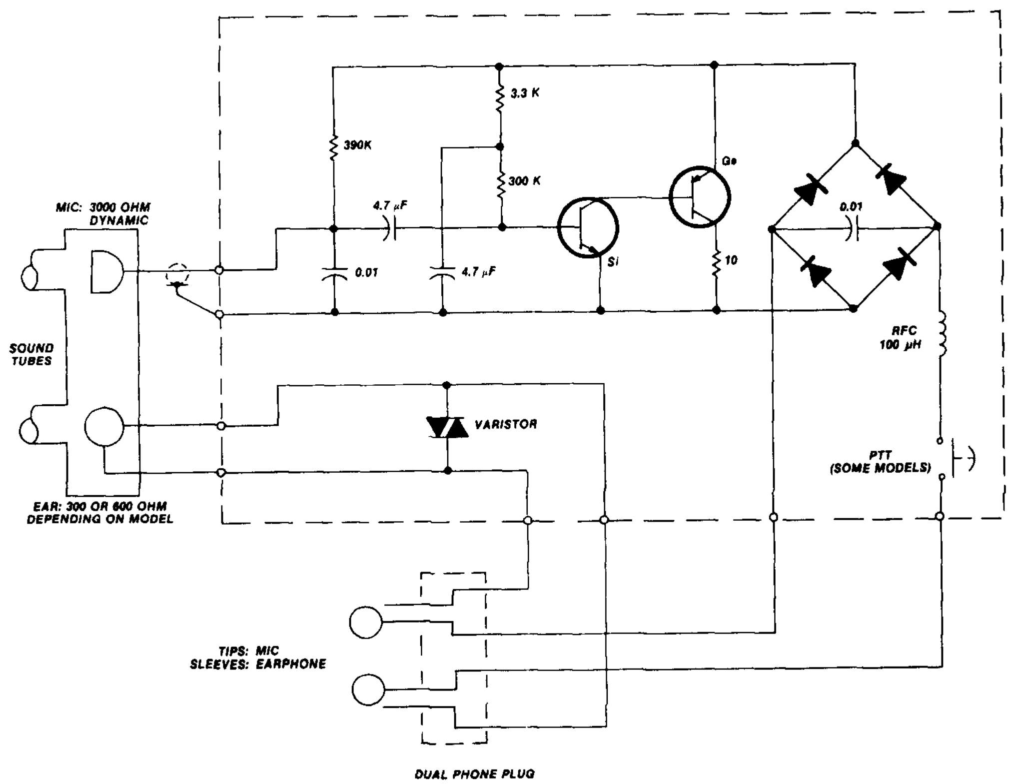


fig. 3A. Schematic of Pacific Plantronics MS-50 headset, telephone switchboard model. Diodes ensure proper polarity to preamp regardless of how plug is inserted but may detect rf, causing feedback.

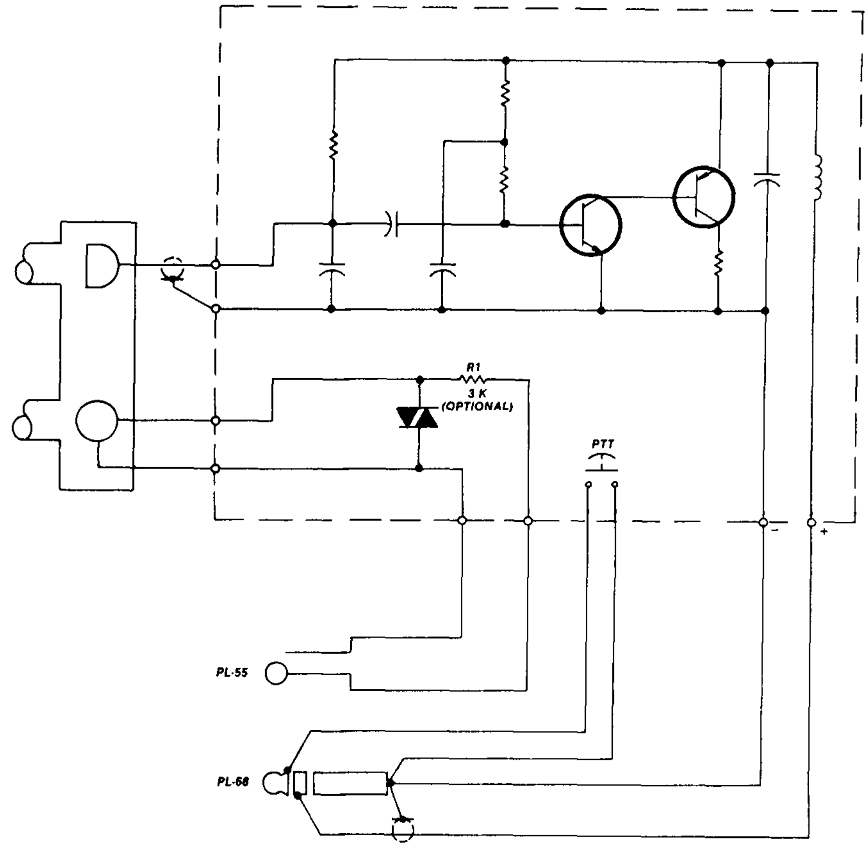


fig. 3B. The same circuit as in (A), modified to prevent rf feedback: diodes have been removed and shielded cable added. *R1* can be added as an attenuator to equalize earphone and speaker levels.

which is powered by dc microphone-bias current supplied by the transmitter. The preamplifier modulates the bias current, producing an audio signal. The preamplifier is sometimes inside a sealed unit with the microphone element, or may be on a separate circuit board.

adapter circuit

Transmitters designed for carbon microphones may supply anywhere from 10 mA to 60 mA of microphone current. Most simulated-carbon microphones will work properly over this entire range of currents. **Fig. 2** shows a circuit for supplying microphone bias current. R1 and C1 form a decoupling network. R1 and R2 determine the microphone current. C2 blocks dc and couples audio to output level-control pot R3.

construction

If the adapter is built in a small shielded box, you can transfer it among several rigs. Microphone circuits pick up rf interference easily, so use good construction practice in shielding and bypassing. Shield

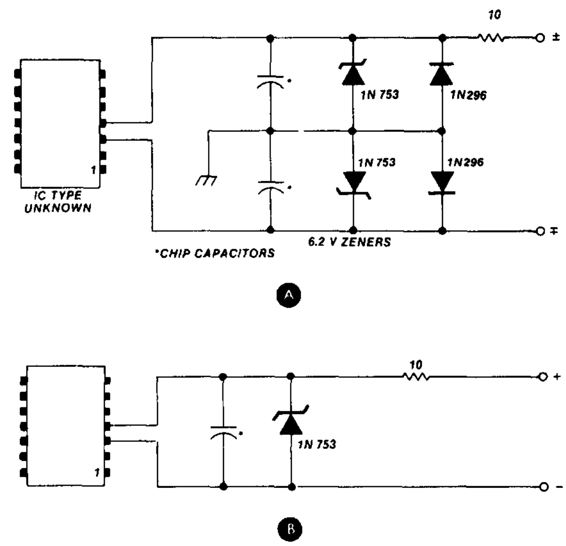


fig. 4A. Partial schematic of Plantronics *StarSet* preamplifier (telephone model), showing zener diodes in current-steering network.
fig. 4B. *StarSet* preamplifier modified for radio use.

the wire to the external power supply, but ground only one end of the shield. Ground the adapter circuit *only* at the transmitter microphone connector, or ground-loop current may cause hum in the output.

The adapter components may be mounted inside the transmitter if you don't mind modifying your equipment. The voltage-regulator IC can be eliminated if you can find a well-regulated source of 8 to 11 volts inside the rig.

adjustment

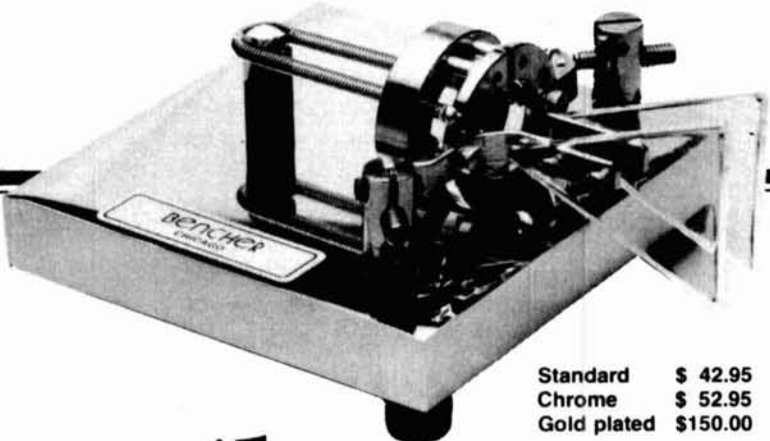
The level control must be set to provide the proper amount of audio to the transmitter input. To set the level, I connect an oscilloscope to the transmitter input terminals and observe the output of the rig's original microphone while talking normally, then substitute the adapter and adjust the pot until the signal reaches the same peak value. On an SSB transmitter with output meter, the meter can be used to compare microphones. You should then use an oscilloscope to inspect the rf output waveform for proper modulation.

converting surplus headsets

Headsets are great for contest and mobile operation, but most are bulky, uncomfortable, and can dangerously restrict a driver's hearing. The tiny Pacific Plantronics headsets overcome these limitations but cost up to $200 from suppliers of aircraft equipment. Slightly different models designed for telephone switchboard use are often available at hamfests and surplus outlets. Their preamplifiers contain current-steering diodes so that they will work properly with any bias supply polarity (**figs. 3A, 4A**). They usually work well with no modification, but they may pick up rf interference if used with high-power stations. To prevent rf feedback problems, remove diodes, rewiring as shown in **figs. 3B** and **4B**. Replace the telephone cord with a multi-conductor replacement-type microphone cable having at least one shielded wire inside. Add your own push-to-talk switch if necessary. With diodes removed, you must determine proper polarity and use some type of polarized connector. The standard aircraft microphone plug (military designation PL-68) is wired as shown in **fig. 1**. It looks like a three-conductor stereo phone plug but is smaller in diameter. Surplus PL-68s are plentiful at hamfests (scouring powder will polish the brass nicely).

The circuit of **fig. 2** is not recommended for small hand-held portables, where the microphone current would contribute significantly to battery drain. The 3000-ohm dynamic microphone element in most models of Plantronics headsets can drive many rigs directly, or through a small matching transformer.

ham radio



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More Deaails? CHECK—OFF Page 94

It's not a lot of Malarkey —
it's a ground plane antenna

junk-box portable antenna

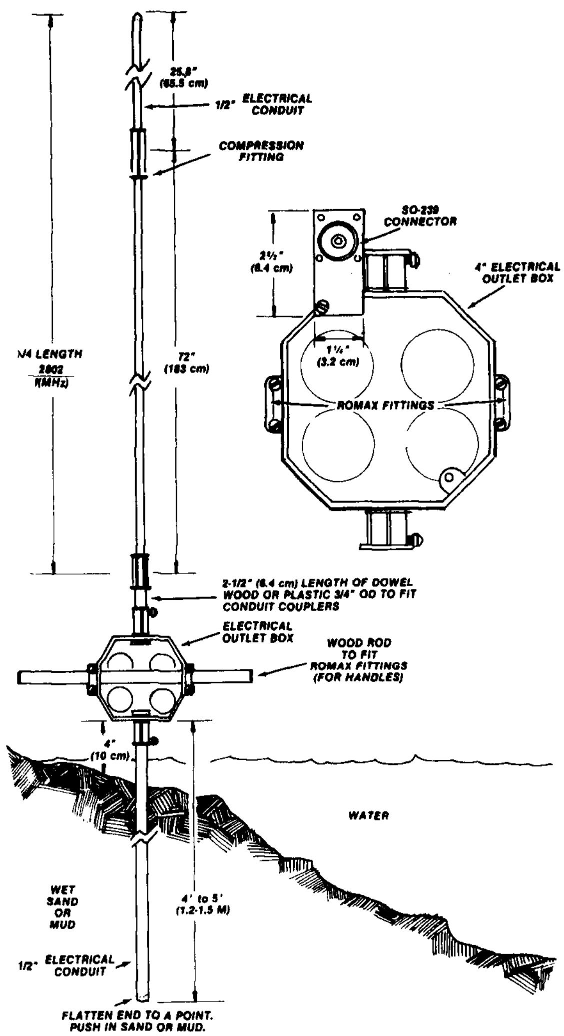


fig. 1. Ugly is beautiful. Construction details of the portable antenna. Design is based on a resonant frequency of 28.7 MHz.

Antenna experts have a favorite saying: "Vertical antennas radiate equally poorly in all directions." There's some truth in this statement if the ground system is inefficient. However, if you live within a reasonable coax-cable length of a lake or any water more than a wavelength (no pun intended) wide, the vertical antenna described here may be worth a try. It's a low-cost system and can be made of readily available materials. You probably have them in your garage or basement.

background

My wife and I have an RV (recreational vehicle). This vacation season we set up the RV right by a lake in Sussex county, Delaware. I had my Ten-Tec OMNI-D and, as usual, a 40-meter dipole antenna to string up in the trees for a little R & R. Things went well.

One day I thought, "Hey, some 10-meter operation would be fun." But that required another antenna. Then it hit me: that lake is nature's ground plane. All I have to do is get 8 feet (2.4 meters) of something to stand *up on* or *in* it. Back at home in the garage I had some 1/2-inch thin-wall conduit and some electrical outlet boxes. What could be better!

the portable vertical

Take a look at **fig. 1**. Ugly, right? But it works and works well. And it doesn't cost a bundle. All you need is the material listed in **table 1**. Collect this stuff, get out your electric drill motor, and heat up your soldering iron. Open a can of beer and you're ready to start.

construction

1. Mount set screw connectors to the top and bottom of the electrical outlet box (square or hexagonal).

By John J. Malarkey, W3SMT, 383 Windemere Avenue, Landsdowne, Pennsylvania 19050

2. Mount two Romax fittings to the sides of the outlet box.

3. Insert a 1/2-inch (12.5-mm) diameter wooden dowel 12 to 18 inches long into the Romax fittings; tighten securely. These are handles for screwing the assembly into the ground.

4. Secure a coax connector (SO-239) to a small piece of aluminum plate.

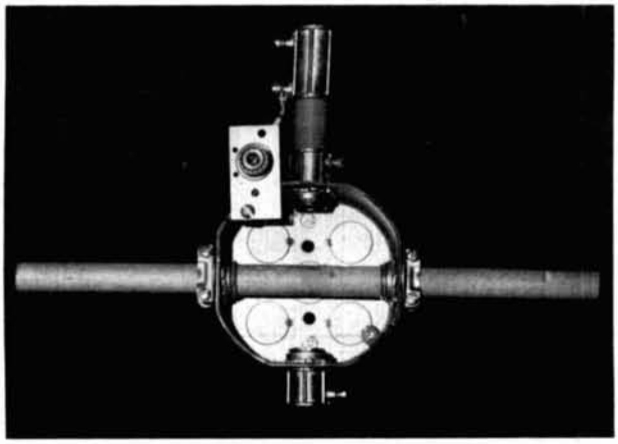
5. Drill a clearance hole (3/16-inch or 5-mm) in the aluminum plate 1/4 inch (6.5 mm) from lower left corner (in and up). This allows the coax-fitting mounting plate to use the existing screw hole that would normally be used for the cover plate and makes the ground connection.

6. Cut a 2-1/2 inch (6.4-cm) wood or plastic dowel (3/4 inch or 19 mm O.D.). This is the center insulator. Insert it into the top screw connector on the outlet box and secure with a setscrew.

7. Install a 1/2-inch setscrew coupler on top of the dowel.

8. Solder one end of a 2-inch (5-cm) piece of No. 12 (2.1 mm) wire to the center contact on the SO-239 coax connector.

9. Install a closed-eye solder lug on the other end of the wire.



Details of the electrical outlet box, which forms the base of the 10-meter antenna. Wooden dowels are handles for working the bottom piece of conduit (not shown) into mud or sand.

10. Bend the lug to pick up the bottom screw on the setscrew coupler. Draw it down to make contact with solder lug and secure the coupler onto the center insulator.

11. Select one of the 10-foot (3-meter) pieces of conduit and, using a pipe cutter, cut a piece 72 inches (183 cm) long. (This length was chosen to make carrying in the trunk of the car easier.)

table 1. Materials list for the junkbox portable antenna. (Note that metric equivalents are not given for standard electrical conduit and fixtures.)

materials	quantity	use
4-inch outlet box (no cover)	1	to hold antenna and handle
1/2-inch setscrew connector	2	1 for ground 1 to hold vertical insulator
Romax connector	2	to hold handle
wood or metal rod to fit Romax connector, 12-18 inches (30-46 cm)	1	to make handle
SO-239 coax connector	1	for coax cable
small piece of aluminum plate	1	to hold SO-239 connector
2 1/2-inch (6.4 cm) wood or plastic dowel 3/4-inch (2 cm) O.D. to fit 1/2-inch conduit coupler	1	insulator for antenna
1/2-inch setscrew coupler	1	to connect insulator to vertical element
2-inch (5-cm) length of No. 12 (2.1-mm) wire	1	center of coax connector to top of conduit coupler
solder lugs and washers, closed-eye, to fit screws on couplers	—	to make connections
10-foot (3-meter) length 1/2-inch electrical conduit (thin wall)	2	1 for vertical element 1 to push in mud/sand
1/2-inch compression fitting	1	to hold vertical elements together

Note: formula: 2808/f in MHz = length of 1/4-wave element in inches (2.54 cm/inch). Materials are for antenna resonant at 28.7 MHz.

12. From the remaining length of this conduit, cut a piece 25.8 inches (65.5 cm) long.

13. Now, from the second 10-foot (3-meter) piece of conduit, cut a piece about 5 feet (1.5 meters) long. Flatten one end to make a point (so it can be pushed into sand or mud). Set it aside.

on-site assembly

1. Join the 72-inch (183 cm) and the 25.8-inch (65.5 cm) conduit with a 1/2-inch compression coupler. Set all this aside. This is the vertical element.

2. Attach the 5-foot (1.5-meter) piece to the bottom set screw connector on the outlet box.

3. Push the outlet box with its 5-foot (1.5-meter) piece of conduit into mud or wet sand until it's approximately 4 inches (10 cm) out of water.

4. Put the vertical element, previously assembled in step 1 above, into the top set screw coupler in the outlet box; tighten.

5. Connect 50-ohm coax to SO-239 and to transmitter.

6. Start calling CQ.

results

They were great! First contact: VE6CGN in Alberta, Canada. Then HP1XWA, in Panama. The antenna was doing fine. The SWR was 1.2:1 over the phone band. I did not use a tuner at all and ran full output from the OMNI D.

afterthought

Late in the evening I remembered I had a piece of metal tape from a broken windup rule. Why not? It turned out that, you guessed it, 35 feet (10.6 meters) was left with the hook end. So I cut it at 32 feet, 4 inches (9.9 meters), drilled a hole in the end (using light pressure, because thin metal will split, then backed it up with wood). I installed two solder lugs (closed-eye) back-to-back. Then I sanded the paint off the end of the rule and attached a solder lug with a machine screw and nut. Next, I put a piece of nylon fish line over a tree limb at the edge of the lake and pulled up the 40-meter vertical. The end with the solder lugs was put under the screw in the setscrew coupler, and the 10-meter element was removed.

results

Again, results were great! The VSWR was 1.4:1 over the phone band; plus it also worked on 15 meters.

So give it a try; you'll like it! I have some experiments going on with garden hose — I'll keep you informed.

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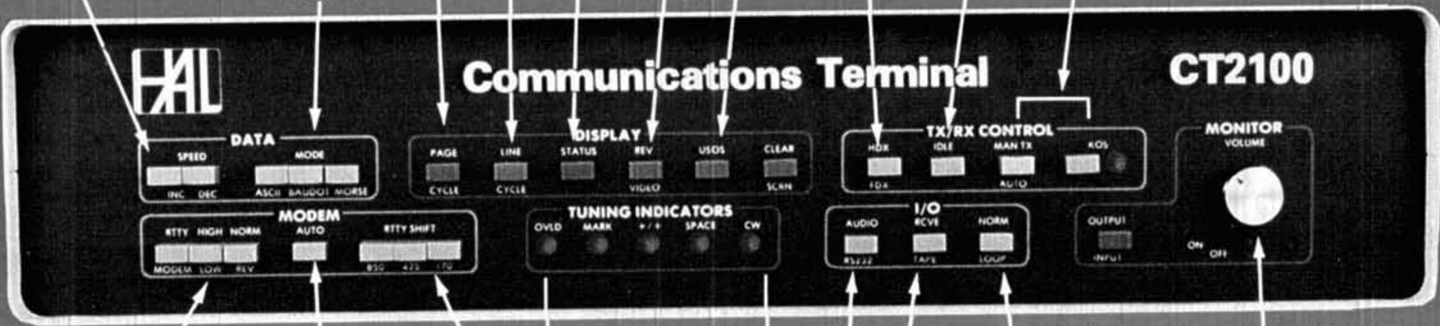

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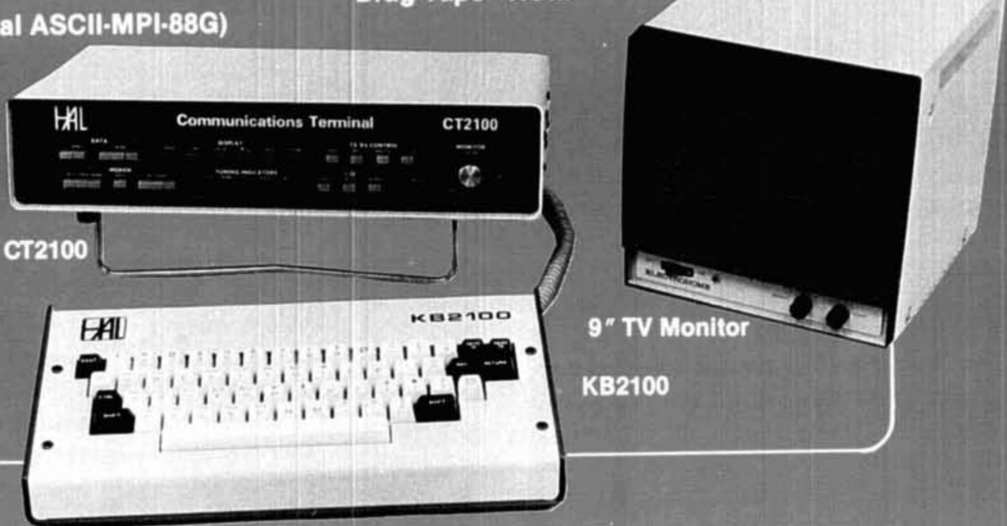

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operation upgrade: part 2

The second part in a continuing series designed to help you get that higher ticket

Last month, in the first of our series of articles, we explained some of the topics identified by the FCC as being in the tests for Amateur licenses. That article explained in basic terms such fundamental things as voltage, current, resistance, Ohm's law, inductors, capacitors, and power, and how they are interrelated in some relatively simple dc circuits.

This month we will try out some ac circuit theory involving these same concepts. This is an area of electricity that many people seem to shy away from because of its angles, tangents, cosines, and so forth. But much of this information is quite important if you want to understand how radio circuits actually work. Our engineering friends may turn up their noses at this down-to-earth treatment of a highly complex field of theory, but let's plunge in anyway.

inductive reactance and impedance

Our discussions about the inductance of a coil of wire indicated that a counter EMF (CEMF) develops whenever current changes value in an inductor. The CEMF always tries to oppose whatever the current wants to do. If the current tries to increase, the CEMF tries to prevent it. If the current tries to decrease, the CEMF tries to increase it. The resulting opposing, or resisting, effect produced by the CEMF is properly called inductive reactance, symbolized by X_L (X indicates reactance, L indicates inductance). The unit of measurement of X_L is the ohm, usually shown by either a capital Greek letter omega, Ω (the same as is used for resistance), or by a lower-case omega, ω. We will use Ω for purely resistive values, and ω for values having reactance. This should help prevent confusion when we are talking about the various forms of oppositions in electricity.

The formula to determine how much opposing effect that inductive reactance has in ohms is:

$$X_L = 2\pi fL$$

By Robert Shrader, W6BNB, 11911 Barnett Valley Road, Sebastopol, California 95472

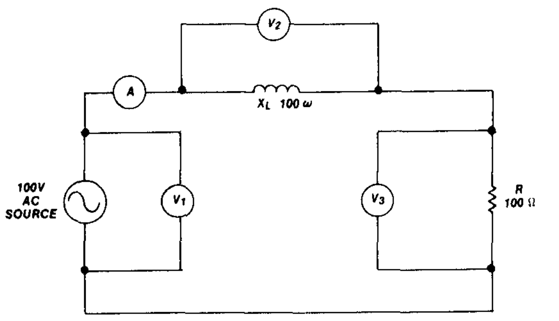


fig. 1. Ac circuit with inductive reactance and resistance in series as the load.

where X_L = inductive reactance in ohms, ω

π = 3.1416

f = frequency in hertz, Hz

L = inductance in henrys, H

As an example, the inductive reactance of a 2.5-henry coil to 1000-Hz ac is $X_L = 2\pi fL$, or (6.28) (1000) (2.5), or 15,500 ω. Can you see from this formula that the same inductor (coil) will have twice the reactance at twice the frequency because X_L is directly proportional to f? A resistor, on the other hand, has the same resistance value regardless of the frequency of the ac, or even if dc is used with it.

In a resistor, the current that flows through it varies in phase (in step) with any voltage change occurring across the resistor. If the voltage increases across a resistor, the current increases proportionally. In a coil, which has inductive reactance, the voltage of an alternating current passing through the inductor can, of course, be plotted (with respect to time) as a sine curve. The current passing through the coil can also be plotted (with respect to time) as a sine curve. It will be found that, if the two curves are compared on the same graph, the sine curve representing the current will lag 90 degrees behind that representing the voltage. We can consider this to be caused by the building up of the magnetic field around the coil, and by the counter-EMF developed in the coil.

Let's see what we can find out about the ac circuit shown in **fig. 1**. An ac generator or alternator (the circle with a one-cycle sine wave in it) feeds a circuit composed of X_L in series with an R. Since this is a series circuit, the same current flows in all parts of the circuit, so only one ammeter is needed. The three voltmeters measure all possible voltages in the circuit.

If the source of EMF had been shown as a battery or a dc generator, from Ohm's law ($I = E/R$) the current in the circuit would have been $I = E/R$, or 100/100, or 1 amp. In this case, with dc flowing, X_L would have no opposing effect, and the load in the circuit would be the resistor alone. What do you think voltmeter V_1 would read? _____ V_2? _____ V_3? _____

V_1 would read the 100-volt source voltage. With dc being used, V_2 is measuring across zero ohms resistance (the coil is assumed to have no R value) and therefore would read zero volts. And V_3 would have to read the 100 volts of the source. What power would the circuit be dissipating? (Remember, the basic power formula is $P = EI$.) Work it out for yourself. P = _____

This brings up an important point. Since in this case, the coil has dc flowing through it, there is no varying magnetic field around the coil and no CEMF is being developed. There is energy in the coil's magnetic field, but it is static (meaning stationary). Any energy stored in the static magnetic field will be returned to the circuit when the current is turned off. The only thing dissipating energy (heat in this case) is the resistor. It is dissipating $P = EI$, or 100(1), or 100 watts of heat.

Now let's return to the illustration as it is shown, with the source 100 Vac. The load is a 100 ω X_L in series with a 100 Ω R, right? So the total opposition to the ac is going to be *100 + 100 = 200 ohms* — right? WRONG! It will be only 141.4 ω. Where did *that* value come from? Let's see.

Resistance is a true and constant opposition under essentially any conditions. We can draw a horizontal vector arrow representing 100 Ω resistance and label it R, as shown in **fig. 2**. The reactance of the coil does not oppose the flow of current by 180 degrees as the resistance does, but it opposes the current at *exactly 90 degrees*. Therefore, we draw the opposi-

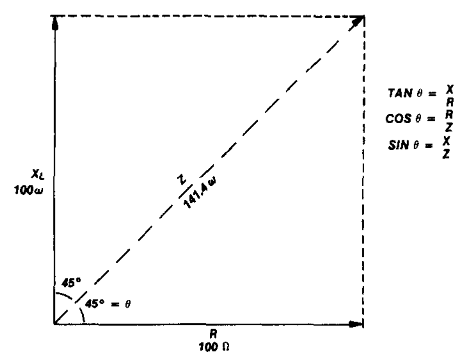


fig. 2. Developing an R, X_L, and Z triangle from R, X_L, and Z vectors, and three useful trigonometric formulas.

tion of the X_L at an angle of 90 degrees from the resistance, at right angles, or upward. By drawing dotted lines parallel to both the R and X_L vector arrows, the resultant opposition of R plus X_L will be that shown by the dashed vector arrow labeled Z. This resultant opposition is called the impedance, Z, of the circuit, and has a value of 141.4 ω. (We use ω for ohms because part of the opposition is reactive.) How did we get the 141.4 Ω value? Well, you could lay out the vector arrows to scale on a piece of graph paper and measure the impedance value with a metric ruler, which is probably the simplest but least accurate way of doing it.

A second method is to use the Pythagorean theorem for right-angled triangles, which says that the square of the Z side of this right-angled triangle (made up of the R, the Z, and the dotted X_L side) is equal to the sum of the squares of the R and X_L sides. As a formula this is expressed as:

$$Z^2 = R^2 + X_L^2$$

Or, in our particular circuit:

$$Z^2 = 100^2 + 100^2$$

$$Z^2 = 10{,}000 + 10{,}000$$

Solving for Z (taking the square root of both sides of the equation),

$$Z^2 = 20{,}000$$

$$Z = 141.4$$

The complete formula to find impedance is therefore:

$$Z = \sqrt{R^2 + X_L^2}$$

Here is a problem to try. The answer is at the end of the article. **Problem 1**: What would be the impedance of a series ac circuit having $R = 80\Omega$, $X_L = 40\omega$? Answer ______.

A third way you might find the impedance is to first determine the phase angle (how many degrees the I lags or leads the E in a reactive circuit). The phase angle, usually shown as the Greek letter theta, or Θ, is the angle developed at the meeting point of sides R and Z. In our circuit, with $R = 100$ and $X = 100$, and being at right angles or 90 degrees, the R-Z angle must be half of 90 degrees, or 45 degrees. Thus, the phase angle, or Θ, for this circuit is 45 degrees.

However, when R and X are not equal, we must find Θ some other way. One way is to use a protractor to measure the angle if you graph the problem. The tangent (tan) ratio of our triangle, which is the ratio of the X side to the R side, or X/R, can be used to find Θ very accurately. Tan Θ in our case is X/R, or 100/100, or 1.0000. Refer to **table 1**, which shows a few selected tangent and cosine ratio values and their angles. By searching through the table you will find that, when $\tan \Theta = 1.0000$, $\Theta = 45$ degrees. (With one type of electronic calculator, enter the tangent value of 1.000, then punch in ARC, then TAN, and it should show 45 degrees. However, your calculator may use a different method of determining tangents.)

Now that we know the phase angle (how many degrees the current lags behind the voltage in an inductive circuit), what about the impedance value? Whereas the tangent ratio of the RXZ triangle is X/R, the cosine ratio is R/Z. This cosine ratio is handy for us because it includes not only the R and Θ values, which we know, but also the Z value, which we want to know. Using the cosine ratio we can determine the Z value with the information we now have. The cosine (cos) formula is

$$\cos \Theta = \frac{R}{Z} \quad \text{or} \quad \cos 45 \text{ degrees} = \frac{R}{Z}$$

From the table you can find that cos 45 degrees is equal to 0.707. By plugging the known information into the cos formula we get

$$\cos \Theta = \frac{R}{Z}$$

$$0.707 = \frac{100}{Z}$$

If you have not been doing much math lately, let's try solving for the unknown value (Z) of this equation by using the cheap and dirty method of cross multiplying and then dividing out the unwanted to find what

table 1. Some trigonometric function values.

angle (degrees)	tan	cos
0	0.000	1.000
5	0.0875	0.9962
10	0.1763	0.9848
15	0.2678	0.9659
20	0.3640	0.9397
25	0.4663	0.9063
30	0.5774	0.8660
36.87	0.7500	0.8000
39.8	0.8333	0.7682
40	0.8391	0.7660
45	1.0000	0.7071
50	1.1918	0.6428
55	1.4281	0.5736
60	1.7321	0.5000
65	2.1445	0.4226
70	2.7475	0.3420
75	3.7321	0.2588
80	5.6713	0.1737
85	11.430	0.0872
89	57.290	0.0175
90	Infinite	0.0000

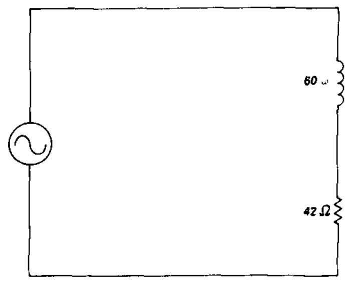


fig. 3. Ac circuit for problem 2.

Z equals. In this case

$$\frac{0.707}{1} = \frac{100}{Z}$$

Now, by cross multiplying top and bottom values we get the relatively straightforward equation

$$0.707(Z) = 100(1) \quad \text{or} \quad 0.707Z = 100$$

To find the Z value, divide out from both sides of the equation the unwanted information on the left side, giving us

$$\frac{0.707Z}{0.707} = \frac{100}{0.707}$$

This leaves

$$Z = \frac{100}{0.707}$$

$$Z = 141.4\,\omega$$

Incidentally, the sine $\Theta = X/Z$ formula shown in **fig. 2** could also have been used to solve for Z if sine tables are used. These three trigonometry formulas, tangent, cosine, and sine (sin), are very handy in ac circuit computations.

How about trying to solve an impedance problem on your own? **Problem 2:** What is the Z of the series circuit shown in **fig. 3**? *Tan* Θ = ______ *Angle* Θ = ______ *Cos* Θ = ______ Z = ______.

Of course, it is possible to compute ac circuits of this type if only the inductance in henrys and the resistance are given. You would have to first convert the inductance value to inductive reactance. The frequency of the ac would also have to be known to find the X_L value. You would be surprised what you can do with these ac circuits if you list what values you know, and then consider filling in the information into one or more of the formulas that you know. You can find voltage-drops across components (with Ohm's law), currents, phase angles, impedances, reactances, power values, and so on, provided you understand the relatively few facts we have discussed so far. This doesn't mean that ac circuits can't become extremely complicated. They can!

capacitive reactance and impedance

In **fig. 4**, a series ac circuit is shown using a capacitor in place of the inductor of **fig. 1**. If the capacitor has very little capacitance, only a small current can be driven back and forth through the resistor with a given ac voltage. If the capacitor is larger it can be charged and discharged with more electrons and the ac charging current that would now flow through the resistor will increase. Thus a capacitor must have both an ac conducting and an opposing effect, or *reactance*. Capacitive reactance, X_C, opposes ac somewhat like resistance does, but it is not the same as resistance.

To determine just how much opposing effect, in ohms, a capacitor will have in an ac circuit, use the formula

$$X_C = \frac{1}{2\pi fC}$$

where X_C = capacitive reactance in ohms, ω

π = 3.1416

f = frequency in hertz, Hz

C = capacitance in farads, F

As an example, what reactance does a capacitor of 0.01-μF have to a 7 MHz ac?

$$X_C = \frac{1}{2\pi fC}$$

$$X_C = \frac{1}{6.28(7{,}000{,}000)(0.000\,000\,01)}$$

$$X_C = \frac{1}{0.4396}$$

$$X_C = 2.27\,\omega$$

Can you see that a 0.01-μF capacitor acts as a pretty good conductor of ac at 7 MHz, which is one edge of the 40-meter Amateur band? A 0.001-μF capacitor would have only 22.7 ω. Thus, to couple rf ac from one circuit to another, capacitors make very good coupling devices. Capacitors may couple ac, but they will stop dc current completely. However, if the dc is varying, a capacitor will pass the varying part, or ac component, and block the dc component. Note that the same capacitor used on the 3.5-MHz Amateur band will have twice the reactance that it would have at 7 MHz, because X_C is inversely proportional to frequency.

In a resistor the current through it and the voltage-drop across it are always in phase. As mentioned pre-

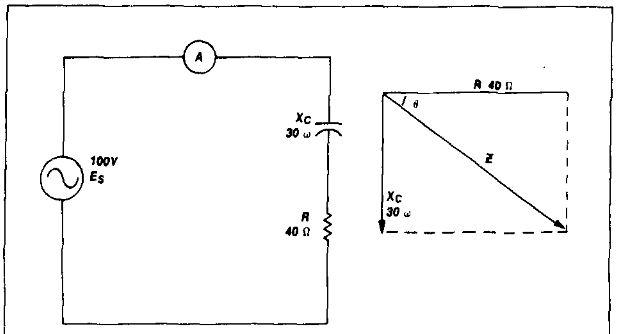


fig. 4. Series type capacitive and resistive ac circuit and its vector diagram.

viously, an inductor always has its current lagging behind the circuit voltage by 90 degrees. A capacitor always has its current *leading* the circuit voltage by 90 degrees. These reactive phase shifts are important in the operation of ac circuits. For one thing, it is possible to add capacitance to an inductive-resistive circuit to reduce a phase lag of the current caused by the inductance.

What would be the phase angle, the impedance, the current, and the voltage drops in the **fig. 4** circuit? We can apply exactly the same computing ideas to a capacitively reactive circuit as we did with the inductively reactive circuit before. The phase angle (the number of degrees by which the current leads the voltage) may be found by $\tan \Theta = X/R$, or in this case $\tan \Theta = 30/40$, or 0.750. From the table, the angle Θ is 36.87 degrees.

Knowing $\Theta = 36.87$ *degrees*, then $\cos \Theta = R/Z$, and by cross multiplying, $Z = R/\cos \Theta$. In this case, from the table of cosine values, $\cos 36.87$ *degrees* $= 0.8000$, or $Z = 40/0.8000$, or $Z = 50\ \omega$.

If $Z = 50\ \omega$ and the effective source voltage, E_s, is 100 volts we can make the dc Ohm's law formulas work for ac circuits by substituting Z for R. Thus, $I = E/Z$, or $E = IZ$, or $Z = E/I$. In our circuit, $I = E/Z$, or 100/50, or 2 amps flows through the capacitor and the resistor. (Actually, electrons do not flow *through* a capacitor, but it charges and discharges through the resistor, allowing current to flow through the resistor and the ac source.)

There is an interesting thing about computing power in ac circuits. If we have a 2-amp current flowing in the **fig. 4** circuit and a source voltage of $E_s = 100$ *volts*, then from the power formula $P = EI$ we would expect to have 100(2), or 200 watts being dissipated. But a wattmeter in this circuit would show only 160 watts! The 200 value from a voltmeter and an ammeter is called the reactive power, or the volt-amperes (VA) of the circuit. The true power, that amount of energy actually lost by the circuit, is what the resistor alone is dissipating. (Remember, the reactor does not lose energy. It may store energy, but it returns it all to the circuit when the current is turned off.) The true power can be found by $P = E_r I_r$, or by $P = I_r^2 R$, or by $P = E_r^2/R$. Since we do not know the voltage across the resistor at this time, we can use the formula $P = I^2R$, or $2^2(40)$, or 160 watts. So, for this circuit the reactive power is 200 VA, and the true power is 160 watts. Note that a wattmeter always indicates true power, and that the formula $P = I^2R$ always tell us the true power.

The ratio of true power (P) to volt-amperes (VA) is known as the power factor of the circuit. In our circuit of **fig. 4**, the power factor (pf) $= P/VA$, or 160/200, or 0.8000. You can express a pf of 0.8000 as a pf of 80 percent by moving the decimal point over two places and adding the percent sign. You will also find that the power factor is always equal to the cosine of the phase angle ($\cos \Theta = pf$). For our circuit, the pf is 0.8000, the cosine of Θ is 0.8000, and from the table, $\Theta = 36.87$ *degrees* as determined previously.

In our circuit, if a 2-amp current flows through a 30ω X_C, the voltage-drop across X_C by Ohm's law, but using reactance in place of resistance, is $E = IX_C$, or 2(30), or 60 volts. The voltage-drop across the R will be $E = IR$, or 2(40), or 80 volts. Note that the simple sum of the vector voltages across X_C and R add up to more than the source voltage. That is, $E_{x_C} = 60$ *volts*, and $E_r = 80$ *volts*, for what appears to be a total of 140 volts. But if we try plotting these two voltages as vectors at right angles as we did with X_C and R, we will find that the resultant vector, which represents the source voltage, will be exactly 100 volts, as it should be.

Suppose we have a circuit with X_L, X_C, and R all in series, as in **fig. 5**. The reactances are graphed as before, X_L upward, X_C downward, and R to the right. Can you see that the 50 ωX_L is cancelling 50 of the 75 ω of X_C, resulting in a total of only 25 ω of effective reactance (capacitive) for the circuit? To determine the impedance of this series circuit we would use the values of 30 Ω of R, and the resultant value of 25 ω of X_C. To check your understanding try **Problem 3:** With $X_C = 25\ \omega$ and $R = 30\ \Omega$, what is tan Θ? ______ Θ? ______ cos Θ? ______ Z? ______ I? ______ E_r? ______ E_x? ______ P? ______ Does I lag or lead? ______

series and parallel circuits

When two resistors are connected in series, as in **fig. 6A**, the total resistance is simply the sum of the two resistors, or $R_t = R_1 + R_2$. But if the two resistors are in parallel as in B, they form a better conductor (less resistance) than either one alone. There are two formulas given which produce the proper total resistance of two parallel resistors. These are

$$R_t = \frac{R_1R_2}{R_1 + R_2} \text{ and } R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$

If R_1 is 100 Ω and R_2 is 100 Ω, what will the total resistance be? Try working this out with both formulas and see if you don't come up with 50 Ω in each case. What if there are more than two resistors in parallel? Well, if there are three, then compute two of them in parallel and use this answer to compute the third resistor in parallel. If there are four in parallel compute the first three and use this answer along with the fourth in parallel.

When two inductors are connected in series as in **fig. 6C**, the total inductance in henrys is the simple sum of the two inductors. Similar to resistors, two parallel inductors, as in **D**, can be computed with the same two parallel component formulas, substituting *L*s for *R*s in the formulas.

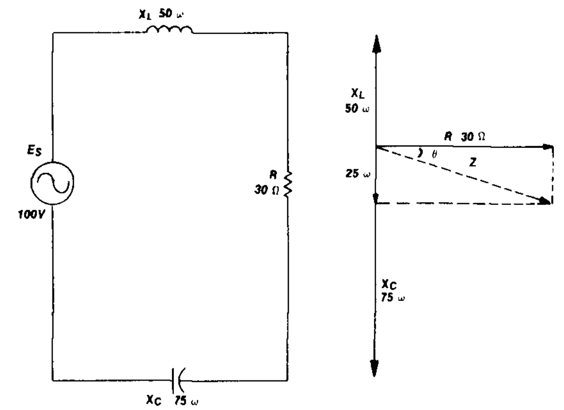


fig. 5. Series X_L, X_C, and R ac circuit and vector graph.

When two capacitors are connected in series, as in **fig. 6E**, between the top of the circuit and bottom there is now a greater dielectric separation than for either capacitor alone, and therefore less capacitance. So we cannot use the simple addition of capacitances, but must use the parallel resistor type formulas for capacitors in series, or

$$C_t = \frac{C_1C_2}{C_1 + C_2} \text{ or } \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}}$$

When two capacitors are connected in parallel, as in **F**, the total capacitance is the simple sum of the two capacitors, or $C_t = C_1 + C_2$.

In **fig. 7** we have the same circuit configurations but this time the components are labeled in resistance, inductive reactance, and capacitive reac-

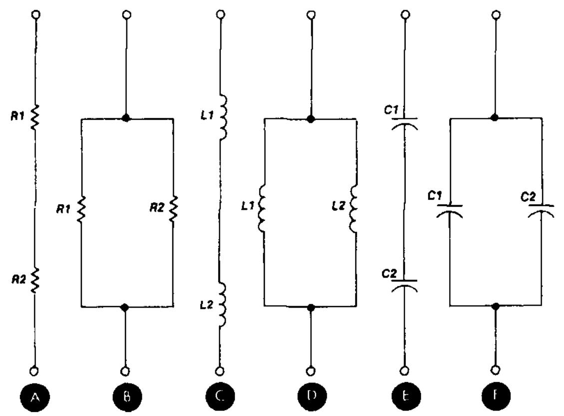


fig. 6. Series and parallel resistors, inductors, and capacitors.

tance. Now, all oppositions, resistance and reactances, if in series, are found by simply adding the component values. Similarly, when in parallel you use the parallel resistance type formulas to determine the total oppositions, substituting *X*s for *R*s.

In **fig. 8A**, the circuit is shown with resistance, inductance, and capacitance values given. To compute the circuit parameters (values) it is necessary to first convert the L value to an X_L value, using the given frequency and the formula $X_L = 2\pi fL$. The capacitance must similarly be converted to X_C by the formula $X_C = 1/2\pi fC$ (using farads, not the μF value that is given). The impedance of such a series RLC circuit is computed as explained in the previous section. In this case the Z value is computed as 200 ΩR and 796 ωX_C minus 314 ωX_L, or as 200 ΩR and 482 ωX_C, or $Z = \sqrt{200^2 + 482^2}$, or 521.8 ω.

The circuit in **fig. 9** shows a resistance and an inductive reactance in parallel. There are a variety of

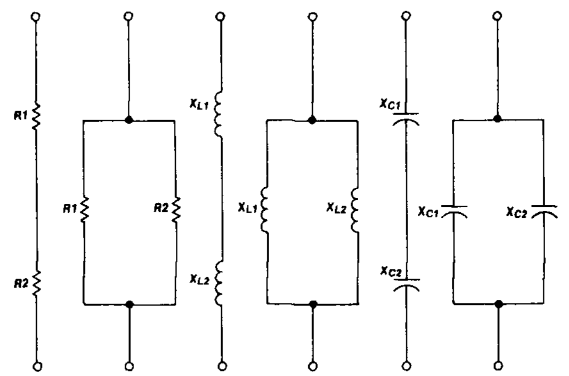


fig. 7. Series and parallel resistors, inductive reactors, and capacitive reactors.

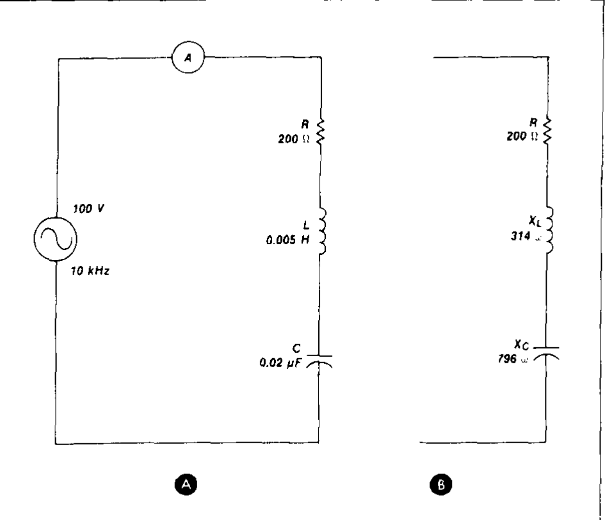


fig. 8. (A) Series RLC circuit must be converted to (B) R, X_L, and X_C values to compute it, using the given frequency.

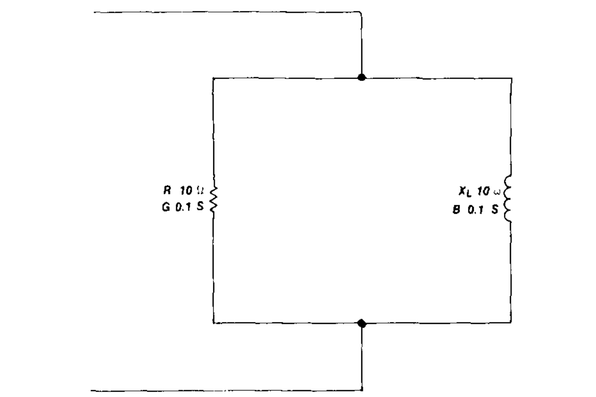


fig. 9. Parallel R and X_L circuit, labeled in ohms and in siemens.

ways of computing the impedance of such a circuit. We will discuss only one of them. We cannot use the series-type impedance formula ($Z = \sqrt{R^2 + X^2}$) unless we use reciprocal values in it. ($1/R$ is the reciprocal of R, called conductance, symbolized G. $1/X$ is the reciprocal of X, called susceptance, B. $1/Z$ is the reciprocal of Z, called admittance, Y.) The unit of measurement of these reciprocal values is either mho (reverse spelling of ohm), or siemen, S. So, to solve a parallel RX circuit as **fig. 9**, the basic formula would be

$$\frac{1}{Z} = \sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X}\right)^2} \quad \text{or} \quad Y = \sqrt{G^2 + B^2}$$

Substitute the values given in **fig. 9** into the second formula, and check these steps:

$$Y = \sqrt{0.1^2 + 0.1^2} = \sqrt{0.01 + 0.01}$$

$$Y = \sqrt{0.02} = 0.1414 S$$

$$Z = \frac{1}{Y} = \frac{1}{0.1414} = 7.07\,\omega$$

Note that in any simple R and X parallel circuit the total Z will always be less than either of the R or X component values. As you might expect, a parallel R and X_C would be solved in exactly the same way as a parallel R and X_L. In the inductive circuit the phase angle of the source current would be lagging, in the capacitive case the current would be leading, but not by 90 degrees.

If a capacitor is added across a parallel R and X_L circuit, as in **fig. 10**, we have a parallel RLC circuit. Since the B_C and B_L values would plot 180 degrees apart (as their X_C and X_L values do), the total susceptance, or B_t, will be equal to the smaller susceptance subtracted from the larger. (Do not subtract X_C from X_L in parallel circuit computations!) In our problem, the formula is expanded to subtract B_L from B_C, and is worked as shown. Can you follow each step?

$$Y = \sqrt{G^2 + (B_C - B_L)^2}$$

$$Y = \sqrt{0.04^2 + (0.05 - 0.02)^2}$$

$$Y = \sqrt{0.04^2 + 0.03^2}$$

$$Y = \sqrt{0.0016 + 0.0009}$$

$$Y = \sqrt{0.0025}$$

$$Y = 0.05\,S$$

$$Z = \frac{1}{Y} = \frac{1}{0.05} = 20\,\omega$$

If you think about it a little, you will see that if X_C and X_L happened to be equal in **fig. 10**, then B_C and B_L will be equal and would cancel each other completely, resulting in a reactance value of zero. Such a circuit is said to be parallel resonant, which we will discuss later. The total impedance would then be the

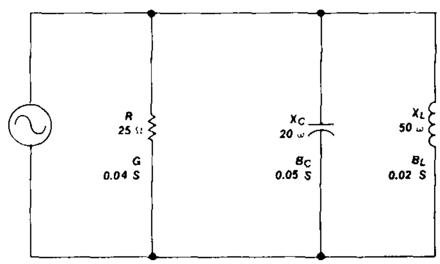


fig. 10. Parallel RLC circuit labeled with both ohms and siemens (mho) values.

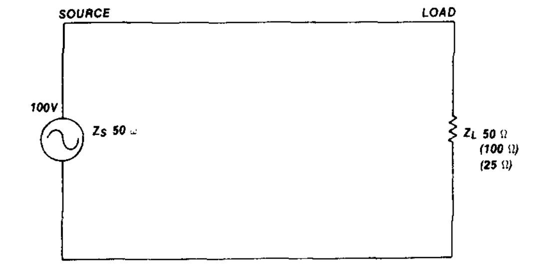


fig. 11. Circuit used to explain effect of matching and mismatching a load impedance to a source impedance.

resistance value only, or $Z = 25\ \Omega$, not 25 ω, because now the source sees a circuit that is exhibiting no reactive effects at all.

impedance matching

One of the most important requirements when operating rf ac power equipment is to match the impedance of the load to the internal impedance of the source. Consider the circuit shown in **fig. 11**. Here a load impedance (resistor Z_L) is coupled across an ac source (Z_s). Assume that the source produces 100 volts and has an internal impedance of 50 ω (or 50 Ω). Using a Z_L of 50 Ω to match the source impedance, the current through the load will be

$$I = E/Z = 100/(50 + 50) = 100/100 = 1\ amp$$

The simplest means of determining the power dissipated in the load would be by

$$P = I^2R = I^2(50) = 50\ watts$$

Incidentally, the power dissipated in the source would also be 50 watts, and the whole circuit would be 50 percent efficient.

If the load resistance is doubled, to 100 Ω, the impedances mismatch. The circuit current would now be $I = E/Z$, or 100/(50 + 100), or 100/150, or 0.66 amp. Now, the power output, or that dissipated in the load resistor, would be $P = I^2R$, or $0.66^2(100)$, or 0.436(100), or 43 watts. The power dissipated in the source would be 0.436(50), or 21.5 watts. The efficiency is 43/64.5, or 66 percent. The efficiency may be higher, but the power output into the load is lower.

If the load resistance is halved, to 25 Ω, the impedances again mismatch. The circuit current would now be $I = E/Z$, or 100/(50 + 25), or 100/75, or 1.33 amps. The power output in the load would now be $P = I^2R$, or $1.33^2(25)$, or 1.77(25), or 44.25 watts. Again the power output is less than when the impedances matched. The power dissipated in the source is now $P = I^2R$, or $1.33^2(50)$, or 1.77(50), or 88.5 watts. With this mismatch the efficiency is only 44.25/132.75, or 33 percent. So, if you have a transmitter with 50 Ω output circuit you had better be sure that the antenna you couple to it also has an impedance as close to 50 Ω as it is possible to arrange. This way you will get maximum power into your antenna.

Transformers can be used to match impedances, particularly in audio frequency ac circuits. If a transformer has a primary with 100 turns and a secondary with 300 turns, it will step up any ac voltage applied to it by three times (may be shown as either a 1:3 or 3:1 ratio). If 2 volts ac is applied to the primary, the secondary voltage should be 6 volts. If a transformer is used to match impedances, a 1:3 transformer will convert the primary impedance by a factor equal to the turns ratio squared. Thus a 1:3 turns ratio allows the transformer to convert the output or secondary impedance to 3^2, or to 9 times the impedance of the primary. Formulas that may be used are

$$\left(\frac{T_P}{T_S}\right)^2 = \frac{T_P}{T_S} = \sqrt{\frac{Z_P}{Z_S}}$$

These formulas say that the turns ratio squared equals the impedance ratio, or the turns ratio equals the square root of the impedance ratio. As an example, you want to match a 30 Ω transistor output circuit to a 4 Ω loudspeaker, **fig. 12**. What ratio transformer should you use? With the second formula, if the impedance ratio is 30/4, or 7.5:1, the turns ratio must be equal to the square root of 7.5 (or $\sqrt{7.5}$), or 2.74:1. Actually, either a 2:1 or a 3:1 turns ratio transformer would operate quite satisfactorily, with the 2:1 possibly sounding a little better, although somewhat weaker. The higher the load impedance the less audio distortion that may be produced.

With air-core radio-frequency transformers, impedance matching is usually controlled by the degree of primary-to-secondary coupling. The tighter the coupling the lower the impedance reflected back into the primary circuit.

series and parallel resonance

Whenever the X_C of an ac circuit matches the X_L in series with it, a condition of resonance occurs. If the capacitor and coil are in series the circuit is said to be resonant, or series resonant, **fig. 13A**. If the capacitor and coil are in parallel the circuit is said to be anti-resonant, or parallel resonant, **fig. 12B**. These two resonant type circuits do not behave the same in any way.

In a series resonant circuit, as in **fig. 13A**, the two reactances completely cancel the reactance effects of each other. In any series circuit there is only one current. In the series resonant circuit the X_C voltage

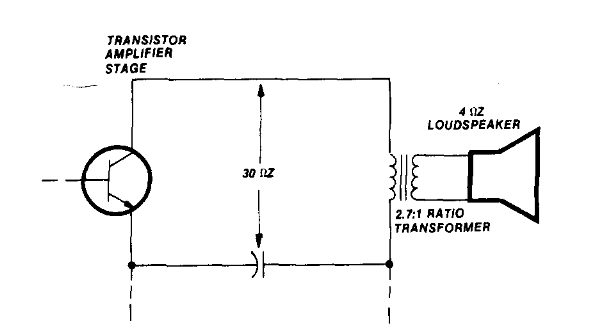


fig. 12. Transformer needed to match a 30-ohm Z to a 4-ohm load.

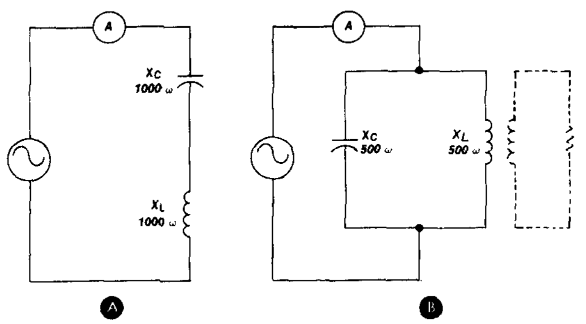


fig. 13. (A) Resonant or series resonant circuit. (B) Anti-resonant or parallel resonant circuit, with possible means of coupling to a load.

will lag the current by 90 degrees, and the X_L voltage will lead the current by 90 degrees. These two equal but opposite voltages (180 degrees out of phase) cancel, leaving the source looking at a zero voltage-drop load, or a short circuit. A series resonant circuit acts as an impedance of zero ohms, and if there is no resistance in the line the ammeter and the source might burn up.

In an anti-resonant, or parallel resonant, circuit, as in **fig. 13B**, the two reactances cancel each other in another way. Since the current lags in an inductor and the current leads in a capacitor, at anti-resonance there is one voltage across the circuit, with equal but opposite currents in the two reactances. A 90-degree current lag + a 90-degree current lead means the two currents are 180 degrees out of phase. If the current flows up in the inductor and an equal current flows down in the capacitor, there is zero current demand from the source. The source sees the circuit as no load at all, or as infinite impedance ($Z = \infty\Omega$, since the reactances cancel). The ac current circulates back and forth between the L and C, but the source is required to produce no further current once the current starts oscillating back and forth in the LC circuit at the LC circuit's resonant frequency. The ammeter would read zero amperes once the LC circuit current starts oscillating. If there were any resistance anywhere in the LC circuit there would be a $P = I^2R$ loss in the resistance, and the meter would read the current value needed to support this power loss. Also, if a secondary coil is coupled to the inductor of the LC circuit and the secondary has a resistance load on it, this load will reflect back a resistance effect into the LC circuit coil, and the ammeter will read higher. The tighter the coupling the higher the ammeter will read, and the greater the power output, until the reflected resistance value drops below the source impedance value. This would represent overcoupling, an impedance mismatch, and less power output.

There is a very significant point about oscillating LC circuits. If there is no resistance in them, once they start oscillating theoretically you can disconnect the source and the LC current will continue to oscillate indefinitely. Of course there is no such thing as a resistance-free circuit. The more resistance in the LC circuit the faster the amplitude (strength) of the oscillating current will damp (die) out. This ability to maintain an oscillation in an LC circuit is known as flywheel effect. It is the basis of operation of all oscillator circuits using LC circuits and determines their frequency of operation.

Most resonant circuits in radio have either the L or the C made variable so that the reactances can be made to be equal at some desired frequency of operation.

The basic formula of oscillation for any resonant or anti-resonant circuit is:

$$X_C = X_L \quad or \quad \frac{1}{2\pi fC} = 2\pi fL$$

From the second form of the formula we can algebraically rearrange the symbols to develop formulas to tell us, for example, what capacitance is needed to match a given inductance for a certain frequency of operation. These formulas are:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$C = \frac{1}{(2\pi f)^2 L}$$

$$L = \frac{1}{(2\pi f)^2 C}$$

where f = frequency in hertz, Hz

C = capacitance in farads, F

L = inductance in henrys, H

For example, if you have a known value coil and known value capacitor and you connect them in parallel (or series), use the first formula to determine the frequency at which they will be anti-resonant (or resonant).

If you have a known value of inductance and you want to know what value of capacitance is required to bring such an LC circuit to resonance at a given frequency, use the second formula.

If you have a known value of capacitance and you want to know what value of inductance to use with it to make it oscillate at a desired frequency, use the third formula.

Before we start wrestling with very big and very small numbers, let's make sure you understand powers of 10. For example:

$$1 \times 10^1 = 10$$
$$1 \times 10^2 = 100$$
$$1 \times 10^3 = 1{,}000$$
$$1 \times 10^6 = 1{,}000{,}000$$
$$1 \times 10^9 = 1{,}000{,}000{,}000$$
$$1 \times 10^{12} = 1{,}000{,}000{,}000{,}000$$

In other words, the power (number) attached to the 10 indicates how many zeros to add after a 1. Thus, 3×10^6 means $3 \times 1{,}000{,}000$, or 3,000,000. Also, 4,250 can be expressed as 4.25×10^3.

We can also use powers of 10 to express small numbers:

$$1 \times 10^{-1} = 0.1 \text{ (one tenth)}$$
$$1 \times 10^{-2} = 0.01 \text{ (one hundredth)}$$
$$1 \times 10^{-3} = 0.001 \text{ (one thousandth, m)}$$
$$1 \times 10^{-6} = 0.000\ 001 \text{ (one millionth, } \mu)$$
$$1 \times 10^{-9} = 0.000\ 000\ 001 \text{ (one billionth, n)}$$
$$1 \times 10^{-12} = 0.000\ 000\ 000\ 001 \text{ (one trillionth, p)}$$

A negative power (such as 10^{-3}) indicates how many decimal places to put in front of a number. Thus, 3×10^{-6} means $3 \times 1 \times 10^{-6}$, or $3 \times 0.000\ 001$, or 0.000 003, which is three one-millionths. Also, 7.35×10^{-4} can be expressed as 0.000 735 by moving the decimal point over four places and inserting the necessary zeros. Note that 10^0 indicates unity, or 1.

Just for fun, let's see if we can engineer a coil and capacitor LC circuit that will resonate at 4 MHz, which is one edge of the 80-meter Amateur band. Assume we have a 50-pF capacitor to start with. What inductance coil do we need? Using the third formula, and plugging in the given values,

$$L = \frac{1}{(2\pi f)^2 C}$$

$$L = \frac{1}{[2(3.14)(4 \times 10^6)]^2\ (0.000\ 000\ 000\ 05)}$$

$$L = \frac{1}{(2.5 \times 10^{14})(5 \times 10^{-11})}$$

$$\text{(Now subtract } 10^{-11} \text{ from } 10^{14} = 10^3)$$

$$L = \frac{1}{3.155 \times 10^3} = \frac{1}{31{,}550}$$

$$L = 0.000\ 0317\ H \text{ or } 31.7\ \mu H$$

A difficulty with LC circuits is all of the stray resistances and capacitances that may occur in circuits. These can degrade the operation of a resonant circuit. For one thing, all wires have some resistance, and as a result the Q of LC circuits tends to be lowered. Q can be thought of as meaning quality. A coil with little resistance is essentially all inductance and no resistance. Its quality as an inductor is high. Q can be determined by

$$Q = \frac{X_L}{R} \quad \text{or} \quad Q = \frac{2\pi f L}{R}$$

From the second formula form it would be assumed that as frequency (f) increases the Q would also increase. However, when ac current flows in a wire the CEMF tends to force electrons to flow less in the center of the wire and more on the outer surface, or skin, of the wire. Constricting the usable volume of a wire makes the wire appear to be smaller to the ac current, and the wire exhibits greater resistance to the current flow. This is called skin effect. Skin effect increases the R value in the Q formula, tending to lower the Q at higher frequencies.

Since capacitors have very little wire associated with them they tend to have high Q, even though the Q of a capacitor can be computed by the formula $Q = X_C/R$ also. In an LC circuit the Q is usually assumed to be essentially that of the coil. However, when loaded (ac power coupled out of it), an LC circuit's Q lowers. A high-Q rf LC circuit in a radio receiver, for example, may have a Q value of perhaps 100 or more. If loaded normally, the working Q of a transmitter amplifier LC circuit may range from perhaps 8 to 15. If overcoupled the Q may drop below the value of 8. Adding resistance in series with either the capacitor or the inductor of an LC circuit, or across the circuit, will lower the circuit's Q.

Consider an LC circuit connected across an ac source whose output ac frequency is variable from a low frequency to a very high frequency, **fig. 14**. At a low frequency the reactance of the coil would be very low. As a result, the voltage developed across the LC circuit would be very small. Most of the ac voltage would be dropped across resistor R. At a very high frequency, the reactance of the capacitor would be very low, and again the voltage across the LC circuit would be very small. However, at some intermediate frequency, where X_L equals X_C, the two reactances cancel to form a nearly infinite impedance, resulting in maximum voltage-drop across the LC circuit and none across R. When this is graphed we see a peaked resonance curve, with the LC circuit voltage (or current) peak occurring at the frequency

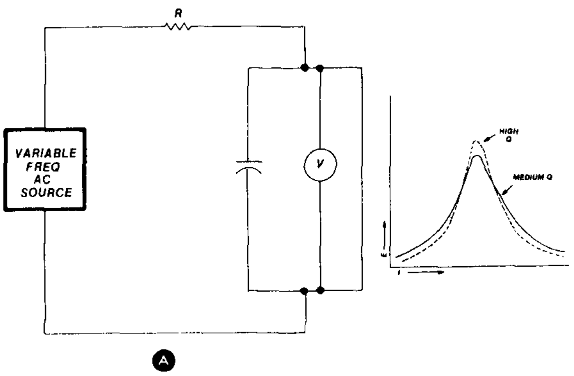


fig. 14. (A) An *LC* circuit across a variable frequency source of ac. (B) Frequency response curves of two *LC* circuits of different *Q*s but resonant at the same frequency.

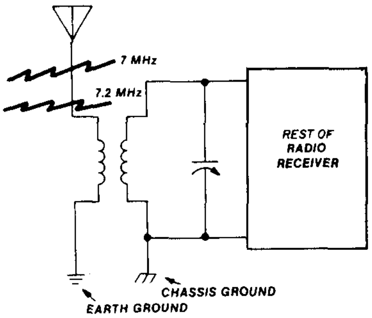


fig. 15. Resonant circuit used at the input of a radio receiver to select the desired frequency to receive.

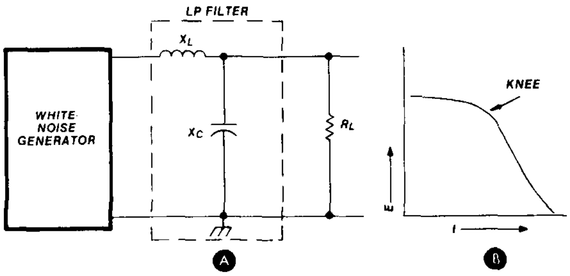


fig. 16. (A) Lowpass L-type filter and (B) response curve.

of resonance. We can read this curve to indicate that the *LC* circuit's response to frequencies removed from the resonant frequency drops off rather rapidly. The dashed curve indicates the relative response of a higher-*Q* *LC* circuit. The higher the *Q* the narrower the bandwidth of an *LC* circuit, and the steeper the skirts of the curve.

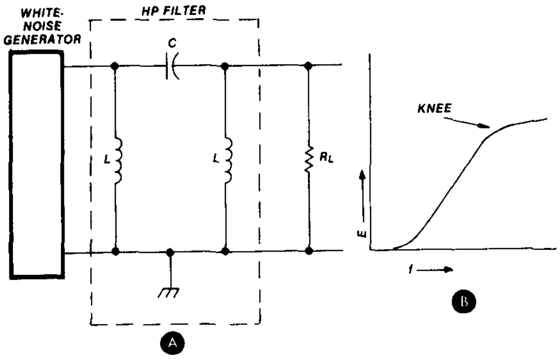


fig. 17. (A) Highpass π-type filter and (B) response curve.

An application of a resonant *LC* circuit is shown in **fig. 15**. An antenna wire is connected to a coil and the bottom of the coil is "grounded" to a water pipe or a pipe driven into the earth. Coupled to this antenna coil is the inductor of a tuned *LC* circuit. The *LC* circuit in this case has a variable capacitor to enable the resonant frequency to be changed, or "tuned." (A fixed capacitor with a variable inductor might also have been used.) There are two different frequency radio waves shown crossing the antenna and inducing two different frequencies of ac into it. If the *LC* circuit is made resonant to 7 MHz, the receiver will receive maximum response at this frequency, and will tend to attenuate (decrease) the response to the 7.2-MHz signal. If the capacitance is lessened so that the resonant frequency of the *LC* circuit is raised to 7.2 MHz, this frequency will produce maximum signal for the receiver and the 7 MHz signal will now be attenuated. The basic idea of a radio receiver is to use tuned *LC* circuits to select which frequency is to be received. The higher the *Q* of the *LC* circuit the narrower the bandwidth or the more selective the *LC* circuit and the receiver will be. Bandwidth is usually measured from the low frequency half-power point on the resonant curve, through resonance, to the half-power point on the high frequency half of the curve.

The bandwidth of an *LC* circuit is determined by *Q*, in the ratio

$$BW = \frac{f_o}{Q}$$

where BW = half-power point frequencies (in Hz, kHz, or MHz)
f_o = resonant frequency (in same units)

In general, the higher the frequency of resonance the wider the bandwidth that *LC* circuits will have. The *LC* circuits of 28-MHz Amateur band circuits will have much wider bandwidths than 3.5-MHz band circuits. It will be harder to tune out nearby frequencies on the higher frequency bands.

filter circuits

While most ac signal generators generate only a single frequency at one time, there are some special devices that can generate what is called white noise. This term denotes the production of a broad spectrum of frequencies all at the same time, from a few hertz to hundreds of megahertz. If a white-noise generator's output is fed through an L-type (from its L shape) lowpass filter, **fig. 16A**, only the low frequencies will pass through, and the high frequencies will be attenuated as indicated by the curve of **fig. 16B**. The circuit of this LP filter can be analyzed as having the X_L passing low frequencies (low reactance to them) to the load resistor, and opposing or attenuating higher frequencies. The X_C has almost no shunting (shorting) effect on low frequencies, but acts as a shunt or short circuit across the circuit for high frequencies. The larger the L and C values used the lower the frequency that the knee of the response curve will have. For audio frequency work, iron-core inductors are used.

If the positions of the L and C are reversed, as in **fig. 17A**, and a second inductance is added, a π-type (from its π shape) highpass filter results. The drop-off past the knee of the curve is much steeper (**B**) with the added component. In fact, the more components used in filters the steeper the skirts become.

Another form that filters take is the T type (from their component configuration), **fig. 18**. This is also a highpass filter, and can have characteristics similar to those of the filter in **fig. 17**.

Two resonant circuits connected as shown in **fig. 19A** produce a band stop filter. If both are tuned to the same frequency, 6 MHz for example, XL_1XC_1 acts as an infinite impedance to this frequency and almost none of this frequency can pass through the filter. If any does, then the zero impedance of the series resonant circuit, XL_2XC_2, shorts the ac signal at that frequency to ground. A band stop filter is also known as a notch filter. Frequencies on both sides of resonance will pass, **fig. 19B**. If the two LC circuits are resonant to different frequencies, perhaps 1 kHz apart, the curve will flatten off at its base (dashed curve) rejecting a wider group of adjacent frequencies, increasing the bandwidth of the filter. If only one resonant circuit is used to stop a frequency, such an LC circuit may be termed a wave trap. Wave traps are handy circuits for keeping unwanted rf ac out of electronic equipment. Band stop filters are sometimes called stop-band filters.

If the resonant circuit positions are reversed, as in **fig. 20A**, the circuit becomes a bandpass filter. Both circuits work to pass the frequency to which they are tuned. An air-core transformer with either or both primary and secondary tuned to the same frequency is also a form of bandpass filter. Several of these are used in every receiver and transmitter.

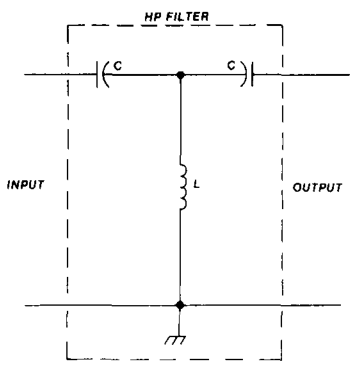


fig. 18. Highpass T-type filter.

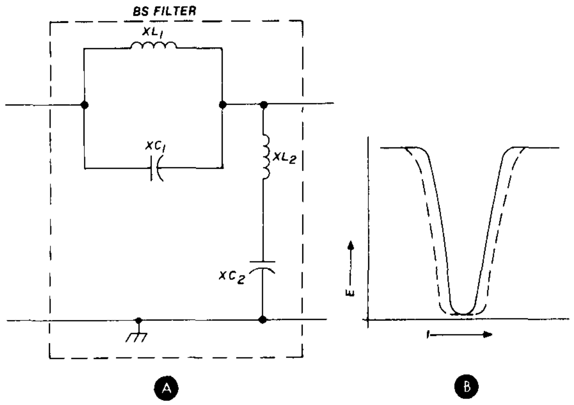


fig. 19. (A) Stop-band L-type filter and (B) response curve.

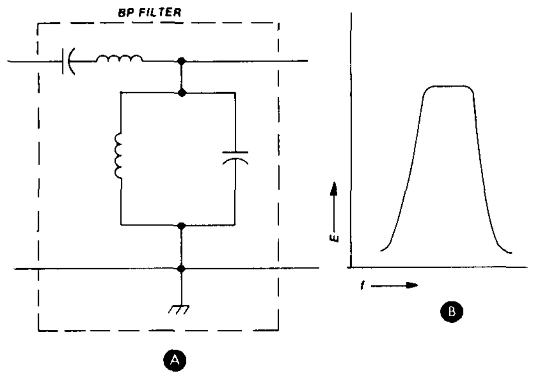


fig. 20. (A) Bandpass L-type filter and (B) response curve.

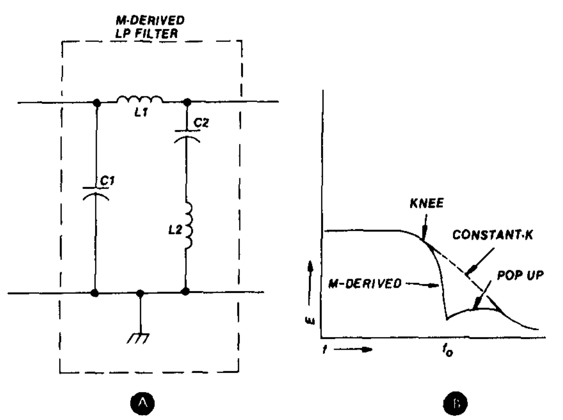


fig. 21. (A) A π-type m-derived lowpass filter and (B) a possible response curve.

The simple lowpass and highpass filters of **figs. 16** and **17** are known as constant-k filters because if the X_L and X_C values are multiplied together for any one frequency, the same product value (or k) will be produced at any other frequency. These filters do not have very steep skirts unless many similar sections are used in cascade (one following the other). Since every section produces some attenuation of the signal being passed through it, many-section filters may have excessive attenuation values.

Another form of *LC* filter, called an m-derived filter, uses a resonant circuit in it to force a steep slope. An example of a π-type m-derived lowpass filter is shown in **fig. 21A** with its response curve, **fig. 21B**.

Inductor L_1 and capacitor C_1 pass low frequencies but attenuate highs as in any lowpass, constant-k filter. The series resonant *LC* circuit shorts out its resonant frequency, f_o, but the response pops up past this frequency until it meets the descending constant-k response, shown dashed. The m value refers to the difference in frequency between the knee of the constant-k part of the filter and f_o. If the knee frequency and f_o are the same, $m = 0$ and the circuit acts like a constant-k filter with a wave trap in it. If the frequency at the bottom of the constant-k curve and f_o are the same, $m = 1$ and the circuit acts as a simple constant-k filter. An m value of about 0.6 gives a rapid drop-off and relatively little pop up past f_o, and is often the m value used.

The m-derived filters can be made in the π-type LP form as shown, or in HP, BP, and BS forms. Composite filters can be made with some constant-k sections cascaded with one or more m-derived sections. All filters are engineered to operate from and into given impedance values. If the proper impedances are not used, the filter will not work properly.

If resistors are substituted for the inductors in constant-k-type, highpass and lowpass filters, the steepness of the resulting curves are not very good. However, in many cases an RC filter will do the job adequately. They are much lighter and less costly than *LC* filters.

black box circuits

The FCC speaks of replacement of a voltage source and a resistive voltage divider with an equivalent circuit consisting of a voltage source and one resistor. This is an application of what is known as Thevenin's theorem, which says in effect, "Any complex resistive circuit with one or more voltage sources in it may be replaced with an equivalent operating circuit consisting of a single series resistor and a single voltage source."

The "black box" of **fig. 22** illustrates a resistive voltage-divider circuit and a battery inside the box. All we can see of this circuit are points **A** and **B**. Effectively, what single resistor in series with a single battery will work the same as this more complex circuit as far as any load connected across terminals **A** and **B** is concerned?

The answer to this can be determined by using a resistor load, an ammeter in series with it, and a voltmeter, as indicated. First, we measure the **A** to **B** voltage with no load. Let's assume it is 25 volts. Next, connect the load across **A** and **B** and read the voltage again. We will assume it is now 20 volts. We can say that connecting the load produces a change in voltage (delta V, or dV) of d5 volts. When no load is connected, the external current flow is zero amperes. Let's assume that with the load connected the current is 0.8 amp. This means that changing from load to no-load conditions produces a d0.8 amp. Using our delta values in the Ohm's law resistance formula results in $R = dE/dI$, or d5/d0.8, or 6.25 Ω internal resistance. Since we know that the effective internal EMF is 25 volts, the internal circuit could be replaced with a 25-volt battery and a 6.25Ω resistor in series.

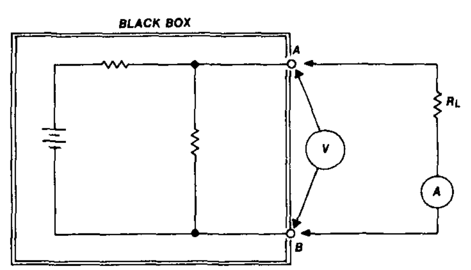


fig. 22. Black box and means of determining effective internal voltage and resistance.

FCC test topics

Although there are no specific Novice FCC test topics in this article, it would be wise for Novice applicants to begin to learn the necessary theory for future Technician/General, Advanced, and Extra class licenses.

The following Technician/General class FCC test topics are discussed in this article, but should be understood by Advanced class license applicants also:

- Reactance
- Impedance
- Electrical power calculations
- Power measurement
- Series and parallel combinations of resistors, of capacitors, and of inductors
- Impedance matching
- Turns ratio, voltage, current, and impedance transformations in transformers
- Highpass, lowpass, and bandpass filters

The following Advanced class FCC test topics are discussed in this article, but should be understood by Extra class license applicants also:

- Phase angle between voltage and current, given resistance and reactance
- Reactive power
- Power factor, given phase angle
- Series and parallel resonance
- Selecting a coil or capacitor to resonate at a given frequency
- Resonant frequency, bandwidth and Q of RLC circuits, given component values
- Skin effect
- Filters: constant-k, m-derived, stop band, notch, pi-section, T-section, L-section (general characteristics, not design equations)
- Replacement of a voltage source and a resistive voltage divider with an equivalent circuit consisting of a voltage source and one resistor.

Problem answers: 1: 89.4 ω. **2:** 1.4286, 55 degrees, 0.5736, 73.2 ω. **3:** 0.833, 39.80 degrees, 0.7682, 39.05 ω, 2.561 amps, 76.83 volts, 64.03 volts, 196.8 watts; it leads.

For additional information on these subjects you can refer to *Electronic Communication*, by Robert L. Shrader, W6BNB, McGraw-Hill Book Company, available through Ham Radio's Bookstore.

ham radio

Loading problems and cures with regard to solid-state transmitters

ham radio TECHNIQUES

Bill Orr W6SAI

My column "A Survey of Antenna Tuners" in July, 1981, *ham radio* brought some feedback in the form of interesting mail. The subject under discussion was the problem of loading a solid-state, high-frequency transceiver into some of today's modern antennas. Many proud users of the latest in ham gear experienced loading problems, feedback, TVI, erratic operation, a "hot" microphone and other melancholy exceptions to normal operation.

What is the problem? What causes this unusual plague of difficulties?

It seems to reduce down to this: The modern, state-of-the-art, high-frequency transceivers with transistor output stages all have one thing in common — they provide their full power into an antenna load *only* under conditions of a *low* SWR on the transmission line. Many solid-state transceivers, when presented with a high-SWR antenna load, simply start to turn themselves off. As an example, one popular transceiver, when working into an SWR of about 2 to 1, will reduce its output by 25 percent (100 watts to 75 watts). And when the SWR reaches about 3 to 1, the transceiver output drops by 50 percent (100 watts to 50 watts).

Someone may say "small potatoes," but a 50-percent power drop is a signal loss of 3 dB, and when the user is paying for the power, I don't see why he can't use it! **Fig. 1** sums up the problem.

what to do about loading problems

Perhaps the loss in power output is not important, but the attending problems mentioned previously are often coupled with the SWR problem. It is all of one piece, so to speak. The answer, then, is to tailor the *antenna system* to provide a better and more compatible load for the solid-state equipment.

From the mail I get on the subject, the antenna that seems to provide the greatest loading problems is the popular tri-band Yagi beam for 10, 15, and 20 meters. Sometimes this antenna is a "bearcat" to tame, especially on 10 meters. So let's take this antenna as an example, remembering that the discussion applies to other antennas as well.

The problem breaks down into two separate parts. First, getting the rf power where it belongs — into the antenna — and not where it is liable to end up — in the telephone wires, utility wires or Grandpa's new stereo system. Second, making the antenna system compatible with the transceiver so the latter "looks into" a reasonably low value of SWR. Neither problem is insurmountable.

getting the rf power where it belongs

It is easy to allow the output power from your transmitter to get into outlandish places. A favorite 40-meter dipole of mine had to be taken down because when I ran a few hundred watts into it, the dining room light fixtures illuminated by themselves, even with the light switch in the off position. And a friend of mine had a talking garbage disposal whenever he went on 15-meter SSB. Many operators have been bitten from a "hot" microphone on 10 meters. Sometimes speech processors break into oscillation, or loading changes when the microphone is grasped.

All of this means that the transmitter rf is getting where it is not supposed to be — into the power mains and back into the transmitter's exciter stages. There are several ways to combat this problem.

First, it is bad medicine to have the station in the near-field of the antenna. Getting the antenna up in the air, away from the station equipment, helps a lot. When the antenna is on a short tower right above the radio room, the station equipment is exposed to the strong radiation field from the antenna. Moving the antenna away from the station is the answer. Or, moving the station away from the antenna accomplishes the same result. My antenna, for example, is on a tower near my garage. Moving the station from the garage workshop to a spare bedroom certainly helped a lot. (My wife had other ideas about that move, but that's another story.)

antenna currents

One aspect of the problem is caused by antenna currents that flow on the *outside* of the coax to the antenna. Antenna currents can be caused by current induced into the outer shield of the line because it is in the field of the antenna. The worst case is when the line length is resonant; that is, a multiple of a half wavelength at the operating frequency. Under this circumstance, you have a resonant conductor (the transmission line) in the near-field of the antenna. Maximum line pickup comes about when the transmission line runs *parallel to the antenna.*

Antenna currents can be reduced by detuning the line and moving it so that it doesn't run parallel to the antenna. In the case of a rotary beam, it is a good idea to bring the coaxial line *and* rotor control cable down to ground level and run them along the ground, or bury them inside a garden hose sunk below ground level. A bad idea is to string the coax and cable above the ground from tower to radio room. My coax and cables came off my tower at about the 10-foot (3-meter) level, then ran across the rooftop to the window of the operating room. This caused no end of problems, especially on 10 meters.

I finally dropped the wires down to ground level and brought them into the radio room through a hole drilled into the corner of a closet floor (when no one was looking). Relocating the cables improved transmitter operation and stability immensely.

The *ARRL Antenna Book* has a good dissertation on antenna currents and how to decouple the line to avoid line resonance. The solution proposed is to cut the line to a length that avoids resonance. Recommended lengths for the high-frequency bands that avoid the problem are: 27, 39, 57, 76, 95, 110, and 145 feet (8.2, 11.9, 17.4, 23.2, 29, 33.6, and 44.2 meters).

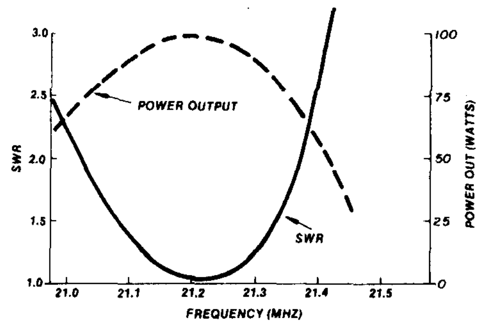


fig. 1. Representative SWR *vs* power output for solid-state transmitter. As SWR of antenna increases, power output of transmitter drops rapidly. At 21.45 MHz, for example, 100 watt nominal output is reduced to less than 30 watts because of high SWR on antenna system. A line flattener will reduce input SWR and boost power output of the transmitter.

the line choke

Another approach is to wrap a few turns of the transmission line into a coil, forming an rf choke, that will suppress antenna currents that might flow on the outside of the outer shield of the coax. I have used five turns of RG-8A/U, about a foot (30.5 cm) in diameter. In one instance, where I didn't use a balun, but fed a balanced beam with a coaxial line, I noticed that my front-to-back ratio was very poor. The beam seemed to have a bidirectional pattern. The five-turn choke coil was placed in the coaxial line, atop the tower, and about 3 feet (0.9 meter) from the feedpoint of the beam. (Placement was determined by the fact that I am a coward atop the tower, hanging on with both arms and a safety belt.) Once the line was wrapped and taped into a roughly shaped coil, the front-to-back ratio of the beam improved dramatically.

Another stunt is to wrap two turns of the transmission line around a large ferrite core. I've used the Amidon T-200 (6-mix, yellow, with a $u = 8$) with two turns of RG-8A/U through it in a 12-inch (30.5-cm) diameter coil with good results, too.

summing up

So there you have it. *Don't* run your coax line parallel to the antenna elements or, if you must, run it along the ground. *Do* make sure your coax line is not resonant at your operating frequencies. Either detune the line by trimming it to the previously suggested lengths, or wrap a portion of the line into an rf choke. Bring the line *down* the tower — *don't* run it off at an angle below the antenna.

if all else fails

Sometimes attention to antenna currents on the transmission line doesn't completely solve the problem of rf feedback, a "hot" microphone, or RFI (Radio Frequency Interference). *I* know. Some years ago I lived in an area remarkably free of TVI. I had no TVI problems, including TVI in my own home. One fine day a neighbor decided to add an extra room to his garage — sort of a combined rumpus room and workshop. No sooner was the room added when the neighbor complained to me of severe TVI from his new set installed in the garage room. Sure enough, I wiped it out! And a highpass filter in the TV lead in didn't seem to do any good.

Well, after a lot of fruitless investigation, on-the-air checks, and so on, we discovered that the TVI on this particular receiver could be completely eliminated by merely moving the set from the garage room back into the house!

It seems that my neighbor's house, my house, and the surrounding houses had been wired with solid electrical conduit. That is, all electric wiring was encased in metal conduit which, in turn, was grounded at several points in the homes.

To save building costs, my neighbor decided that conduit was too expensive, so his new garage room was wired with exposed, knob-and-tube wiring! The result was that the electrical wiring acted as a giant antenna, picking up my signal and pumping it directly into the power line of the TV set. Moving the set back into the house, which was wired with solid shielded conduit, completely protected the vulnerable input circuits of the receiver.

What to do? Investigating around the attic area of the new room revealed that the 120-volt wiring was as "hot as a baker's apron" when I was on 20 meters, less so on 15 meters, and again sensitive to 10-meter operation.

It was impossible to retroactively shield the wiring, so an attempt was made to cool things off. At every wall outlet each side of the power line was bypassed to the neutral wire (a three-wire circuit: 120 volts, 120 volts, and ground) with 0.01-μF 1.4-kV disc ceramic capacitors, rated for 125 volts ac and 1400 volts dc. (The capacitors are tested at 2800 volts.)

Three well known manufacturers that supply these line capacitors, and their type number are: Aerovox type AC-7, Centralab type CI-103, and Sprague type 125L-S10. These capacitors, or their equivalents, are suitable for the 120-volt, 60-Hz power line. *Do not* use garden-variety 600-volt disc ceramic capacitors, as they are not rated for this service.

Bypassing the line at various points helped to clean up the trouble, and when a highpass filter was placed in the ribbon line to the TV set, it did the job. Result: no more TVI in the new garage room!

the line flattener

Taming the rf floating around the radio room and cleaning up your neighbor's receiver doesn't go all the way in solving the loading problems inherent in some solid-state rigs, but it surely helps. The last trick in the deck is to use a *line flattener* — this is a simplified matching network that is placed between the transmitter and the antenna to reduce the SWR on the line to a value acceptable to the transmitter. Mind you, the SWR at the antenna and on the line doesn't change — the line flattener is merely a matching device that makes the real world more palatable to the station equipment. A good line flattener can drop an SWR of more than 5 to 1 to unity in the wink of an eye!

The schematic of a line flattener for power levels up to 250 watts PEP (or slightly more) is shown in **fig. 2**. A connoisseur will recognize this circuit as a simple pi network with three adjustable components. The line flattener is inserted into the transmission line *after* the SWR meter, and the

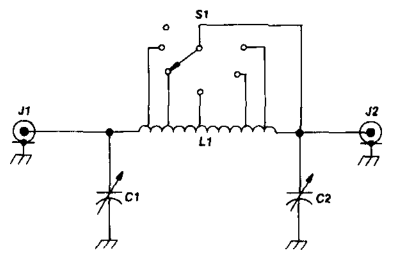


fig. 2. Line flattener for coaxial cable. Many components for the line flattener can be found in the junk box. J1, J2 are coaxial receptacles to match the plugs used in your antenna system (type SO-239 receptacles mate with plug PL-259, for example). Capacitors C1 and C2 are 100 pF (for 10-15-20 meter operation) and 250 pF for 40-80 meter operation. Single-spaced, receiving types will be satisfactory for power levels up to 100 watts PEP output. For higher power levels, the surplus capacitors found in the BC-series "Command" transmitters are ideal. Fair Radio Sales, in Lima, Ohio, has a good selection of transmitting capacitors.

The coil, L1, is ten turns of No. 12 (2.1 mm) 1 inch (2.54 cm) diameter and 1-1/2 inches (3.8 cm) long (10-15-20 meters); 20 turns, 1 inch (2.54 cm) diameter 3 inches (7.6 cm) long (40-80 meters). Five taps, every other turn on every fourth turn. The coil is not critical; the air-wound type is satisfactory, or it may be hand wound on a ceramic form. Use what you have. Switch S1 is a ceramic affair with an insulated shaft extension. Or, it may be mounted on an insulated plate affixed over an oversized panel hole. Remember: the arm of the switch is at rf potential. Again, Fair Radio Sales is a good choice for suitable switches.

controls are adjusted to reduce the SWR to a minimum value. Suitable components for the line flattener are listed in the drawing caption.

To keep everything shipshape and rf tight, the line flattener should be built into an enclosure such as an aluminum utility cabinet. The Bud AU-1040, measuring 9 by 6 by 5 inches (22.8 by 15.2 by 12.7 cm), will do the job as will any equivalent cabinet that is all-metal and does not have plastic end panels. The input and output coaxial fittings can go on either end of the cabinet, or on the rear, depending upon your particular equipment layout.

It is a good idea to use extra screws to hold the box panels in place; the box is pretty leaky when it comes to rf shielding. And don't forget to clean any paint off the mating lips of the box and panels to make a good electrical joint.

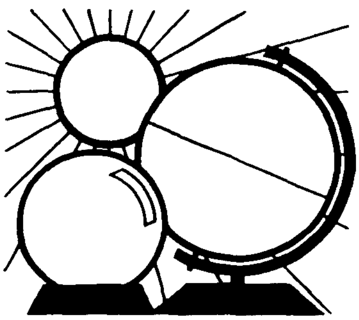
tuning the line flattener

Easy! Place the SWR meter between the line flattener and the coax line to the transmitter. You'll need a short, extra length of line to reach from flattener to transmitter. And *be sure* to properly install *all* coax plugs on your antenna line as recommended by the manufacturer. A sure-fire way to get into trouble is to improperly use the connectors. The temptation is great to jam the connectors onto the cable and forget about soldering the shield and inner conductor. *Don't do it!*

When everything is together, fire up the transmitter and adjust the controls of the line flattener for the lowest value of *reverse power* (or SWR) as read on the SWR meter. That's all there is to it. Log the control settings for each band for future use.

Need more information on antennas, feedlines, and beams? Read *The Radio Amateur Antenna Handbook,* by W6SAI and W2LX. It's available from Ham Radio's Bookstore, Greenville, NH 03048. Price, $6.95 plus $1 to cover shipping and handling.

ham radio



DX FORECASTER

Garth Stonehocker, KØRYW

last-minute predictions

The lower-frequency bands are expected to be favored for DX for the first half of the month; then the higher bands, 10-15-20, will pick up with excellent openings in the last part of the month. Some periods of disturbance may be experienced around the 10th, 19th, and 30th, with fairly lengthy (3-5 days) of low signal strengths on polar paths and excellent trans-equatorial long-hop openings. Both paths may have some QSB and DX from unusual locations associated with the disturbances.

October is an equinoctial month so expect more than normally disturbed conditions. The solar flux is still high enough in the declining part of the 11-year cycle to give good high maximum usable frequencies for trans-equatorial propagation. The 10 and 15 meter bands have most of this type propagation as one can see on the paths to the south, southeast, and southwest on the chart. Even some of the 10-meter openings are marked with an asterisk, which indicates possible openings on 6 meters during that hour during the month. The best chance for these openings are during high solar flux values and high geomagnetic A or K values as broadcast from radio station WWV at 18 minutes after each hour.

During October the Orionid meteor showers are visible from the 15th to the 25th. The maximum rate is between 10-20 per hour on the 20-21st of the month. The moon is full on the 13th and perigee on the 15th of the month, which may be of interest to the moonbounce DXers.

October may be a good month to get antennas ready for the winter DX season, since the summer yard work is over. You may want to consider how effective your antennas are in coupling to the ionosphere (see January 1981 *DX Forecaster*). For getting maximum distance per hop to your favorite DX land for short skip, E region propagation of 1200 miles (2000 km) you need a takeoff angle of about 20 degrees, and for long or regular skip to about 2500 miles (4000 km) about 10 degrees. For the higher-frequency DX bands with the usual horizontal antennas this is approximately 0.75 wavelength and 1.25 wavelength heights above ground respectively. This table gives the approximate heights in feet to shoot for:

band	short skip	regular
10	25	40
15	38	60
20	50	80

Hope you have a good DX season coming up.

band-by-band forecast

Six meters should provide frequent band openings with a peak during the early afternoon hours on many days. Trans-equatorial north-south paths will be the best. Your guide to possible openings will be strong openings on 10 meters and high values of solar flux.

Ten and fifteen meters will be loaded with good DX signals from morning until early evening hours almost every day. Times of geomagnetic disturbance will limit the number of signals heard, but listen carefully — they can be from very unusual places. Fifteen meters should be open later in the day than 10 meters. So, hit 10 first and finish off with 15.

Twenty meters will be the main daytime DX band, as it is almost always open to some part of the world. It opens to the east as the sun rises and extends into the late evening hours to the west. Geomagnetic disturbances do not affect this band as much as the higher ones, but still look for unusual trans-equatorial DX locations to be coming through once in a while. One-hop trans-equatorial DX of 5,000 to 7,000 miles (8,000 to 11,200 km) may be possible in the late evening hours during some of these unusual conditions.

Forty and eighty meters will have much short skip during daylight hours and turn to DX after dark. The bands will open to the east soon after sundown, swing more to the south to Latin America about midnight, and end up to the Pacific areas during the hour or so before dawn. Some nights these bands will be as good as during the winter DX season coming up in November-February. The coastal regions usually have the edge for working the rare DX on these bands.

One-sixty meters will be quieting down substantially now. This band should have renewed interest in DX possibilities with LORAN phasing out and privileges restored. It works much like 80 meters so give it a try.

ham radio

OCTOBER

WESTERN USA

GMT	PDT	N (Asia Far East)	NE (Europe)	E (S. Africa)	SE (S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania Australia)	NW (Japan)
0000	5:00	10	20	15	10	10	10*	10*	10
0100	6:00	10	20	15	10	15	10*	10	10
0200	7:00	10	20	15	10	15	10	10	10
0300	8:00	10	20	15	15	15	10	10	10
0400	9:00	—	—	20	15	15	10	10	15
0500	10:00	—	—	20	15	15	10	15	15
0600	11:00	—	—	20	20	15	15	15	20
0700	12:00	—	—	20	20	20	15	15	20
0800	1:00	20	—	20	20	20	15	20	40
0900	2:00	40	—	—	40	20	20	20	40
1000	3:00	40	—	—	40	20	20	20	40
1100	4:00	40	—	—	40	20	40*	20	40
1200	5:00	20	—	—	20	40	40*	20	40
1300	6:00	20	—	—	20	40	40	20	40
1400	7:00	20	20	15*	10	—	40	20	40
1500	8:00	20	20	10	10	—	20	20	—
1600	9:00	15	15	10	10*	—	15	15	—
1700	10:00	15	15	10	10*	—	10	15	—
1800	11:00	15	15	10	10	15	10	15	—
1900	12:00	15	15	10*	10	15	10	15	20
2000	1:00	15	15	10	10	15	10*	10	15
2100	2:00	15*	15	10	10	15	10	10	10
2200	3:00	10	20	10	10	15	10*	10	10
2300	4:00	10	20	10	10	15	10	10	10

MID USA

GMT	MDT	CDT	N (Asia Far East)	NE (Europe)	E (S. Africa)	SE (S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania Australia)	NW (Japan)
0000	6:00	7:00	—	20	15	10	10	10	10	10
0100	7:00	8:00	—	20	15	10	10	10*	10	10
0200	8:00	9:00	—	20	15	15	15	10	10	15
0300	9:00	10:00	—	40	20	15	15	10	10	15
0400	10:00	11:00	20	40	20	15	15	15	15	20*
0500	11:00	12:00	20	40	20	20	15	15	15	20
0600	12:00	1:00	—	40	20	20	20	15	20	20
0700	1:00	2:00	—	—	20	20	20	20	20	20
0800	2:00	3:00	—	—	20	20	20	20	20	20
0900	3:00	4:00	—	—	40	40	20	20	20	20
1000	4:00	5:00	—	—	40	40	20	20	20	—
1100	5:00	6:00	—	—	—	40	20	20	20	—
1200	6:00	7:00	—	—	—	15	20	20	20	—
1300	7:00	8:00	20	20	—	10	20	20	20	—
1400	8:00	9:00	20	15	10	10	—	—	20	20
1500	9:00	10:00	20	15	10	10*	—	—	20	20
1600	10:00	11:00	15	15*	10	10*	—	15	20*	20
1700	11:00	12:00	15	15*	10	10*	—	10	20	—
1800	12:00	1:00	15	15*	10*	10	—	10*	15	—
1900	1:00	2:00	20	15	10	10	15	10*	10	—
2000	2:00	3:00	20	15	10	10	15	10	10	—
2100	3:00	4:00	—	15	10	10	10	10	10	10
2200	4:00	5:00	—	20	10	10	10	10*	10	10
2300	5:00	6:00	—	20	10	10	10	10	10	10

EASTERN USA

GMT	EDT	N (Asia Far East)	NE (Europe)	E (S. Africa)	SE (Caribbean S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania Australia)	NW (Japan)
0000	8:00	15	20	15	10	15*	10	10	15
0100	9:00	15	20	15	15	15	10	10	15
0200	10:00	15	20	20	15	15	15	15	15
0300	11:00	20	20	20	15	15	15	15	20
0400	12:00	20	20	20	15	15	20*	20	20
0500	1:00	—	40	20*	20	20	20	20	20
0600	2:00	—	40	20	20	20	20	20	20
0700	3:00	—	40	40	40	20	20	20	20
0800	4:00	—	40	40	40	20	20	20	20
0900	5:00	—	—	40	40	20	20	20	—
1000	6:00	—	—	20	40	—	20	20	—
1100	7:00	—	—	20	40	—	20	—	—
1200	8:00	—	15	10	10	—	20	—	—
1300	9:00	20	10	10*	10	—	—	—	—
1400	10:00	20	10	10*	10*	—	—	20*	20
1500	11:00	15	10	10*	10*	—	—	20	20
1600	12:00	15	10	10*	10*	—	—	20	—
1700	1:00	20	10	10	10	—	—	—	—
1800	2:00	20	10	10	10	15	10	—	—
1900	3:00	20	10	10*	10	15	10	—	—
2000	4:00	—	15	10	10	10	10*	15	—
2100	5:00	—	15	10	10	10	10	10	15
2200	6:00	—	20	10	10	10	10	10	10
2300	7:00	—	20	10	10	10	10	10	10

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

Dyna-"mite."

Miniaturized, 5 memories, memory/band scan

TR-7730

The TR-7730 is an incredibly compact, reasonably priced, 25-watt, 2-meter FM mobile transceiver with five memories, memory scan, automatic band scan, UP/DOWN manual scan from the microphone, and other convenient operating features.

TR-7730 FEATURES:

- **Smallest ever Kenwood mobile**
  Measures only 5-3/4 inches wide, 2 inches high, and 7-3/4 inches deep, and weighs only 3.3 pounds. Mounts even in the smallest subcompact car, and is an ideal combination with the equally compact TR-8400 synthesized 70-cm FM mobile transceiver.
- **25 watts RF output power**
  Even though the TR-7730 is so compact, it still produces 25 watts output for reliable mobile communications. HI/LOW power switch selects 25-W or 5-W output.
- **Five memories**
  May be operated in simplex mode or repeater mode with the transmit frequency offset ±600 kHz. The fifth memory stores both receive and transmit frequency independently, to allow operation on repeaters with nonstandard splits. Memory backup terminal on rear panel.
- **Memory scan**
  Automatically locks on busy memory channel and resumes when signal disappears or when SCAN switch is pushed. Scan HOLD or microphone PTT switch cancels scan.
- **Extended frequency coverage**
  Covers 143.900-148.995 MHz in switchable 5-kHz or 10-kHz steps, allowing simplex and repeater operation on some MARS and CAP frequencies.
- **Automatic band scan**
  Scans entire band in 5-kHz or 10-kHz steps and locks on busy channel. Scan resumes when signal disappears or when SCAN switch is pushed. Scan HOLD or microphone PTT switch cancels scan.
- **UP/DOWN manual scan**
  With UP/DOWN microphone provided, manually scans entire band in 5-kHz or 10-kHz steps.
- **Offset switch**
  Allows VFO and four of five memory frequencies to be offset ±600 kHz for repeater access (or to be operated simplex) during transmit mode.
- **Four-digit LED frequency display**
  Indicates receive and transmit frequency during simplex or repeater-offset operation.
- **S/RF bar meter and LED indicators**
  Bar meter of multicolor LEDs shows relative receive and transmit signal levels. Other LEDs indicate BUSY, ON AIR, and REPEATER offset.
- **Tone switch**
  Activates internal subaudible tone encoder (not Kenwood-supplied).

Optional accessories:

- **MC-46** 16-button autopatch (DTMF) UP/DOWN microphone
- **SP-40** compact mobile speaker
- **KPS-7** fixed-station power supply

More information on the TR-7730 and TR-8400 is available from all authorized dealers of Trio-Kenwood Communications
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TR-8400

- **Synthesized coverage of 440-450 MHz**
  Covers upper 10 MHz of 70-cm band in 25-kHz steps, with two VFOs.
- **Offset switch**
  For ±5 MHz transmit offset on both VFOs and four of five memories, as well as simplex operation. Fifth memory allows any other offset by memorizing receive and transmit frequencies independently.
- **DTMF autopatch terminal**
  On rear panel, for connecting DTMF (dual-tone multifrequency) touch pad (for accessing autopatches) or other tone-signaling device.
- **HI/LOW RF output power switch**
  Selects 10 watts or 1 watt output.
- **Virtually same size as TR-7730**
  Perfect companion for TR-7730 in a compact mobile arrangement.
- **Other features similar to TR-7730**
  Five memories, memory scan, automatic band scan (in 25-kHz steps), UP/DOWN manual scan, four-digit LED receive frequency display (also shows transmit frequency in memory 5), S/RF bar meter and LED indicators, tone switch, and same optional accessories.

Specifications and prices are subject to change without notice or obligation.

DIGITAL TECHNIQUES

avoiding built-in digital-circuit problems, part two

Part one of this series stressed the importance of timing to avoid the race condition by providing examples of different counter circuits. Race conditions and spikes are found in all marginal logic designs. But all have solutions. This part of the article looks deeper into counter chains; shows methods of supply bypassing and handling switch controls; and provides methods of reducing RFI for all logic circuits.

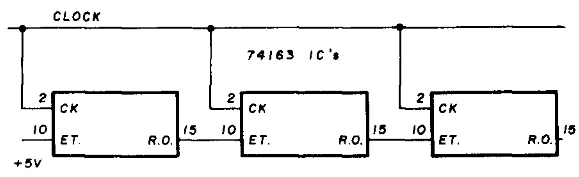

fig. 12. Suggested counter cascading for larger division ratios.

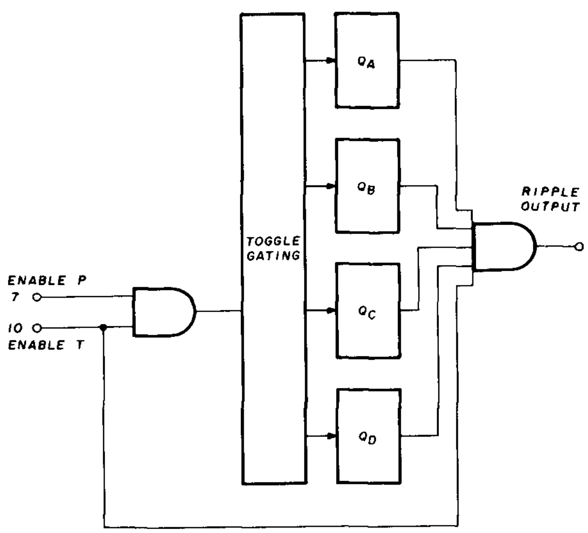

fig. 11. Simplified schematic of 74161 and 74163 counters showing ripple-carry output generation.

an inside look at a synchronous counter

Fig. 11 is a simplified schematic of the ripple carry output circuit in 74161 and 74163 counters. A carry output will not occur until all counter stages are high and the enable-T pin is high. This configuration allows cascading devices to be used, so that a carry output from the last device occurs only when all previous counters are high or logic 1.

A counter cascade, such as in **fig. 12**, should work well. But I've found a situation with 74163 devices that causes a small glitch that can make the output unsuitable for driving other circuits. The cause is a small, differential delay, between a) the enable-T

By Penn Clower, W1BG, 459 Lowell Street, Andover, Massachusetts 01810.

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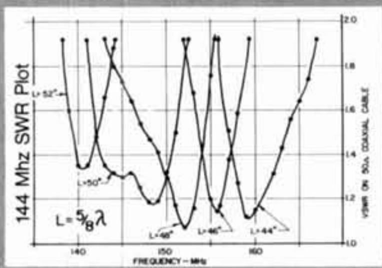

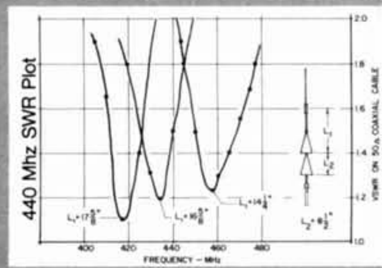

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More Details? CHECK—OFF Page 94

path to carry out, and b) the counter toggling to carry out.

causes, cures and don't-cares

Spike generation is set up when all counters except the last are all ones; the last is one count less than all ones. Enable-T input of the last counter is high. Arrival of a clock edge begins to toggle all counters. All but the last go low after a short delay, while the last counter goes high.

Enable-T input of the last counter can remain high slightly longer due to its output gate delay. If this high state remains, the last counter carry output can go high for 10 to 30 nanoseconds. This short high state is shown in the lower, expanded-time trace of **fig. 13**. With an amplitude of about a volt, it may or may not affect any following circuitry.

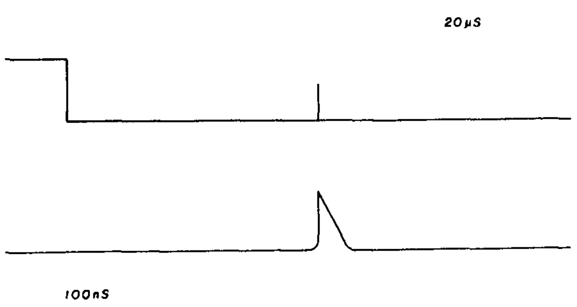


fig. 13. Dual time trace of output of last stage in counter cascade of fig. 12. Upper trace is 20 μsec per division. Bottom trace is expanded time of upper trace center at 100 μsec per division to show spike.

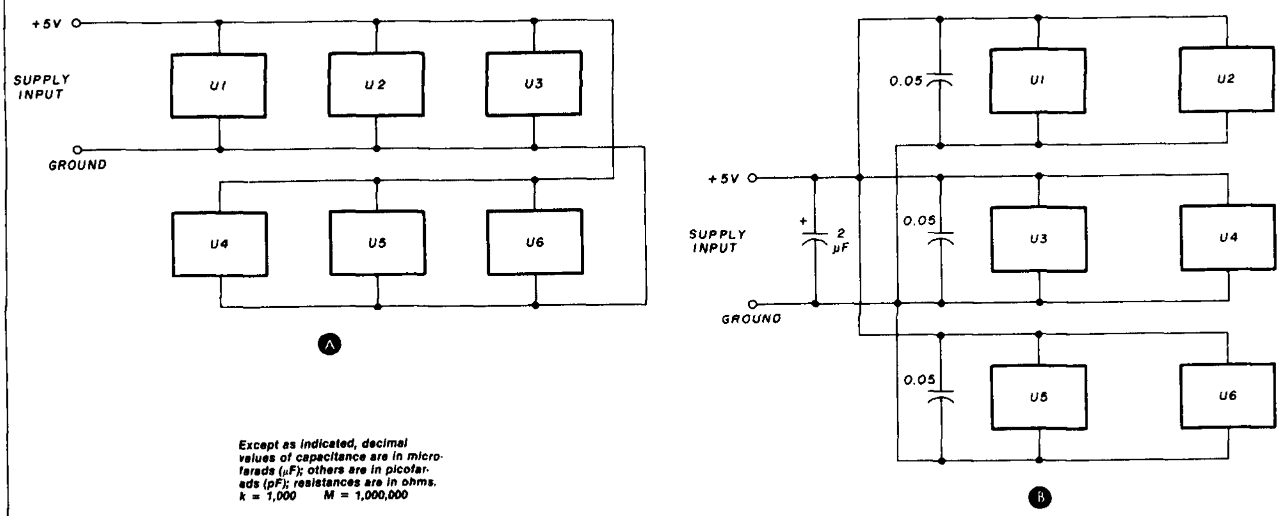


fig. 14. Supply connections with daisy chain in *A*; improved tree method in *B*. The 0.05 μF bypass capacitors in *B* smooth variations in each branch, while the 2-μF cap filters low-frequency components.

Low-pass filtering of long (breadboard) leads may mask this spike, but it can show up in the final, clean-layout circuit. One way to eliminate the spike is to carry it through a low-power inverter to the next circuit. This works with a 74L TTL inverter following a medium-speed or 74LS counter; interfamily loading rules must be followed to apply the 74L inverter properly.

If following circuits are clocked by the same counter input line, the glitch will not affect operation. Clock-triggered devices must have inputs set up *before* the clock edge arrives. The best design is one that pays attention to time delays before using any family mixes or R-C brute-force filtering. You must study all the fine print in data books.

initialization

Initialization is the process of defining starting conditions so that a sequence can begin correctly. There's no guarantee that a flip-flop will start up in a desired state, so all counter or shift register feedback gating must ensure that *any* start-up state will eventually get into the desired sequence.

A divide-by-20 counter could be made with a 20-state, circularly connected shift register. If 19 states are low and one is high, the single high bit will cycle around once for every 20 clock pulses. There must be some setup to achieve this pattern when starting; odds of starting by chance are one in 52,428.* This is

*20 acceptable patterns out of 2^{20} possibilities.

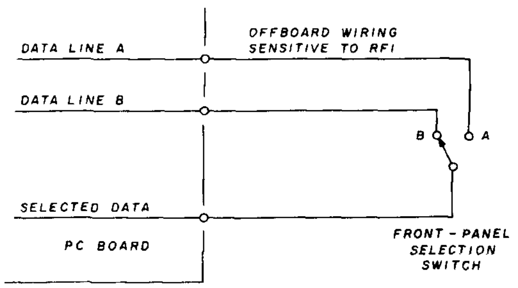


fig. 15. Example of external digital data switching. Data lines act as antennas for RFI and cannot be filtered without destroying data.

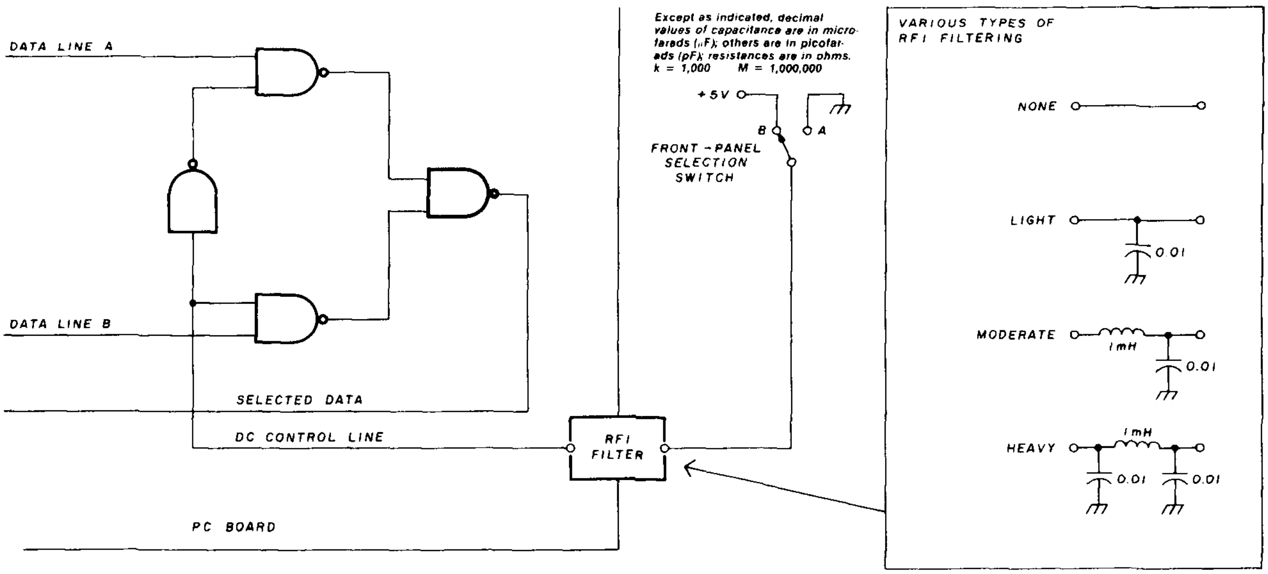


fig. 16. Improved data control allowing dc control and RFI filtering of control line. Inset shows typical RFI filter types.

an extreme chosen to make the point, but many real-life situations do occur.

Start-up states could be initialized by extra circuitry and a front-panel switch. A better way is to study the design in detail and, if necessary, add or rearrange gating for automatic initialization on start up.

layout

Anyone who has built high-gain amplifiers knows that outputs are not placed close to inputs. A completed layout is never exactly like its circuit diagram, since all components have parasitic capacitance, resistance, or inductance. Proper layout can minimize feedback and parasitics. This is also true for digital circuitry.

It is all too easy to think of digital signals as being simply ones or zeroes, disregarding actual voltages. If a digital device has supply-line spikes, outputs of that device will have spikes, and a following IC may interpret these as signals.

power-supply wiring

Proper routing of power-supply currents is crucial in dense circuits. Those with a modest amount of ICs will benefit from care in routing. Supply-line spikes are generated by logic state changes in concert with parasitic supply line and ground inductance.

A clue to the ground-noise problem is a system malfunction when individual system circuits, such as breadboards, work well by themselves. Relief may be achieved by adding bypass capacitors directly at high-current ICs. These capacitors provide local current storage, which reduces the high-frequency current drawn through the entire supply system.

A better correction to decreasing supply impedance is a "supply tree" shown in **fig. 14**. A conventional daisy-chain supply of **fig. 14A** would make U1 susceptible to supply glitches from all others. The tree configuration of **fig. 14B** spreads supply spikes to small branches, while capacitors smooth out branch currents.

layout for the supply lines

Power and ground conductors should be as large as possible; inductance decreases as surface area increases. A good way to reduce impedance is to use a double-sided circuit board with ground on one side, supply on the other. Supply impedance becomes quite low.*

Nonprinted layouts should avoid the supply daisy chain of **fig. 14A**. Bypass capacitors should be added locally. Ceramic caps with values from 0.001 to 0.1 µF, are typical. Leads should be short to avoid series resonance. Harmonic content of spikes is quite high, and a bypass capacitor above series resonance will become an inductor. Electrolytic or tantalum caps in the 1-10 µF range should be added to provide low-frequency smoothing on each board.

off-board wiring

Long digital lines to and from the board are susceptible to crosstalk, signal distortion, and RFI. An example is that of **fig. 15**. The panel switch is a data selector. Long lines to the switch cannot be filtered without destroying the data, and they act as antennas for rf pickup. A better solution is to add a dc-controlled digital selector on the board, such as the quad gate in **fig. 16**. External control is a dc line that can be easily filtered without disturbing data selection.

Many medium- and large-scale ICs have dc control inputs. Using these inputs allows, among other things, oscillator switching, presetting counters, and resetting flip-flops. Multiple data-line switching can be done with multiplexers such as the 74150 or 74151. Adding another device may be a bother, but the RFI elimination may be worth the expense.

curing switch-contact bounce

A clocking waveform should never be generated directly from a mechanical switch. Switches bounce, stutter, and generate a number of transitions for each operation.

A new pushbutton switch was connected, as in **fig. 17A**. The output appears in **fig. 18**. It can get longer and more ragged with age. The cure is to add two gates in a flip-flop latch arrangement, as shown in **fig. 17B**. The first low input from either contact will flip the latch, providing both a sharp logic step and masking the following contact bounce. Gate inputs can be heavily filtered for RFI.

explanations, experience, and understanding

Many possible explanations are available as to why a digital design doesn't work properly. Some faults may be due to inexperience, such as wrong application or lack of complete knowledge of an IC's operation.

*Commercial prototype PCBs with individual circuit bypasses are available. While expensive, they are worthy of consideration.

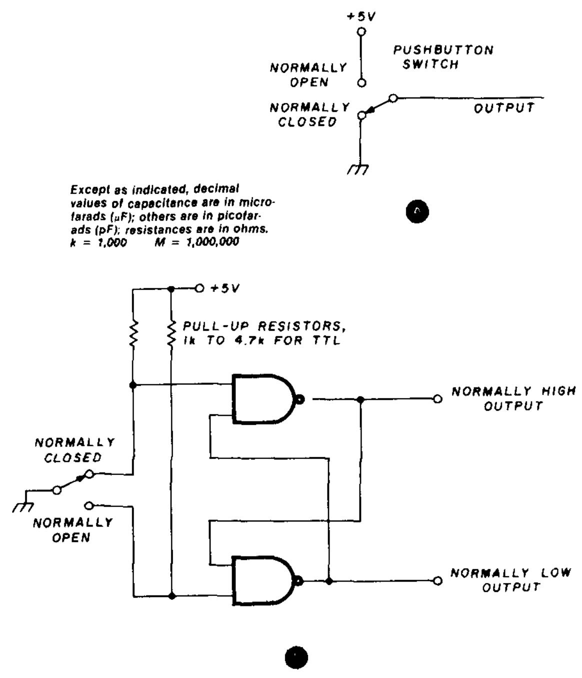


fig. 17. Simple mechanical switch circuit in *A*; improved version in *B*. Added latch gates in *B* remove bounce effects and allow RFI filtering.

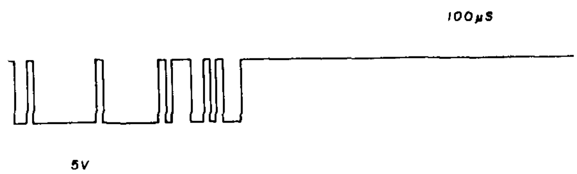


fig. 18. Output from simple switch in fig. 17-A using a new switch. Contact bounce has created at least eight positive-going edges instead of one.

As you gain more experience and learn from past mistakes, your success rate will increase. Bigger and better things will be attempted; bigger projects may have subtle problems that aren't solved by a quick flip through a data book. The purpose of this series of articles is to explain causes and cures of some of these very subtle problems.

I hope that understanding a problem will put you in a position to decide on the cure. The key to success lies in understanding *why* something hasn't worked in the past, so that you can apply the appropriate measures to the present. The alternative answer is to restrict yourself unnecessarily with a constantly growing number of design guidelines.

I shall be glad to answer letters accompanied by self-addressed, stamped envelopes, but I will not critique circuits through the mail.

ham radio

ICOM 701 owners' report

A survey of owners' opinions on the ICOM 701

In recent months, *ham radio* has presented the results of its Collins owners' survey. Thanks to all who participated. This month, we are presenting the results of our survey of the owners of the ICOM IC-701 transceiver. Ninety responses were received and tabulated.

The IC-701 is a solid-state transceiver that delivers 100 watts PEP output on all modes and bands, 160 through 10 meters. It uses a single control knob to tune built-in dual VFOs; frequency readout is by means of eight-digit LEDs. Tuning of the synthesizer can be done at either 100 Hz per division (5 kHz per turn) or 10 kHz per division (500 kHz per turn).

the good features

In response to the question, What is the rig's best feature?, the most frequent responses were small size (portability) and the built-in dual VFOs. A full 32 percent of all who responded to this questionnaire mentioned the small size of this transceiver, and its applicability as a mobile rig, as one of the best features. Thirty percent of the 701 owners who replied to the questionnaire mentioned the dual VFOs and split-frequency operation.

Other features of the 701 frequently mentioned were the solid-state advantages of the transceiver and the fact that no tune-up is necessary, the ease of operation, and the rig's stability. Here are some representative comments:

"Receiver section. Separate rf stage per band. Excellent dynamic range on 80 and excellent sensitivity on 10." — AKØP

"Stability, no-tune output." — N7BZ

"Synthesized, large digital display, dual VFOs." — KØMK

"Built-in dual VFOs, CW filters, portability (the rig was used on a mini-DXpedition to Rhodes and Crete), 100-Hz tuning segments (after I got used to it!), useful meter." — W6GBG

"Digital step tuning that allows selection of tuning speed, microprocessor interface capability, simple controls yet sophisticated capabilities, solid state finals, dual VFO system! The headphone jack that works with either mono or stereo phones is a stroke of genius!" — N1BEJ

"Reliability, no problems at all; sensitive receiver." — KB5CA

"Compactness, easy to use and operate and extremely stable. It's pretty too." — K5ESG

"Ease of operation, fast frequency change via high-speed tuning mode, and exceptionally wide bandspread in slow tuning mode. This rig is simplicity itself to operate. Once the af/rf gains and mic/CW levels are set, just tune around and operate." — WB1CHY

"Accuracy of frequency readout and ease of dropping to low power." — W5QAR

"Very easy to use, dual VFOs, good filters, etc., but mostly I like it because I just turn it on and go!" — AA7O

"Compactness, multiple features, stability, good audio on both transmit and receive, ability to interface with RTTY easily. It is a classic, ahead of its time. I own two, one mobile and one in the house." — W4VOL

"Wonderful synthesized frequency control and readout system." — W7EMP

By Martin Hanft, WB1CHQ, Production Editor, *ham radio* magazine

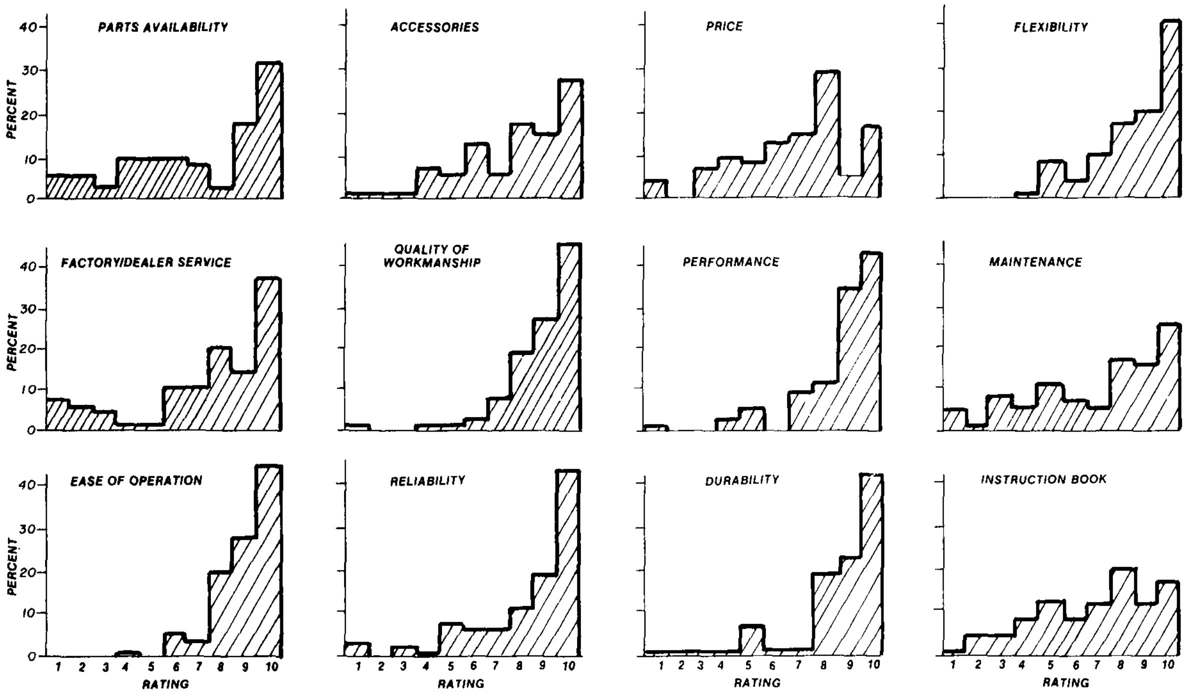


fig. 1. How the ICOM 701 was rated in each of 12 categories.

"Rotary dial with digital readout is the smoothest dial I have ever used, because of the electronic method of operation. Stability of the frequency reading is perfect and frequency itself is extremely stable. Audio quality and sensitivity are excellent!" — VE3UD

"Ease of operation. Everything you need is right up front." — KAØEJX/5

"No tuneup, just turn it on and go. Built in dual VFOs. At the time I purchased the rig there were no options available — it had everything!" — N5ADJ

"Dual VFOs built in. Ease of operation. Portability and mobile use. A lot for the money." — WA2DXJ

"Broadband tuning and high quality construction." — W2JCM

"Operating convenience." — KA1CMR

"I can swish across the band with a twist of the wrist and not have to retune the final. A great feature." — K7GCO

"Slow tuning rate makes it very easy to scan the band." — AA4RE

"Very selective and sensitive receiver, compact size, excellent speech processor. Almost no distortion with the extra average power." — NH6B

"Probably the most advanced circuitry in all hamdom." — VE3AHR

"In my opinion the fast bandswitching and QSY with no tuneup of the final is the best feature. I also am very impressed with the performance of the receiver. The frequency control features and stability are outstanding." — WA5JXC

and the bad

In response to the question, What is the rig's worst feature?, the highest percentage of respondents, 13 percent, replied that the worst feature of the 701 is the fact that the radio returns to the bottom of the band every time it is turned off. One Amateur, who apparently has power-failure problems, said that this is an inconvenience for him, especially when operating split frequency.

The second most frequent complaint was about the front-panel knobs, which were described by many as "tiny." Twelve percent of those responding mentioned the size of the knobs on the front panel. Other features named as worst included lack of passband tuning on CW, low power output, lack of full break-in, and a tendency for the finals to get too warm. Here are some sample replies to the question, What is the rig's worst feature?

"Next to impossible to repair yourself because of small size and board layout. Instruction book doesn't help much." — WB3FYL

"Seems to lack punch in a DX pileup. Power reduction occurs rapidly away from a 50-ohm load. Linears used must have tuned input."

"Non-linear VFO frequency response." — N2AQS

"When you power the rig up or change bands it

table 1. Best feature. The percentage refers to the number of respondents who listed that feature as best. Note that many respondents listed more than one "best feature."

	percent
small size, portability	32
built-in, dual VFOs	30
ease of operation	28
no tune-up needed	27
stability	16
broadband tuning	15
ease of changing bands	14
memory capability	10
fast/slow tune	9
receiver	9
display LEDs	8
quality construction	7
audio	7
sensitivity	7
built-in CW filters	5
narrow tuning	5
appearance	3
split frequency capability	3

table 2. Worst feature. The percentage refers to the number of respondents who listed that feature as worst.

	percent
automatic revert to bottom of band when rig is turned off	13
tiny knobs	12
no passband tuning on CW	9
power output too low	7
receiver overloads	7
not selective enough	6
lack of full break-in	6
inexact tuning	5
finals get too hot	5
requires low SWR	5
lack of general coverage ability	4
poor service manual	3
hard to repair	2
no expansion to WARC bands	2
hard to hook up linear	1

always starts at the bottom of the band." — WAØVNH

"Low power output." — K9GA

"Passband tuning not usable in CW mode." — AKØP

"Overloads. Shotgunning when strong signals close. Not selective enough." — N7BZ

"None." — K5STR

"Too easy to use. I am always on the air, and my XYL threatens divorce." — N9AGB

problems

The most common response to the question, Have you had any problems?, was "None." That is certainly a strong recommendation for the ruggedness of this rig. Some 36.6 percent of those responding to the survey had never had any sort of problem with the 701. The most common problem that was reported was blown final transistors: in many instances this was attributed to the operator's own carelessness. It is very likely that the 701 is the first solid-state rig ever owned by many of the Amateurs responding to this survey, and that fact may account for at least a few of the blown final transistors. There were also the usual sprinkling of assorted problems, including some cold solder joints, diode failures, and dirty switch contacts. Here are a few sample responses to the question, Have you had any problems with this rig?

"Cold solder joint. Had to return the rig to Dallas. This happened after six months of use." — WA2DXJ

"Output transistor failure in first few months, but corrected under warranty." — WB6LSP

"T/R switch section went bad and blew finals." — K7GCO

"Rf feedback with the eletret desk mike." — VE5YD

"Fan never worked from the day it was placed in line." — HP1XRK

"Antenna switching diodes shorted." — DJ4EI

"T/R switching diodes blew up." — DF2KT

"Finals failed when tuning up end-fed wire with tuner at full power. They were replaced at no cost with a caution to tune at reduced power." — K8EX

"Mode switch defective; intermittent CW reception." — NH6B

"None. In terms of maintenance, this has been the

table 3. Problems. The percentage refers to the number of respondents who listed the problem on their survey form.

	percent
no problems	37
blew final transistors	18
bad solder joints	5
other transistor problems	5
bad switch	3
bad capacitor	2
mike problems	2
drift	2
abnormally low output	1

table 4. Accessories. The percentage refers to the number of respondents who bought the accessory in question.

	percent
none needed	38
RM2 remote controller	27
EX1 extension terminal	17
tuner	10
keyer	9
desk mike	3

finest piece of equipment I've ever used." — K9BIL

"None! It gets almost constant use now and still no gremlins or breakdowns." — KB5AH

"Using the standard ICOM mikes I have had rf feedback problems when used with a linear amplifier. Bypassing and filtering have not helped." — WA5JXC

"Continual problem with the mode switch; have to switch and wiggle for good contact." — N7BZ

accessories and related findings

WB1CHY's response to the question, What accessories have you purchased for this rig?, was typical: "None needed. Everything needed comes as standard equipment — VFOs, mike, and power supply. Great!" It's not surprising, then, that 38 percent of those surveyed have never bought an accessory. Most of the Amateurs who did buy accessories bought either ICOM's RM2 remote controller (27 percent) or the EX1 extension terminal (17 percent). About 7 percent of those responding mentioned keyers, and some 6 percent had acquired a tuner. Three percent had purchased a desk mike.

To the question, Have you had the rig serviced?, 46 percent answered yes, 54 percent no. Of those who did have factory service, 85 percent found the service satisfactory. Eighty-four percent reported that they were able to obtain all the accessories and parts they needed, and 90 percent of those who had obtained accessories or parts found them satisfactory.

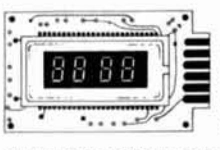
Among the 90 Amateurs who responded to the ICOM 701 questionnaire, there were only two Novices and one Technician. Fifty percent of those who replied held an Advanced class license, thirty percent held an Extra class ticket, and 18 percent were Generals.

The following twelve categories were scored from 1 to 10 (with 1 being poorest, 4 to 6 average, and 10 perfect): Ease of Operation, Reliability, Durability, Instruction Book, Factory/Dealer Service, Quality of Workmanship, Performance, Maintenance, Parts Availability, Accessories (ease of connection), Price, and Flexibility. The scores are reported in **fig. 1**.

would you buy one again?

Seventy-seven percent of those responding said that, yes, they would buy a 701 again. That's a very good showing, and one which demonstrates the ICOM 701 to be one of the most popular rigs we've covered in this series of owners' surveys. No one rig can satisfy everyone. But with 77 percent of the owners of ICOM 701s reporting that they would buy one again, it's clear that the ICOM people are doing something right. **ham radio**

National Semiconductor Clock Modules



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- 12VDC opt. instru.
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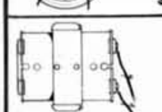
2¼" — 8 Ohm — .25 watt

A0201

$1.25 ea. 2/$1.95 ea. 10/$7.95 ea.



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- Aluminum Case
- 5" leads

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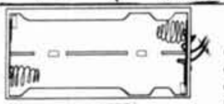
$ .45 each 10/$3.95



BH82721

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- Holds 4 ea. C cells
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JOYSTICKS

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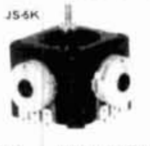

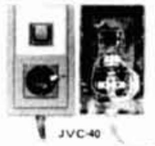

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- Uses MM5314 clock chip
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General Description: The JE215 is a Dual Power Supply with independent adjustable positive and negative output voltages. A separate adjustment for each of the supplies provides the user unlimited applications for IC current voltage requirements. The supply can also be used as a general all-purpose variable power supply.

FEATURES:
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- Power Output (each supply): 5VDC @ 500mA, 10VDC @ 750mA, 12VDC @ 500mA, and 15VDC @ 175mA.
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- 120VAC input
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(Picture not shown but similar in construction to above)

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M-CDP1802	User Manual	7.50
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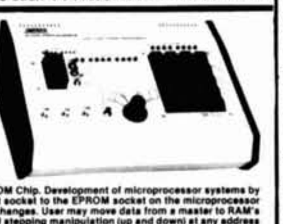
Typical Power Source	Operating Voltage Range	Voltage	No Load Speed RPM	No Load Current AMP	At Maximum Efficiency Speed RPM	At Maximum Efficiency Current AMP	At Maximum Efficiency Torque OZ IN	At Maximum Efficiency Output W	At Maximum Efficiency Eff %	Small Torque OZ IN
DRY CELL	1.5-6.0	3.0	9,200	0.20	6,750	0.90	0.260	1.30	57.0	0.97

.937 O.D. X 1.201 Length

MABUCHI RE280 $ .99 each . . .10/$7.50 . . .100/$50.00

JE608 PROGRAMMER
2704/2708 EPROM PROGRAMMER



GENERAL APPLICATIONS:
- To program EPROMS 2704 and 2708.
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- To compare EPROM(s) for content differences
- To emulate a programmed EPROM
- To store program in RAMS for alterations
- Three separate Display Registers: 8 LED's for Hex Key entries, 10 LED's (2^0-2^9) for Address Register and 8 LED's for Data Memory Register. The Data Memory Register displays the content of the RAMs from the EPROM Chip. Development of microprocessor systems by means of a ribbon cable from the programmer panel test socket to the EPROM socket on the microprocessor board. Rapid checking verification of programmed data changes. User may move data from a master to RAM's or write into RAM's with keyboard entries. Allows manual stepping manipulation (up and down) at any address location. Stand-alone EPROM Programmer consisting of: A 19-key Hexadecimal Keyboard assembly, Programmer Board assembly with 4 power supplies and a LED/Test Socket Panel Board assembly. The Test Socket is zero force insertion type. Power requirements: 115VAC, 60Hz, 6W. Compact desk-top enclosure: Color-coordinated designer's case with light tan panels and molded end pieces in mocha brown. Size: 3¼"H x 11"W x 8¾"D. Weight: 5 lbs.

The JE608 EPROM Programmer is a completely self-contained unit which is independent of computer control and requires no additional systems for its operations. The EPROM can be programmed from the Hexadecimal Keyboard or from a pre-programmed EPROM. The JE608 Programmer can emulate a programmed EPROM by the use of its internal RAM circuits. This will allow the user to test or pretest a program for a system, prior to programming a chip. Any changes in the program can be entered directly into the memory circuits with the Hexadecimal Keyboard so that rewriting the entire program will not be necessary. The JE608 Programmer contains a Programmer/Board w/25 IC's & includes power supplies of: -5V, +5V, +12V and +26V. The Hexadecimal Keyboard and LED/Test Socket Panel board are separate assemblies within the system.

JE608K Kit $399.95

JE608A Assembled and Tested $499.95

JE608-16K ADAPTER BOARD
FOR 2716/2758 EPROMS

GENERAL DESCRIPTION:
The JE608-16K Adapter Board allows the JE608 Programmer to be modified for the additional programming of the 2716 and 2758 EPROMS. The adapter provides for adding an address switch for the 2^{11} bit and also for selecting the proper power and timing pulses to be applied to the EPROM. Programming and emulating the 2716 (16K) EPROM is done separately to each half (1024x8) of the EPROM because of the existing 8K RAM capacity in the JE608 Programmer.

JE608-16K	Adapter Board Kit	$29.95
JE608-Upgrade	(Send assembled JE608 to factory for adapter installation of the JE608-16K Adapter Board Kit)	$99.95
JE608A-16K Mod.	Assembled JE608 w/Adapter (JE608-16K) Installed	$599.95

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30002	National Interface Data Book (704 pages) DP, DS8000, DS3600, DS75000, etc.	$5.95
30003	National Linear Data Book (1376 pages) LM, LF, ADC, DAC, LH Series	$7.95
30004	National Series 80 — Board Level Computer (224 pages)	$4.95
30005	National TTL Logic Data Book (624 pages) 7400, LS, L, H, S, and DM8000 Series	$6.95
30006S	Buy above (5) 30001,2,3,4,5 as a set	$24.95/lot
30009	Intersil Data Book (1074 pages)	$6.95
010400	Intel Component Data Catalog. Full data sheets for Intel's products incl. memory devices, microproc., peripherals & indust./mil. products (1328 pages)	$10.00
205610	Intel Peripheral Design Handbook. Full data sheets, appl. notes for Intel peripheral device components (644 pages)	$7.50

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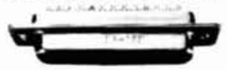
Ideal for use with clocks, games, power supplies or any other type of AC or DC application.

Part No.	Input	Output	Price
AC 250	117V/60Hz	12 VAC 250mA	$3.95
AC 500	117V/60Hz	12 VAC 500mA	$4.95
AC1000	117V/60Hz	12 VAC 1 amp	$5.95
AC1700	117V/60Hz	9 VAC 1.7 amp	$3.95
DV 9200	117V/60Hz	9 VDC 200mA	$3.25
DC 900	120V/60Hz	9 VDC 500mA	$3.95

CONNECTORS



DB25P	D-Subminiature Plug	$2.95
DB25S	D-Subminiature Socket	$3.50
D20418-2	Screw Lock Hdwr. (2) DB25S/P	2/$.99
DB51226	Cover for DB25P/S	$1.75
22/44SE	P.C. Edge (22/44 Pin)	$2.95
UG88/U	BNC Plug	$1.79
UG89/U	BNC Jack	$3.79
UG175/U	UHF Adapter	$ .49
SO239	UHF Panel Recp.	$1.29
PL258	UHF Adapter	$1.60
PL259	UHF Plug	$1.60
UG260/U	BNC Plug	$1.79
UG1094/U	BNC Bulkhead Recp.	$1.29

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16K Conversion Kit

Expand your 4K TRS-80 System to 16K.
Kit comes complete with:
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★ Documentation for Conversion

TRS-16K2	*150NS	$29.95
TRS-16K3	*200NS	$24.95
TRS-16K4	*250NS	$19.95

JE610 ASCII Encoded Keyboard Kit

The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with an industrial grade keyboard switch assembly (62 keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and −12V @ 10 mA for operation. Features: 60 keys generate the 126 characters, upper and lower case ASCII set. Fully buffered. Two user-define keys provided for custom applications. Caps lock for upper-case-only alpha characters. Utilizes a 2376 (40-pin) encoder read-only memory chip. Outputs directly compatible with TTL/DTL or MOS logic arrays. Easy interfacing with a 16-pin dip or 18-pin edge connector. Size: 3½"H x 14¾"W x 8¾"D

JE610/DTE-AK	(After assembled as pictured above)	$124.95
JE610 Kit	62-Key Keyboard, PC Board, & Components (no case)	$ 79.95
K62	62-Key Keyboard (Keyboard only)	$ 34.95
DTE-AK	(case only — 3¾"Hx11"Wx8¾"D)	$ 49.95

NEW! JE212 — Negative 12VDC Adapter Board Kit for JE610 ASCII KEYBOARD KIT
Provides -12VDC from incoming 5VDC . . $9.95

JE600 Hexadecimal Encoder Kit

FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD

The JE600 Encoder Keyboard Kit provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8-bit microprocessor or 8-bit memory circuits. Three additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with 9 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Three user-define keys with one being bistable operation. Debounce circuit provided for all 19 keys. 9 LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation. Size: 3½"H x 8¾"W x 8¾"D

JE600/DTE-HK	(After assembled as pictured above)	$99.95
JE600 Kit	19-Key Hexadec. Keyboard, PC Board & Cmpnts. (no case)	$59.95
K19	19-Key Keyboard (Keyboard only)	$14.95
DTE-HK	(case only — 3½"Hx8¾"Wx8¾"D)	$44.95

SWR meter
for the high-frequency bands

An easy-to-build SWR meter for beginner or old hand

The SWR meter, or standing wave ratio meter, is a small, self-contained device that provides an indication of the match — or degree of mismatch — between your transmitter and antenna system. The unit described here covers the high-frequency bands (80 through 10 meters) and is designed to operate with 50-ohm coaxial feedline, such as the popular RG-8 and RG-58 coaxial cable used in many Amateur installations. The sensitivity is such that it will operate well with most of today's transceivers in the 100+ watt class, and the unit can be left in the line for continuous monitoring of the system performance.

For ease of operation, two meters are employed in the design, thus allowing simultaneous readings of both the transmitter output and the reflected voltage without switching. A single control, used for calibration, is the only operator control on the SWR meter.

This SWR meter is ideal for the first-time builder, or for the casual builder who does not have a lot of special tools at his disposal. Common hand tools and a drill are about all that are required for the project. The construction is easy and the component count is low. The parts cost is also low. The completed unit measures 5 inches wide by 6 inches deep by 3 inches high (13 x 15 x 8 cm).

the circuit

The circuit of the SWR meter, as shown in **fig. 1**, has been in use among the Amateur community for many years and has been constructed in many different forms. The rf signal from the transmitter is applied to the SWR meter via the input jack J1. From J1, the signal travels along the coaxial-cable center conductor to the output jack J2, where it exits the metering package for the antenna feedline. Within

By Ken Powell, WB6AFT, 6949 Lenwood Way, San Jose, California 95120

the metering package we try to maintain the 50-ohm characteristics of the overall system, so as not to make the meter look like a "bump" or mismatch in the feedline system.

The two sense lines which parallel the coaxial-cable center conductor pick up a small portion of the rf signal, and this bit of the signal is rectified, filtered, and applied to the meters for monitoring purposes. Germanium diode CR1 and its associated sense line will pick up the incident or forward signal, rectify it, filter it with capacitor C1, and display the magnitude of this signal on the forward meter, M1. In a like manner, CR2 and its associated sense line will sample the reflected or reverse signal and present its magnitude on the reflected meter, M2. The sense lines and their associated circuits are identical but arranged in such a manner as to read the sampled voltage developed in the cable assembly in opposite directions. The use of two meters allows us to measure both of these samplings at the same time without the need for switching.

The calibration control R1/R2, which is a dual potentiometer, is used to maintain both metering circuits at the same level of sensitivity. This is necessary since the relationship of the forward and reflected meters must be constant. In use, the transmitter is keyed and the calibration control adjusted for a full scale reading on the forward meter. This adjustment of the control will set the same level of sensitivity on both meters, and the SWR, or percentage of reflected voltage, can be read directly on the reflected meter. The reflected reading represents the portion of rf voltage that has been applied to the feedline but has been reflected back from the antenna system due to mismatch.

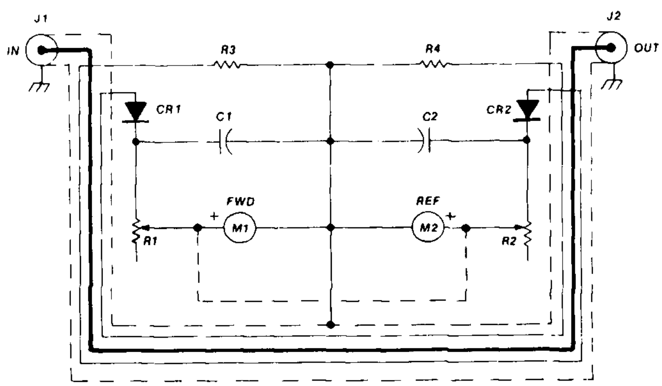
The setting of the calibration control will differ from band to band, because this type of sampling circuit is very sensitive to frequency and the rectified output will increase as the frequency of operation is increased. A few watts of rf will provide full-scale deflection of the forward meter on the 10-meter band, while approximately 60 watts will be required for full-scale deflection on the 80-meter band. This makes the circuit a natural for today's transceivers but makes it impractical for QRP rigs.

construction

The construction of the SWR meter makes it ideal for the first-time builder. The values of the components used are not overly critical, nor can they be damaged as easily as solid-state devices. The rf circuits are sometimes critical, but the SWR meter allows quite a bit of leeway in construction. Standard hand tools and a drill will get you started and, as the case specified in the parts list is made of a soft-grade of aluminum, the mechanical portion of the project is quite easy. A bit of filing is necessary for the rectangular meter cut-outs, but the remainder of the sheet-metal work is accomplished with a drill. I did a bit of sanding and painting on the unit pictured, but that's not essential.

The heart of the SWR meter is the coaxial-cable sampling assembly, illustrated in **fig. 2**. This cable assembly is formed with RG-58/U coaxial cable, and the completed dimensions for the assembly are shown in the illustration. Begin construction of the assembly with the 24-inch (61-cm) length of coax; we will trim it down to size as construction progresses. Remove the entire outside jacket of the coax by cutting it the long way with a hobby knife. With the outside jacket removed, expand the diameter of the shield (braid) slightly by pushing the braid toward the center from each end. This slight expansion of the shield will aid in the easy removal of the center conductor complete with its insulation.

Using No. 24 or No. 22 AWG (0.5 or 0.6 mm) solid wire, cut two lengths approximately 24 inches (61 cm) in length to form the sense wires. Two different colors should be used to aid in identification. Cut the coax braid to a length of 16 inches (41 cm) and insert

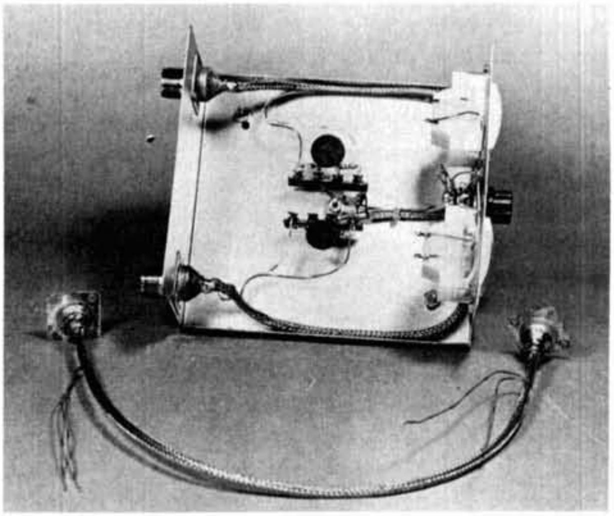


C1, C2	0.005-μF disc capacitors
CR1, CR2	1N34A diodes
J1, J2	UHF connector SO-239 and Hood UG-177/U Amphenol No. 83-1R and 83-765
M1, M2	200-μA meters, Calectro No. D1-907
R1, R2	dual potentiometer, 100 kilohm, Radio Shack No. 271-224
R3, R4	51-ohm carbon resistors
case	5¼x3x6 inches (13.3x7.6x15.2 cm) Radio Shack No. 270-253
knob	0.750x¼ shaft diameter Radio Shack No. 274-415
misc.	wire, solder lugs, small hardware, lettering material

A kit is available from RADIOKIT, Box 411, Greenville, NH 03048-0411.

fig. 1. Schematic diagram for the SWR meter.

the two sense lines into the braid, leaving an equal amount of wire protruding from each end. Bend the excess length of the sense wires over the ends of the braid so the sense wires will not fall out. Now, feed the coax center conductor back into the braid with the sense wires installed. It is easy to manipulate the diameter of the braid by compressing it along its length, and the center conductor should reinstall easily.



Interior of the SWR meter showing component layout. The sampling assembly (foreground) was made from RG-58/U coaxial cable.

After the center conductor is in place, stretch the braid to its normal length to restore it to its original diameter, making it look like a 50-ohm device again. This operation should leave an ample amount of the center conductor and sense line exposed at each end of the braid. The assembly should now begin to resemble that of **fig. 2**.

With a hobby knife or awl, start a small hole in the braid approximately 1 ½ inches (40 mm) from the end of the braid. To form this opening in the braid, don't cut the braid but rather start an opening where the braid windings intersect and expand the size of this opening by compressing the braid from the end. Now manipulate the sense wires within the braid until the ends of the sense wires are visible through the hole in the braid. Fish the sense lines out of the braid through the hole and leave approximately 4 inches (10 cm) of the sense line exposed, as in **fig. 2**. Fold the sense lines back so they are not pulled out of the assembly accidentally.

The hood, a UG-177/U fitting, can now be soldered to the coaxial cable braid. Prior to soldering the hood, pull the cable center conductor back toward the other end of the cable for a distance of 2 inches (5 cm) or so. In this manner, if the center conductor insulation gets a bit warm during the soldering operation the damaged portion can be cut from the cable when it is fitted to the UHF connector. When you have finished the first end of the cable assembly, the sense lines and the hood can be completed similarly for the other end of the coax assembly. When the assembly is complete, stretch the braid out again to restore the original diameter and check the assembly against **fig. 2**. If it is reasonably close, you can put it aside and start on the case.

the case

If you use the case shown in the parts list, or one of similar dimensions, you can follow the general layout seen in the photo. The front panel requires two rectangular cut-outs be made for the meters and a single hole for the calibration control. The rear panel requires holes for the UHF connectors, and a single hole is needed for mounting the two solder lugs that support the diodes, resistors, and capacitors that form the metering circuit. After you've checked all the case-mounted components to make sure they'll fit, the case may be sanded lightly with 320 paper and a couple of coats of spray lacquer applied. While the case is drying we can do a little modification on the two meters.

the meters

The meter assemblies are held together with transparent tape and can be disassembled easily. The meter scales are held in place by two tabs that are parts of the meter face. These two tabs may be straightened out and the meter faces removed for modification. Gently flatten the meter face out and,

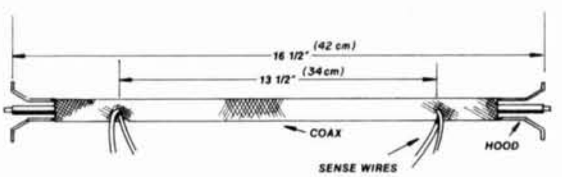


fig. 2. Coaxial assembly with sense wires.

using a typewriter eraser, remove all the printed words from the meter faces, leaving only the scales, which consist of 20 divisions.

Using rub-on lettering, modify the meter faces as in **fig. 3**. The lettering kit used for this purpose was Letraset K19/5, which is a meter lettering set containing both red and black materials. All the lettering on the SWR meter was done in black with the exception of the horizontal line on the reflected meter that extends from the center of the meter scale to the right edge, or full scale position. This was done in red to remind me to keep things in the system under 3:1. When the meter scales are complete, a light coating of clear spray will lend a professional finish to them. After they have dried, the scales can be reinstalled on the meters and the assemblies held in place with transparent tape.

The front and rear panels can now be lettered with rub-ons, and, if desired, the racing stripes may be added by using *Prestape*, available at art supply stores. A coating of clear spray will protect the lettering and level out the finish on the case. I mounted the meters to the case with a dab of epoxy at each of the two mounting ears, to avoid more holes on the front panel. After components have been mounted to the case, the wiring should be completed as in the schematic diagram. The photo of the interior of the unit will assist you with wire routing and general layout. The center conductor of the coax is trimmed to size and wired to the UHF connectors; the hoods are put in place using the UHF connector mounting hardware.

As shown in the diagram, the common, or ground

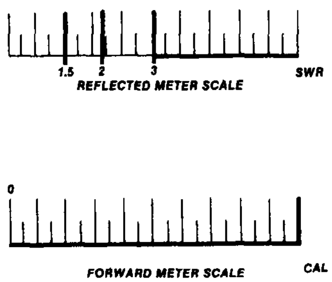


fig. 3. Modified meter scales.

portion, of the circuit is connected to the shield of the coaxial cable assembly at the approximate center of the assembly. In turn, the cable assembly is connected to case-ground via the hood assemblies at the UHF connectors. These are the only connections to the case of the SWR meter. When the wiring has been completed, the case can be closed, the calibration knob installed, and the unit is ready for testing.

testing and use

To test the SWR meter, connect your transmitter output to J1 using 50-ohm coaxial cable. The antenna feedline is connected to J2. Key the transmitter and adjust the calibration control for a full-scale reading on the forward meter. Note the SWR reading on the reflected meter at this time. Next, transpose the input and output leads on the SWR meter. Now the transmitter will be feeding the output jack J2, and the antenna system will be connected to J1. If the sense lines and their associated circuits are working well, the readings on the two meters will be transposed. The reading noted on the reflected meter will now be displayed on the forward meter. If this condition approximates your results, both the sampling circuits have the same sensitivity and the input and out cables can be returned to their normal positions. The SWR meter is now ready to go to work on your antenna systems, checking operation of the system and assisting you in tuning the system to your favorite spot on the band.

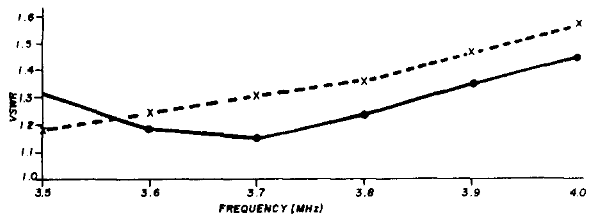


fig. 4. SWR readings for 80-meter band.

I made the graph in **fig. 4** for checking the operation of my 80-meter dipole antenna. Initially, the lowest SWR reading was found at the lower limit of the band and the SWR increased with frequency. This indicated that the dipole elements were a bit too long and a little pruning eventually led to the second reading indicated by the solid line in **fig. 4**. Now the resonant point is at 3.7 MHz and the SWR is well within reason on both the CW and phone segments of the band. Remember, if resonance is at the high end of the band the antenna elements are short; resonance at the low end means elements are long. In this manner, you can really get a good idea of what your system is doing and get things tuned for the highest efficiency. In tuning a multiband antenna system, such as a trap dipole, start with the highest frequency band and work your way down in frequency. Once you are satisfied that the antenna system is working well, the SWR meter can be left in the line if desired to provide a constant indication of transmitter output and antenna resonance.

In conclusion I would say that the SWR meter is a good project for the newcomer or the old-timer getting back into the swing of home brew, and, while I would not call it a lab instrument or anything even close, it is a handy device for keeping your antenna system humming.

ham radio

locating geostationary satellites

Calculator program for solving basic equations

Satellite tracking is becoming very much a part of Amateur Radio. The OSCAR program is alive and well. AMSAT is strong. The future for the Amateur space community looks good. A geostationary Amateur satellite, tentatively named SYNCART (for SYNchronous Canadian Amateur Radio Transponder), is in the works. This spacecraft, which is on the drawing board, will be launched into geosynchronous orbit. This means that SYNCART will be at an altitude of about 22,500 miles (36,225 km) and will be on station over the equator.

This article provides information for locating *any* geostationary satellite, given basic geometric data, using a popular handheld calculator. **Editor.**

By using an inexpensive calculator, such as the Texas Instruments TI58 (or TI59), the look angle (relative to true north) and elevation angle may be determined easily from any point on the globe to any geostationary (fixed) satellite. The only requirements are that the latitude and longitude of the earth station must be known, and the longitude of the satellite must be known. (They are listed later in this article.)

The program takes eight minutes to load and check; fifteen seconds to run. The results, relative to true north, may be used directly or put in terms of magnetic north through correlation with the declination angle, as shown on topographical maps.

basic equations

The calculator program uses the following basic equations:

$$Az^\circ = 180 + \tan^{-1}\left(\frac{\tan\theta}{\sin\alpha}\right) \quad (1)$$

where Az° is the look angle of the earth station relative to true north (azimuth)

θ is the relative longitude between the earth station and the satellite (earth-station longitude-satellite longitude)

α is the earth-station latitude

$$El^\circ = 90 - T - R \quad (2)$$

where El° is the elevation angle looking at the satellite, and

$$R = \cos^{-1}(\cos\theta\cos\alpha)$$

$$T = \tan^{-1}\left(\frac{\sin R}{6.6166 - \cos R}\right)$$

running the program

After the program has been entered into the calculator, data may be entered and the equations solved:

Earth-station latitude (in degrees, minutes, seconds): **STO 00.**

Earth-station longitude (in degrees, minutes, seconds): **STO 01.**

By Walter E. Pfiester, Jr., W2TQK, 1 Skadden Terrace, Tully, New York 13159

program

key		step	code	comments
LRN	RCL	000	43	
	02		02	spacecraft longitude
	–		75	
	RCL		43	
	01		01	earth-station longitude in DMS
2ND	DMS		88	earth station in decimal
	=		95	
	STO		42	
	05		05	
2ND	TAN		30	
	÷	010	55	
	RCL		43	
	00		00	earth-station latitude in DMS
2ND	DMS		88	earth station latitude in decimal
	STO		42	
	06		06	latitude stored
2ND	SIN		38	
	=		95	
	INV		22	
2ND	TAN		30	
	+	020	85	
	1		01	
	8		08	
	0		00	
	=		95	
	STO		42	
	03		03	
	R/S		91	*azimuth relative to true north* (answer)
	RCL		43	
	05		05	

key		step	code	comments
2ND	COS	030	39	
	X		05	
	RCL		43	
	06		06	
2ND	COS		39	
	)		54	
	INV		22	
2ND	COS		39	
	STO		42	
	07		07	
2ND	SIN	040	38	
	÷		55	
	(		53	
	6		06	
	•		93	
	6		06	
	1		01	
	6		06	
	6		06	
	–		75	
	RCL	050	43	
	07		07	
2ND	COS		39	
	)		54	
	)		54	
	INV		22	
2ND	TAN		30	
	+/–		94	
	–		75	
	RCL		43	
	07	060	07	
	+		85	
	9		09	
	0		00	
STO	=		95	
	04		42	
	R/S		04	end of program, elevation (answer)
	LRN	067	91	brings calculator out of program mode

Spacecraft longitude (in decimal form): **STO 02.** Then, reset the program: **RST R/S** calculates antenna azimuth relative to true north. Pushing the **R/S** button a second time results in the antenna elevation.

example

42.48	04	**STO 00**	
76.06	37	**STO 01**	
135.0		**STO 02**	*(location of* RCA SATCOM 1)
RST R/S		247.704° azimuth: **R/S** 13.839° elevation	

Should the answer for elevation angles be negative, the satellite is below the horizon and is not in a position to be viewed by the earth station.

additional program notes

For locations south of the equator, change the following program steps: 21, 22, 23 from 180 to 360.

register notes:

register	use
00	earth-station latitude
01	earth-station longitude
02	spacecraft longitude
03	azimuth
04	elevation
05	del longitude (used later)
06	earth-station latitude, later reused, scratch-pad memory

For satellites located at east longitude, enter as a negative number (–) in register 02. No other program changes need be made.

locations of nonmilitary geostationary satellites

satellite	location (degrees east longitude)
GOES 2	0-35
OTS	10
RADUGA 3	35
RADUGA 4	35
SYMPHONIE 2	49
INTELSAT IV F5	57
INTELSAT IVA F3	60.2
INTELSAT III F3	65.3
MARISAT	73
PALAPA 2	77
RADUGA 2	80
RADUGA 1	80
INDOSAT	80
PALAPA 2	83
MOLNIYA 1S	90
EKRAN 1	99
EKRAN 2	99
KIKU 2	135
HIMAWARI	140
INTELSAT IV F8	174
INTELSAT IV F4	179
MARISAT 1	176.5
METEOSAT	0
INTELSAT IV F7	1
INTELSAT IV F7	6.4
SYMPHONIE I	11.5
STATIONAIR 4	14
MARISAT II	15
SIRIO	15
INTELSAT IV F1	18.5
INTELSAT IV F3	21.7
INTELSAT IVA F1	24.5
INTELSAT IVA F4	34.5
ATS 5	70
SMS 2	75
GOES 2	75
WESTAR V	79
WESTAR III	91
COMSTAR D2	95
WESTAR 1	99
ANIK III	103
SMS 1	105
ATS 3	105.6
ANIK II	109
ANIK IV	109
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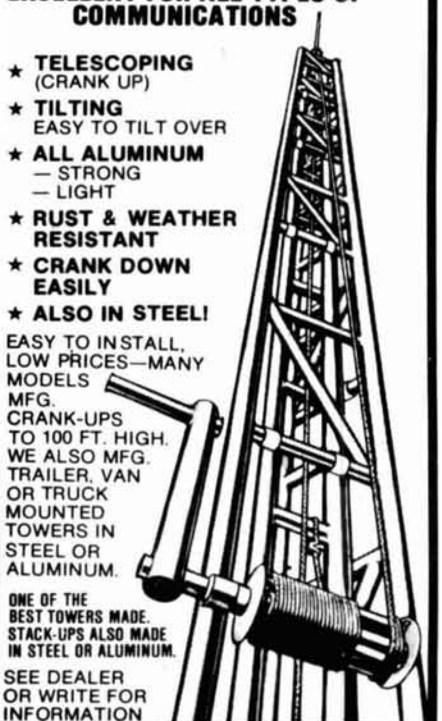

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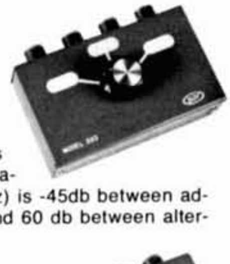

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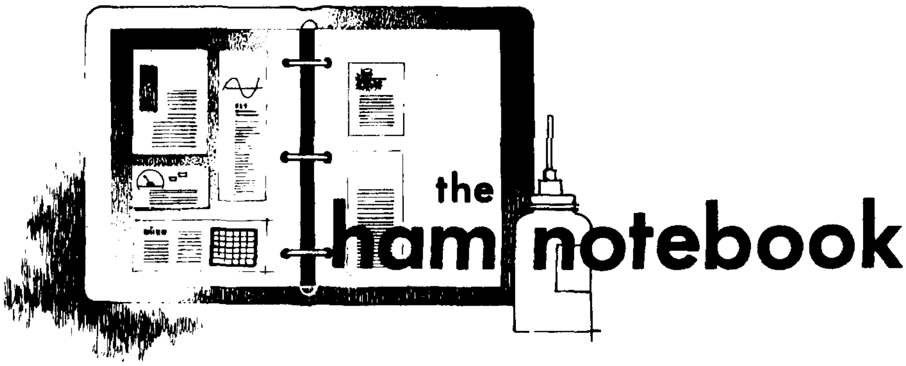

a "free" RTTY tuning indicator

A free lunch may be hard to come by, but here's a trick for getting a simple tuning indicator on a radioteletype demodulator without any increase in the parts count.

As shown in **fig. 1**, in my RTTY terminal unit I use a conventional active filter tuned midway between the mark and space frequencies, and a diode clipper to limit the signal. The unconventional part is the use of LEDs instead of ordinary diodes for the clipper. One of the LEDs is mounted on the front panel of the terminal unit where it can be seen as the receiver is tuned.

As the receiver is adjusted to produce the desired 2125- and 2295-Hz tones from an FSK signal, the LED will start to flicker as the correct adjustment is approached. When the two tones straddle the peak frequency of the filter the LED will appear to be steadily lit. Any drift in the receiver or transmitter will be revealed by the reappearance of flickering. The human eye is quite sensitive to the flicker that results from normal Amateur baud rates, and this is a surprisingly effective aid to tuning. Of course, selective fading will also cause the LED to flicker, but one can quickly learn to use both eyes and ears to interpret what is happening.

By using LEDs to limit the RTTY signal after it passes through a 2210-Hz bandpass filter, the limiting action is made visible, and proper tuning is indicated by minimum flicker. Proper action depends on a relatively broad filter response, so component values are not critical. Those shown were what were available and close to calculated values. The first section of the filter shown here is a 2000-Hz highpass filter to increase the rejection of lower audio frequencies; the idea described here will work without this section, but the system will be more vulnerable to interference.

A.S. Woodhull, N1AW

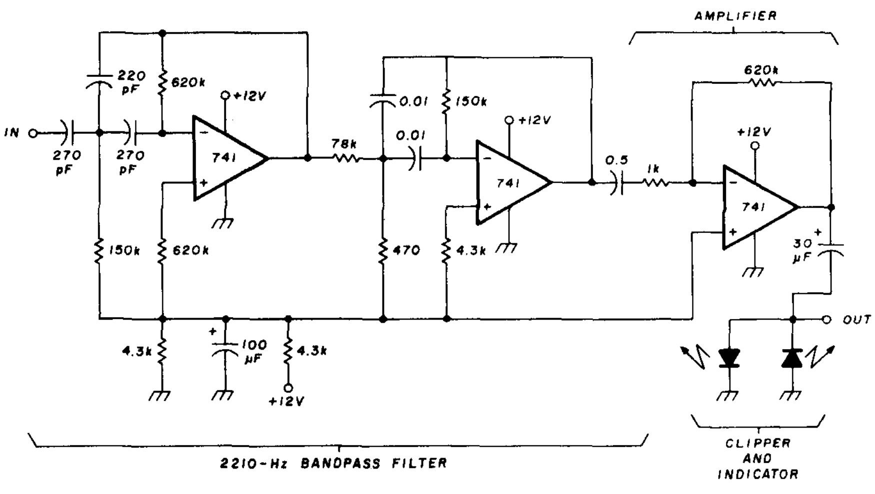

fig. 1. Diagram for RTTY tuning indicator.

light-bulb dummy loads

Light-bulb dummy loads have been used for transmitter testing since the beginning of Amateur Radio. Light bulbs can harmlessly dissipate lots of rf power, and they give a visual indication of approximate power output.

But, as dummy loads, they have two major shortcomings: they are inductive, and their resistance depends on the power level. When checked with an ohmmeter, the cold resistance will usually measure less than 1/10 the full-brilliance resistance. The inductance of a typical 100-watt, 120-

volt bulb is in the vicinity of 1/2 microhenry. At any given frequency this inductance can be tuned out by series resonating it with a capacitor of equal reactance.

Fig. 2 shows an experimental 200-

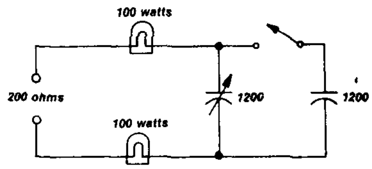

fig. 2. The 1200-pF variable is a three-gang, 400 pF-per-section unit with the stators connected in parallel.

watt, 200-ohm balanced dummy load used to test a 4:1 flyback balun. By adjusting the series capacitor and power level it was possible to obtain a 1:1 SWR on any band, 80 through 10 meters. Theoretically, the bulb resistance should be 288 ohms at full brilliance, which would be an SWR of 1.44 on 50-ohm coax when measured through a 4:1 balun. This, in fact, is what it measured. An SWR of 1.0 was observed at about the 100-watt level, and remained below 1.4 from 50-200 watts.

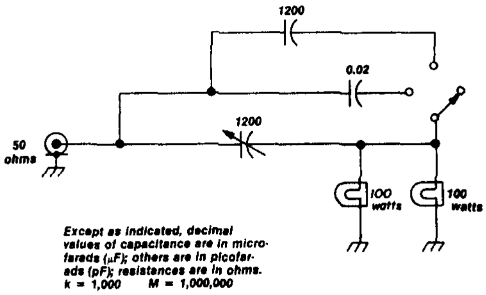

fig. 3. The 1200-pF variable is the same as in fig. 1. The switch is a three-position rotary type.

Fig. 3 shows a 50-ohm version of this load, usable from 50-200 watts on all bands, with an SWR below 1.4.

Series and parallel combinations of light bulbs of suitable wattage ratings can be combined to construct a dummy load of any power capacity with the low SWR so long as the inductive reactance is tuned out with a series capacitor.

Fredrick W. Brown, Jr., W6HPH

dipole antenna length reference chart

Here's a handy reference chart if you're thinking about putting up a dipole for one of the new or old ham bands. Using the formula *L (feet) = 468/f (MHz)*, the length will be correct for practical purposes, and you can prune the antenna later if necessary.

frequency (kHz)	length ft.	in.
	(ft. × 0.305 = meters)	
1,800	260	0
1,820	257	1
1,850	252	11
1,875	249	6
1,900	246	4
2,000	234	0
3,500	133	8
3,600	130	0
3,700	126	6
3,800	123	0
3,900	120	0
4,000	117	0
7,000	66	10
7,050	66	5
7,100	66	0
7,150	65	6
7,200	65	0
7,250	64	7
7,300	64	1
10,000	46	10
10,100	46	1
10,200	45	11
10,300	45	5
10,400	45	0
10,500	44	7
14,000	33	5
14,100	33	2
14,200	32	11
14,300	32	8
21,000	22	4
21,100	22	1
21,200	22	0
21,300	21	11
21,400	21	10
24,500	19	1
24,600	19	0
24,700	18	11
24,800	18	10
24,900	18	9
25,000	18	8
28,000	16	8
28,100	16	7
28,200	16	6½
28,300	16	6
28,400	16	5½
28,500	16	5
28,600	16	4
28,700	16	3½
28,800	16	3
28,900	16	2½
29,000	16	2
29,100	16	1

Many of the new transceivers now have all of the new band crystals installed. You might as well be listening to shortwave broadcasts with a dipole antenna and using the positions until the bands open!

Ed Marriner, W6XM

data retrieval program using the APPLE II computer

One day I was talking to KN5KSQ on 40 meters and he mentioned that we had worked each other once before. I scanned my log quickly but couldn't find KN5KSQ. Then the band went out before I could get more specific information.

Haunted by the fact that we had worked before, I started searching through my logs and lo and behold! There it was: one of my first contacts.

I pondered the situation and stared at my station, which included an APPLE II computer with a tape recorder. I decided I needed a data-retrieval program that's short (for maximum RAM storage), provides fast search of two or three fields, prints all items on the monitor in an easy-to-read format, and provides easy data entry. I found such a program and revised it to run on disk or tape. I now have a disk drive and use the APPLE II for log-data retrieval as well as send/receive SSTV, CW, RTTY, and ASCII — all done with software provided by C.H. Galfo, WB4JMD.

I have over 650 log entries, and it takes about 28 seconds to search all of them. The program is set up to hold 1000 entries or less, depending on RAM size, and the program can be easily modified to suit your needs. I'll be glad to supply a copy of the program. Send a self-addressed stamped envelope with 28¢ postage to WB6YHS, 1220 Vienna Drive, No. 715, Sunnyvale, California 94086.

It's nice to have the capability of quickly finding data on former radio contacts. Another use of the APPLE II!

Charles M. George, WB6YHS

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COLLINS mechanical filters, 455 kHz center freq., 6 kHz BW, Collins P/N 526-9522-001, unused in box $5.00 each. Dave Wells, KD6TC, P.O. Box 27373, Oakland, CA 94602.

WANTED: Help in completing the largest collection of Hallicrafter equipment in the world. Urgently needed are receivers with aluminum colored panels, back lighted plastic dials with "airplane" hands, early transmitters, unusual accessories, etc. Chuck Dachis, WD5EOG, "The Hallicrafter Collector," 4500 Russell Drive, Austin, Texas 78745.

FOR SALE: Kenwood TS-820S new finals, excellent condition, headset with attached boom mic, phone patch all $895. Heath IG-18 sine and square $120. I ship. Certified check or money order. Bruce Bierman, WA8SJC, 7534 Mayfield, Chesterland, OH 44026. (216) 729-4643.

RECIPROCATING DETECTOR Construction Handbook. $10 ppd. Peters Publications, P.O. Box 62, Lincoln, MA 01773.

COLLINS mechanical filters for sale F500Y08 (800 Hz BW) $50.00 each, new in boxes. Also have other frequencies and bandwidths: 455, 250, 200, down to 64 kHz. Hank Olson, P.O. Box 339, Menlo Park, CA 94025.

ELECTRONIC BARGAINS, CLOSEOUTS, SURPLUS! Parts, equipment, stereo, industrial, educational. Amazing values! Fascinating items unavailable in stores or catalogs anywhere. Unusual FREE catalog. ETCO-012, Box 762, Plattsburgh, NY 12901. SURPLUS WANTED.

HAM RADIO REPAIR, experienced, reasonable, commercial licensed. Robert Hall Electronics, P.O. Box 8363, San Francisco, CA 94128. W6BSH, (408) 292-6000.

KEYER PADDLES, iambic, more features, better action. Kits available. $15.00 up. Write Earl Snyder, 213 W. Davis, Sapulpa, OK 74066.

DX QSL manager volunteer, Duane E. Traver, KA3BTG, P.O. Box 141, Dushore, PA 18614.

AMATEUR RADIO REPAIR — Professional service, reasonable rates, ALL BRANDS. Official KDK after warranty repair center. Amateur Radio Repair Center of IEC, Inc., 1020 Brookstown Avenue, Winston-Salem, NC 27101. (919) 725-7500.

490T ANTENNA TUNING UNIT WANTED for cash or trade. DCO, 10 Schuyler Avenue, No. Arlington, NJ 07032. (800) 526-1270.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature, Estes Engineering, 930 Marine Dr., Port Angeles, WA 98362.

HX 1681, HR1680, PS23 Heath Twins EC asking $360.00, Globe Chief 90A, Clegg 22'er, AMECO 621 VFO, Kantronics Freedom VFO (80 & 40) — all best offer. Pete, WA2ROF, (201) 236-6108.

WANTED: Government Surplus radar equipment, microwave equipment and "old" General Radio test equipment. P. J. Plishner, 2 Lake Avenue Extension, Danbury, CT 06810 WA1LDU.

TUBES, TUBES wanted for cash or trade: 340TL, 4CX1000, SCX1500. Any high power or special purpose tubes of Eimac/Varian. DCO, 10 Schuyler Avenue, No. Arlington, NJ 07032. (800) 526-1270.

HALLICRAFTERS HT-40 transmitter and Globe 755 vfo for sale. Jon Titus, KA4QVK, Box 242, Blacksburg, VA 24060. (703) 951-2684.

ANTIQUE SPY RADIO SET. Good condition. RR-6A receiver. RT-6 transmitter. Power supply and converter. Best offer. John Pankow, Box 86, Chiefland, FL 32626.

NEEDED: Western Electric and Bell System manuals on residential telephones and accessories, including model 500, Trimline, Touch-A-Matic S, speakerfone, jacks, wiring, installation procedures, etc. C. Sarver, 256 West 88th St., New York, NY 10024. 212-874-3529.

FT-101E, fan, three filters SSB, 600, 250 installed. Includes spare tubes (originals ok), free UPS shipping. $675 firm. John Skubick, 791 - 106 Ave., Naples, FL 33940.

ETCH IT YOURSELF PRINTED CIRCUIT KIT, Photo-Positive Method — No darkroom required, All the supplies for making your own boards, direct from magazine article in less than 2 hours. Only $24.95, S.A.S.E. for details: Excel Circuits Co., 4412 Fernlee, Royal Oak, MI 48073.

FOR SALE: Kenwood TS-120S, absolutely mint, $495; Kenwood TS-180S, w/DFC and Dual IF Filters, excellent, $725; Hammurlund HQ-170AC-VHF, 160m-2m, clock, $135; MFJ-752 SSB/cw Superfilter, mint $50; Heathkit Q-multiplier, $15; Motorola VHFm Walkietalkie #H13-1AL, $25; TCS-12 receiver, $18. WA7ZYQ, 208-245-2070. 238 - 10th, St. Maries, ID 83861.

MIRROR-IN-THE-LID, and other pre-1946 television set wanted. Paying 500+ for any complete RCA "TRK" series, or General Electric "HM" series set. Also looking for 12AP4, MW-31-3 picture tubes, parts, literature on pre-war television. Arnold Chase, WA1RYZ, 9 Rushleigh Road, West Hartford, Conn. 06117 (203) 521-5280.

HELP WANTED SPARE TIME. UHF RF power devices PC boards design. Commtele, 9625 Catlett, La Porte, TX 77571.

PRINTED CIRCUIT BOARDS: From $0.25 to $0.40 per square inch with your negative. Free estimates. Communications Design, Inc. 1105 Lehr, West Memphis, AR 72301.

SWAN 350c 10-80 meters with power supply and speaker. Very good condition, $250. I ship UPS. Paul, WA8PJK, 1146 East 76th, Cleveland, Ohio 44103. (216) 391-0241.

MUSEUM for radio historians and collectors now open. Free admission. Old amateur (W2AN) and commercial station exhibits, 1925 store and telegraph displays. 15,000 items. Write for details. Antique Wireless Assn., Holcomb, NY 14469.

62S1 FOR SALE. Anyone wanting to complete his S-line. J. Darmento/W4SXK, Rt. 3, Box 930C, Merritt Island, FL 32952.

WANTED: AN-MS connectors, synchros, etc. Send list, Bill Williams, P.O. 7057, Norfolk, Virginia 23509.

2 SINGER-GERTSCH FM-7, 2 Motorola T1020A frequency/deviation meters, cables & manuals. Cover 20-1000 MHz. 0.0001% accuracy. AM/FM modulation. $300 each. Technical Enterprises, 21851 Newland #244, Huntington Beach, CA 92646. (714) 960-2169.

WANTED: Micor and Master II base stations, 406-420 MHz. Any solid state 2 and 6 GHz microwave equipment, AK7B, 4 Ajax Place, Berkeley, CA 94708.

COAXPROBE — In-Line Coaxial RF probe for frequency counters and oscilloscopes. Monitor your transmitted signal directly from the coax line with the CoaxProbe RF Sampler. The Coax-Probe provides .3-1.8 volts output from 1 to 2000 watts with 3000 volts of isolation for your equipment. Connect the CoaxProbe into your transmis-

More Details? CHECK—OFF Page 94

sion line and connect frequency counter or oscilloscope to the output jack to monitor frequency or waveform. Insertion loss is less than .2 dB. Usable to 450 MHz. Over 2000 sold to satisfied amateurs throughout the world. Send $9.95 plus $1.50 shipping to Eagle Electronics, Box 426, Portage, MI 49081. Satisfaction guaranteed.

SATELLITE TELEVISION...HOWARD/COLEMAN boards to build your own receiver. For more information write: Robert Coleman, Rt. 3, Box 58-AHR, Travelers Rest, SC 29690.

TEN-TEC Century 21/570, matching 670 keyer, 276 calibrator, 277 tuner, all manuals, low hours, clean. $300 UPS, 10% off if pick up. Schere, 115 E 87 Street, New York, NY 10028. (212) 289-2368.

MAKE HAM RADIO FUN! Supplement your learning programs with a motivational hypnosis cassette. Tape #3, Learning the Code; Tape #4, Breaking the Speed Barrier; Tape #7, Electronic Theory. Free catalog. For tapes, $10.95 each to Gem Publishing, 3306 North 6th St., Coeur d-Alene, ID 83814.

VERY in-ter-est-ing! Next 5 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60187.

CB TO 10 METER PROFESSIONALS: Your rig or buy ours — AM/SSB/CW. Certified Communications, 4138 So. Ferris, Fremont, Michigan 49412; (616) 924-4561.

NEED HELP for your Novice or General ticket? Recorded audio-visual theory instruction. No electronic background required. Free information. Amateur License, P.O. Box 6015, Norfolk, VA 23508.

CASH for December 1915 to June 1920 QST's for personal collection. Kenn Miller, K6IR, 16904 George Washington, Rockville, Maryland 20853 (301) 774-7709.

HAMS FOR CHRIST — Reach other Hams with a Gospel Tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

FREE SAMPLE Ham Radio Insider Newsletter! Send large S.A.S.E.. W5YI, Box #10101-H, Dallas, Texas 75207.

BUY-SELL-TRADE Send $1.00 for catalog. Give name address and call letters. Complete stock of major brands new and reconditioned amateur radio equipment. Call for best deals. We buy Collins, Drake, Swan, etc. Associated Radio, 8012 Conser, Overland Park, KS 66204. (913) 381-5900.

Coming Events
ACTIVITIES
"Places to go..."

CONNECTICUT: The SCRAMS and Tri-City Amateur Radio Clubs of Groton are co-sponsoring an auction, Saturday, October 24, 10 to 4, St. Mary's Parish Hall, Groton. Talk-in on 07/67 or 34/94. Admission free. 10% of proceeds to be donated to the two radio clubs. For further information: Anne Hibbert, WB1GVL, 64 Giant's Neck Road, Niantic, CT 06357. (203) 739-4970.

INDIANA: The Hoosier Hills Ham Club's annual Hamfest, Sunday, October 11, Lawrence County 4-H Fairgrounds, just south of Bedford. Refreshments, flea market, door prizes, vendors, free camping available. Grand prize: Azden PCS-3000. Raffle prize: TRS 80 Mod. III 4KL1 computer. Admission: $3.00. Talk-in W9QYQ, 146.13/73. For further information: HHHC, P.O. Box 891, Bedford, IN 47421.

MASSACHUSETTS: The Framingham Amateur Radio Association's 6th annual Fall Flea Market, Sunday, October 25, Framingham Police Station drill shed. New England's largest indoor Ham Flea Market. Doors open 10:00 AM. Sellers setup 8:00 AM. Admission: $1.00. Sellers $8/table prior to October 15; $10/table after October 15. Talk-in on 75/15 and 52 direct. Contact: Ron Egalka, K1YHM, 3 Driscoll Drive, Framingham, MA 01701. (617) 877-4520.

MASSACHUSETTS: The Wellesley Amateur Radio Society's tailgate flea market, Saturday, October 10, 9 AM, Wellesley High School, 50 Rice Street, Wellesley Hills, off Route 16. Admission: $1.00 per person, buying or selling. Talk-in on 147.63/03. For information: Nels Anderson, K1UR, (617) 323-5029.

NEW YORK: The TuBoro ARC will hold a mini Flea Market and Auction, Sunday, October 28, 9 AM to 4 PM, Odd Fellows Hall, 149-14 - 14th Avenue, Whitestone. Admission: $1.00 donation. For information and table space: Marty (212) 359-6923 after 7 PM, or Ed, WB2IBQ, (212) 746-4080 after 7 PM. Talk-in on 145.62 simplex.

OHIO: The Marion Amateur Radio Club's 7th annual Heart of Ohio Ham Fiesta, Sunday, October 25, 0800 to 1600, Marion County Fairgrounds Coliseum. Door prizes, check in prize, food. Tickets $2.00 advance; $3.00 door. Tables $4.00. Check-in on 146.52 or 147.90/30 or 223.34/224.94. For information, tickets or tables: Paul Kilzer, W8GAX, 393 Pole Lane Road, Marion, OH 43302.

PENNSYLVANIA: The Irwin Area Amateur Radio Association's Swap & Shop, Saturday, October 17, Circleville V.F.D., Robbins Station Road, Irwin. Flea Market, prizes, vendors, food, free parking. Talk-in on 146.925/.325 and 146.52 MHz. For further information: Bill Stash, WA3AQQ, 421 Dailey Drive, N. Huntingdon, PA 15642.

PENNSYLVANIA: The R.F. Hill ARC's 5th annual Hamfest, November 8, Sellersville National Guard Armory, Sellersville. Doors open 7 AM, sellers; 8 AM, buyers. Talk-in on 28/88 and 52. Grand prize, door prizes, refreshments. For information: R.F. Hill ARC, Box 29, Colmar, PA 18915 or Chet Pierson, K3TV, Box 336, RFD 1, Greenlane, PA 18054.

PENNSYLVANIA: Symposium on Small Computers in the Arts, November 20-22, University City Holiday Inn on the Penn campus, Philadelphia. Tutorials, workshops, demonstrations, presentations, film/video showings and the 4th Annual Computer Music Concert. Sponsored by: Philadelphia Area Computer Society, University of Pennsylvania, the IEEE Computer Society and IEEE Philadelphia Section. For information: Symposium on Small Computers in the Arts, Box 1954, Philadelphia, PA 19105 or call Philadelphia IEEE office. (215) 243-8109.

PENNSYLVANIA: The Foothills ARC's annual Swap & Shop, Saturday, November 7, St. Bruno's Church, South Greensburg. 9 AM to 3 PM. Registration $2.00 each or 3/$5.00. All indoor facilities. Main Prize: Kenwood TS-530S HF Rig. First Prize: Icom IC-2A Handheld. Talk-in on 146.07/.67 and 146.52 simplex. For advanced table reservation: Chuck Hamman, WB3HZM (412) 837-9194 after 5 PM.

TENNESSEE: The Mid-South Amateur Radio Association, the Memphis VHF Club, Raleigh ARA and Delta ARC will hold the Memphis Hamfest, October 10 and 11, Memphis Fairgrounds Youth Bldg. (same as last year), 8 AM to 4 PM Saturday and 8 AM to 2:30 PM Sunday. Admission: $3.00, under 14 free. Motel accommodations nearby. Indoor/outdoor Flea Market. ARRL Forum, ladies' activities, DX forum, Antenna forum, computer displays and Amateur Radio related forum. FCC exams pending at this time. Dance with snacks in Hamfest area Saturday night. *For details: Memphis Hamfest, 28 North Cooper, Memphis, TN 38104* or Call Clayton Elam, K4FZJ (901) 274-4418 days; (901) 743-6714 nights. Howard Smith, WD5DVB, M.A.R.A. President (901) 372-9618. Talk-in on 34/94 and 52 simplex.

OPERATING EVENTS

"Things to do..."

OCTOBER AND NOVEMBER: DXpeditions to NIUE Island. Five members of the Northern California DX Club will operate from Niue Island (ZK2) for both the CQ WW phone and CW contests. WB6EXW and WA6AHF will operate October 21-29, and K6RU, AA6AD, and N6HR, November 25-December 3. License arrangements are complete but call signs will not be known until arrival on Niue. Operation on all bands 10m-160m with emphasis on low bands during non-contest periods. QSL via: The Northern California DX Club, Inc., P.O. Box 608, Menlo Park, CA 94025.

OCTOBER 3 & 4: The Parkersburg ARK of West Virginia's in-state DXpedition to the top of Spruce Knob, the highest mountain point in West Virginia, Randolph County. Starts 1500 UTC. Station call N8CDD. Listen 52.150 and 52.5225 MHz and 144.2, 144.19, and 144.11 MHz. For special QSL send SASE to N8CDD, 902 23rd Street, Vienna, VA 26105.

OCTOBER 10 AND 11: The Jefferson County ARC, DeSoto, MO, will be operating a special events station, KAØIAR, commemorating the Population Center of the U.S., as determined by the 1980 census, from 1700 GMT, October 10 to 1700 GMT, October 11. Approximate frequencies: 25kc up from bottom edge of General portions of 10, 15, 20 and 40 meters; and center of Novice portions. For certificate: SASE with QSL to: KAØIAR, 3009 High Ridge Blvd., High Ridge, MO 63049.

OCTOBER 10, 11: 9 Land QSO Party. Starts 1800 UTC, Saturday, October 10; ends 2359 UTC, Sunday, October 11. Suggested frequencies: CW, 1805, 3560, 7060, 14060, 21060, 28060 + VHF. SSB, 1815, 3895, 7230, 14280, 21355, 28600 + VHF. Novice, 3725, 7125, 21125, 28125. Certificates awarded to top score in each state, province and ARRL country. For further information: SASE to Ill Wind Contesters c/o John W. Sikora, WB9IWN, 8747 Northcote, Munster, IN 46321.

OCTOBER 10-12: The Southern Sierra ARS, Tehachapi, is conducting a dual-site expedition using K6RL from Badwater, Death Valley, and the summit of Mount Whitney, California, during the Columbus Day weekend. 1900 UTC October 10 to 0100 UTC October 12. Modes: CW QRP 21.105 or 28.105, 7.105 MHz. Two CW stations will be operating on different bands. 2-meter FM on 146.550 MHz simplex. The Badwater station will operate from 1900 UTC October 10 to 1900 UTC October 11 on CW ± 21.100 and 7.110 MHz. For a commemorative certificate confirming your QSO, send QSL and $1.00 to SSARS, Rt. 2, Box 338, Tehachapi, CA 93561.

OCTOBER 13, 14, 15: The Colquitt County Ham Radio Society will be operating club station WD4KOW from the fourth annual Sunbelt Agricultural Exposition. 0900 to 1600 EDST each day. The Sunbelt Expo, Spence Field Airbase near Moultrie, Georgia, is the largest agricultural show in the south. Operations on 40 and 20 meters around 7.250 and 14.300 MHz with some in the other HF bands. Visiting Hams listen on local repeater 146.19/79. Visit the amateur booth at the Expo and operate the Amateur station. Receive a special QSL card for contacts.

OCTOBER 16, 17, 18: The Stark RTTY Group, WB8RVM, will be operating a special event station at the Mellet Mall Hobby Show, Canton, Ohio, to demonstrate Amateur Radio to the general public. Modes and frequencies: SSB, 5 kc up from low end of general portions of 80 thru 10 meters; CW, 3540, 7040, and 14.060. RTTY on 14.090 and 3620. Local contacts on 146.52 MHz. From 1400 to 0100 GMT, October 16 and 17. From 1400 to 2200 GMT, October 18. A special certificate awarded to all Amateurs contacted during this period. Send QSLs and SASE (9 × 11) to: The Stark RTTY Group, WB8RVM, 138 Page Street N.W., Massillon, OH 44646.

OCTOBER 17: 27th Annual VHF Conference, Kohrman Hall, Western Michigan University, Kalamazoo, MI 49008. This is a technical conference for Amateurs and Radio Engineers. For further information: SASE to Western Michigan University, Department of Electrical Engineering, Kalamazoo, MI 49008. Att: Dr. Glade Wilcox, W9UHF.

OCTOBER 17, 18: QRP Amateur Radio Club's International CW QSO Party. From 1200 UTC, Saturday, October 17 to 2400 UTC Sunday, October 18. Suggested frequencies: 1810, 3560, 7040, 14060, 21060, 28060, 50360. Any VHF/UHF contacts must be direct, no repeaters. Novice frequencies: 3710, 7110, 21110, 28110. Call: CQ QRP de *Call Sign*. For further information: SASE to QRP ARCI Contest Chairman, William W. Dickerson, WA2JOC, 352 Crampton Drive, Monroe, MI 48161.

OCTOBER 21 & 22, NOVEMBER 4 & 5: YL ANNIVERSARY PARTY. All licensed women operators worldwide are invited to participate. CW, Wednesday, October 21, 1800 UTC to Thursday, October 22, 1800 UTC. Phone: Wednesday, November 4, 1800 UTC to Thursday, November 5, 1800 UTC.

OCTOBER 24 AND 25: The Wiesbaden Amateur Radio Club's second Contest DXpedition to Luxembourg in conjunction with the CQ Worldwide Phone DX contest. Call sign, DA1WA/LX. Operations on all bands, 10 through 80 meters. Stateside QSLs, SASE to Steve Hutchins, Box 4573, APO New York 09109. Other QSLs to DSØLC, Dr. Hugo Jakobljevich, Am Weinberg 10, 6200 Wiesbaden-Auringen, West Germany. For further information: Steve Hutchins or Claude Matchette, HHC, V Corps (G-2), APO New York 09079.

NEW products

ETS Morse-code training package

Many methods have been offered for learning Morse code, some good and some not so good. This is a good one. We at *ham radio* have had an opportunity to study the Morse-code training package by Educational Technology and Services, Incorporated (ETS). This training package is not just an ordinary collection of code tapes that progress from low to high speed. The training method is based on scientific principles — a Perceptual Learning Model developed at the University of Minnesota and from research conducted at Southern Illinois University and at the Research and Development facility of ETS.

It has been found that, when using conventional Morse-code teaching methods, students progress to a speed of 10-13 WPM, at which point they reach a plateau. From then on, learning to copy code at higher speeds becomes more difficult. This plateau results from the shift from one method of copying, in which the student must analyze the code character, to another method in which the student begins to perceive the code character. ETS studies have resulted in the identification of the variables that contribute to the plateaus experienced in the Morse-code learning process and have developed a concept that eliminates the problems associated with traditional Morse-code training programs.

With the ETS package, the entire alphabet can be learned in 25 trials. The letters are presented at, and spaced at, 18 WPM. Now this may scare you off — whoever heard of starting to learn Morse at 18 WPM? That's where the ETS perceptual learning concept comes in. You learn to recognize, and translate to paper, letters and words not at, say, 5 WPM with gradually increasing speed, but at 18 WPM from the very beginning. Trial number one starts you off with two letters randomly presented. Each successive trial adds a single letter until the entire alphabet is learned. When the last trial is mastered, the entire alphabet can be copied at 18 WPM. The method allows you to master the code in 40 percent less time than conventional Morse-code instruction techniques.

The ETS Morse-code training package consists of four phases:

1. Twenty-six letters of the alphabet
2. Numbers
3. Punctuation and special characters
4. Plain text practice

The ETS Morse-code training package, consisting of five cassettes (6½ hours total practice) is available at Ham Radio's Bookstore for $18.95. — *ham radio* staff.

MFJ CW/SSB/notch filter

All modern receivers have more than adequate filtering capabilities. However, despite all the fancy filters available, there are still those of us who need more help. MFJ, long known as the supplier of add-on accessories, has designed an excellent outboard audio filter: the MFJ 722 Signal Optimizer. Using the latest chip technology, the Signal Optimizer design includes a tunable notch filter and selectable high-pass/low-pass filter on SSB, and a bandpass filter on CW.

Hookup and installation of the 722 is simple and straightforward. The receiver audio is routed through the filter and back to the speaker. A 1/4-inch (6.4-mm) jack is included in the filter so you can use headphones should you prefer. The only other connection is to provide 12 volts dc to the filter. Signal Optimizer design allows ease of use under any operating situation.

As with every new piece of equipment, there is a learning curve associated with using the filter. The 70-dB notch filter is a bit tricky to use at first. But MFJ's operating manual clearly explains the tricks of using the notch, and that complete explanation eliminates any problem you might have.

When filtering in the SSB mode, the 722 attenuates all the high and low frequencies. In the high-pass position, all signals below 375 kHz are efficiently eliminated. When switched to 2.5, 2 and 1.5 kHz a low-pass filter is engaged in progressively narrower units to achieve desired filtering.

On CW, the Model 722 uses an active IC bandpass filter of progressively narrower windows. One problem that has occurred before with some outboard filters is that the narrower the filter becomes, the more it tends to ring or give you the impression you are listening through a pipe. The MFJ 722 has no ring.

During many hours of use, both in casual rag chewing and DXing, the Model 722 filter has been quite a nice addition to the shack. A real test comes each summer with 160-meter QRM.

The MFJ Signal Optimizer measures 5 × 2 × 6 inches (13 × 5 × 15 cm) and sells for $69.95 plus shipping. A 12-volt dc power supply is also available for $7.95 plus shipping. For more information write MFJ Enterprises, Box 494, Mississippi State, Mississippi 39762.

wire cut and strip tool

A new concept for easy and clean stripping of wires for wire-wrapping, electronic, and appliance applications, the ST-100 strips without nicking and automatically generates the proper strip length. Biomechanically designed for maximum efficiency, its slim design makes it ideal for storage in pocket, belt holder, or tool kit.

Simply place wires (up to four) in stripping slot with ends extended beyond cutter blades, press tool and pull. Wire is cut and stripped to prop-

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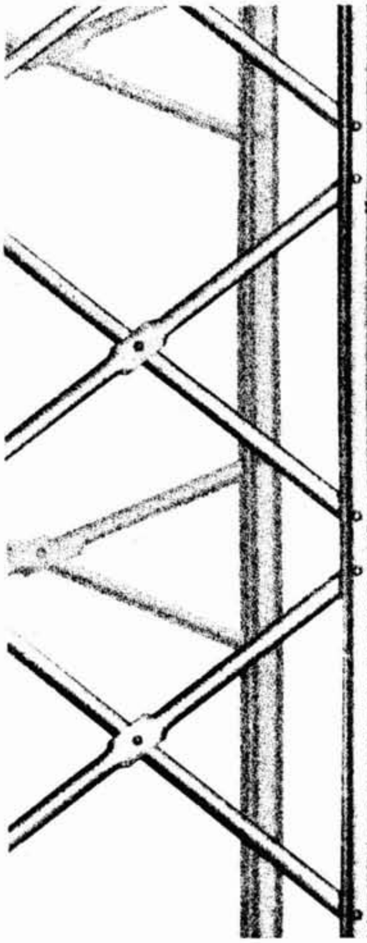

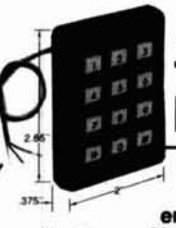

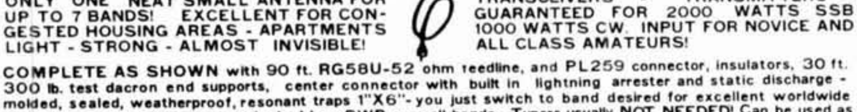

NEW products

er wire-wrapping length. Hardened steel cutting blades and sturdy construction ensure long life. The stripping blade is easily replaceable. It is handy tool for production field work. Available for wire sizes from 20 to 30 AWG (0.8 to 0.25 mm). For further information contact O.K. Machine and Tool Corporation, 3455 Conner Street, Bronx, New York 10475.

inexpensive bridge rectifiers

Four new low-cost, single-phase, rectifier bridge assemblies — the MDA2550/1 and the MDA3550/1 — have been introduced by Motorola. These economy 25- and 35-amp bridges use prime button rectifiers from Motorola's high-volume, low-cost automotive alternator rectifier line.

The new devices are offered in the most popular 50- and 100-volt ratings. These bridges have 400-amp surge capability and an electrically isolated base up to 1800 volts. Immediate availability is from OEM and authorized Motorola distributor stocks (or contact Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, Arizona 85036).

Mini-Reader

Only a few years ago, to receive in the RTTY mode, you had to spend hours putting together a demodulator, learning how to operate a Model 15 or 19 machine, reloading paper, and on and on. Seemed like you felt more like an auto mechanic than a Radio Amateur. Big and bulky was the name of the game.

Things have changed. The great strides of the electronics industry to miniaturize components have resulted in smaller and smaller products. A good example is the Kantronics Field Day Code and RTTY Reader. The

Field Day Reader is large — about the size of an fm transceiver. Kantronics engineers then miniaturized the Field Day to hand size and renamed it the Mini-Reader. The Mini-Reader can do everything that its larger brother, the Field Day, can but in a much smaller package, measuring only 5.75 × 3.62 × 1.25 inches (14.6 × 9.2 × 3.2 cm). The Mini-Reader fits easily into your pocket and comes at the attractive price of $314.95.

Mini-Reader features

The Mini-Reader copies Morse from 3-80 WPM; RTTY with any shift at 60, 67, 75, and 100 WPM Baudot; and 110 and 300 WPM ASCII.

To assist in logging, the Mini-Reader can function as a 24-hour clock. And if that isn't enough, the Mini-Reader can also be programmed to function as an audio-frequency counter. For tuning ease, the Mini-Reader has a tuning LED that indicates exactly when a station is properly tuned in. Also, the Mini-Reader has a built-in 250-Hz bandwidth filter to reduce interference. The earlier Field-Day Reader used digital circuitry, which required a fairly large package. To accomplish miniaturization, Kantronics has designed the Mini-Reader around a programmed microprocessor.

interfacing with your receiver

Hookup of the Mini-Reader is carefully explained in the owner's manual and takes only a few minutes. While connecting the Mini-Reader to a receiver in preparation for this review, we inadvertently put plus to minus and minus to plus. With some equipment this would mean sure disaster or irrevocable damage. But the Mini-Reader, thanks to careful design, took our abuse in stride and worked perfectly when we realized our mistake and corrected the power leads.

The real test came when audio from the receiver was applied. Tuning across the top of 20 meters, we found a nice strong RTTY signal that was relatively free from interference. Plugging in the audio jack brought garbled words across the bright green ten digit screen. A small turn of the VFO lit the tuning LED to a bright red and, Hey! This really works — 100 percent perfect copy. We spent at least two hours tuning across the ham bands listening to RTTY transmissions that first night. We also tuned across commercial circuits and had a lot of fun listening to UPI, AP and ships at sea.

receiving manual CW

Enough about RTTY. Now it's time to try the Mini-Reader on CW. As the instruction manual states, decoding CW is not an easy task. This is because of the different techniques and styles of sending Morse code. If everyone's spacing and character weight were the same, code readers wouldn't have any problems.

Despite a bit of skepticism on our part, the Mini-Reader copied every signal we listened to except a ham who was using a bug and seemed to delight in his Lake Erie swing.

The Mini-Reader had a field day with the speed merchants on the low end of the 40-meter band. The only time the Mini-Reader failed to decode signals was in the presence of loud static crashes and QRM.

specifications

Morse speed tracking: 3-80 WPM

Filtering: active 250-Hz bandwidths; 750-Hz center frequency

Display: 10 alphanumeric, 14-segment units

Modes: Morse; Morse with speed display. Morse practice RTTY at 60, 67, 75, 100 WPM, ASCII at 110 and 300 WPM. Clock test and audio-frequency counter.

Audio-frequency counter: 0-79 kHz +0.01 percent

Power: 8-18 Vdc at 240 mA.

The Mini-Reader is a fascinating addition to any Amateur station. For more information contact Kantronics, 1202 E. 23 Street, Lawrence, Kansas 66044. — *ham radio* staff.

Johnson AIR Variables

1/4 x 2 1/2" shaft
$2.50 each

193-10-6	2.2 to 34 pF
193-	1.5 to 27.5pF
193-	.6 to 6.4pF

$1.00 each

160-107-16	.5 to 12 pF
193-10-9	2.2 to 34 pF
193-10-104	2.2 to 34 pF
193-4-5	3 to 30 pF

RF Power Device

MRF454 Same as MRF458
12.5 VDC, 3-30 MHz
80Watts output, 12dB gain
$17.95 ea.

E.F. JOHNSON TUBE SOCKETS

#124-0311-100 .... 6.99 each
For 8072 etc.

#124-0107-001 .... 13.99 each
For 4CX250B/R, 4X150A etc.

#124-0111-001 .... 4.99 each
Chimney for 4CX250B/R and 4X150

#124-0113-001 and 124-0113-021
$12.99 each
Capacitor for #124-0107-001

#123-209-33 Sockets....6.99 each
For 811A, 572B, 866, etc.

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6.8pF	47pF
8.2pF	62pF
10pF	100pF
12pF	160pF
13pF	180pF
14pF	200pF
20pF	240pF
24pF	380pF
33pF	470pF
36pF	1000pF
43pF	

350V $1.00 each

86 Pin Motorola Bus Edge Connectors

Gold plated contacts
Dual 43/86 pin .156 spacing
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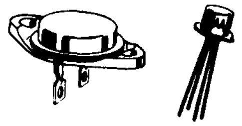
Transistors



2N2857JAN	2.50
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2N2947	15.00
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2N3375	8.00
2N3553	1.57
2N3818	5.00
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2N3866JAN	2.50
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2N3925	10.00
2N3948	2.00
2N3950	25.00
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2N4072	1.60
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2N4429	7.00
2N4877	1.00
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2N5108	4.00
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2N5590	8.00
2N5591	11.00
2N5635	5.44
2N5636	11.60
2N5637	20.00
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2N5643	14.00

2N5645	10.00
2N5842	8.00
2N5849	20.00
2N5942	40.00
2N5946	14.00
2N5862	50.00
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7.4585	7.4925	9.585	10.170	11.700	12.000	17.365
7.4615	7.4985	10.000	10.180	11.705	12.050	37.600
7.4625	7.5015	10.010	10.240	11.730	12.100	37.650
7.4665	7.5025	10.020	10.245	11.750	16.965	37.700
7.4685	7.5065	10.030	10.595	11.755	17.015	37.750
7.4715	7.7985	10.040	10.605	11.800	17.065	37.800
7.4725	7.8025	10.0525	10.615	11.850	17.165	37.850
7.4765	9.545	10.130	10.625	11.855	17.215	37.900
7.4785	9.555	10.140	10.635	11.900	17.265	37.950
7.4815						38.000

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CFM455E	455 KHz	5.50
CFU455H	455 KHz	3.00
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TEXAS INSTRUMENT TIL-305P
5 x 7 array alphanumeric display
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423	7-100pF	1.00	422	4-40pF	1.00
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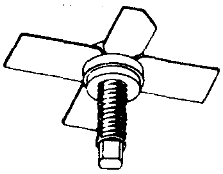
RF Transistors



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12.5 VDC, 27 MHz
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PRICES ARE SUBJECT TO CHANGE WITHOUT NOTICE. Prices supersede all previously published. Some items offered are limited to small quantities and are subject to prior sale.

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NEW CHERRY BCD SWITCH
New end plates
Type T-20............ 1.29 each

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189-503-105	1.4 to 9.2pF
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189-508-5	2.1 to 22.9pF
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545-043	1.8 to 11.4pF

More Details? CHECK—OFF Page 94

Food for thought.

Our new Universal Tone Encoder lends its versatility to all tastes. The menu includes all CTCSS, as well as Burst Tones, Touch Tones, and Test Tones. No counter or test equipment required to set frequency-just dial it in. While traveling, use it on your Amateur transceiver to access tone operated systems, or in your service van to check out your customers' repeaters; also, as a piece of test equipment to modulate your Service Monitor or signal generator. It can even operate off an internal nine volt battery, and is available for one day delivery, backed by our one year warranty.

- All tones in Group A and Group B are included.
- Output level flat to within 1.5db over entire range selected.
- Separate level adjust pots and output connections for each tone Group.
- Immune to RF
- Powered by 6-30vdc, unregulated at 8 ma.
- Low impedance, low distortion, adjustable sinewave output, 5v peak-to-peak
- Instant start-up.
- Off position for no tone output.
- Reverse polarity protection built-in.

Group A

67.0 XZ	91.5 ZZ	118.8 2B	156.7 5A
71.9 XA	94.8 ZA	123.0 3Z	162.2 5B
74.4 WA	97.4 ZB	127.3 3A	167.9 6Z
77.0 XB	100.0 1Z	131.8 3B	173.8 6A
79.7 SP	103.5 1A	136.5 4Z	179.9 6B
82.5 YZ	107.2 1B	141.3 4A	186.2 7Z
85.4 YA	110.9 2Z	146.2 4B	192.8 7A
88.5 YB	114.8 2A	151.4 5Z	203.5 M1

- Frequency accuracy, ± .1 Hz maximum - 40°C to + 85°C
- Frequencies to 250 Hz available on special order
- Continuous tone

Group B

TEST-TONES:	TOUCH-TONES:		BURST TONES:			
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1500	852	1477	1700	1950	2250	2500
2175	941	1633	1750	2000	2300	2550
2805			1800	2100	2350	

- Frequency accuracy, ± 1 Hz maximum - 40°C to + 85°C
- Tone length approximately 300 ms. May be lengthened, shortened or eliminated by changing value of resistor

Model TE-64 **$79.95**

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HAM CALENDAR

October

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				WEST COAST QUALIFYING RUN — 1. **1**	**TEXAS STATE CONVENTION** — K5RC, 12610 Barbizon, Houston, TX 77089. **2-4.** **2**	**RADIO AMATEURS OF GREATER SYRACUSE HAMFEST** — Art & Home Bldg., NY State Fairgrounds. WA1DA or KN2CZZ **3.** **SUNCOAST CONVENTION** — Sheraton Sand Key Hotel on Sand Key, South of Clearwater Beach. W4EGM. **3-4.** **MIDWEST DIVISION** — Salina, KS. John Shoultys, 2157 Edward, Salina, KS 67401. **3-4.** **MISSISSIPPI COAST ARA** — Biloxi, MS. W5PDG. **3-4.** **CALIFORNIA QSO PARTY** — **3-4.** **VK/ZL PHONE CONTEST** — **3-4** **3**
19-79 REPEATER ASSOCIATION'S ANNUAL FLEA MARKET — Beachmont VFW Post, 150 Bennington St., Revere, MA. K1AZE. **4.** **GIANT ELECTRONICS FLEA MARKET** — Loral Electronics Parking Lot, Fullerton Ave., Yonkers, NY. Call (914) 969-1053. **4.** **YORK COUNTY 30TH ANNUAL HAMFEST** — Joslin Park, Rock Hill, SC. WA4OQG. **4.** **4**	**BLOSSOMLAND ARA 15TH ANNUAL HAMBASH** — Lake Michigan College Convention Center, near Benton Harbor, MI. WB8WIV. **5.** **5**	**6**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **7**	**8**	**SCOTTSDALE ARC SOUTHWESTERN DIVISION CONVENTION** — Safari Resort, Scottsdale, AZ. **9-11.** **WORLD'S FAIR OF ELECTRONICS** — The Electronic Emporium, Ross at Central, Dallas, TX. **9-10.** **9**	**WESTERN NORTH CAROLINA ARS 1981 AUTUMNFEST** — Asheville Civic Center, Asheville, NC. **10.** **VK/ZL CW CONTEST** — Contact VK6NE for details. **10-11.** **DELTA DIVISION CONVENTION** — Memphis, TN. **10-11.** **9-LAND QSO PARTY** — Contact WB9IWN for details. **10-11.** **10**
HOOSIER HILLS HAM CLUB ANNUAL HAMFEST — Lawrence Co. 4-H Fairgrounds, South of Bedford, IN WA9OQT. **11.** **COLUMBIA ARA FIFTH ANNUAL HAMFEST** — Howard County Fairgrounds, 15 miles west of Baltimore just off I-70 on Rt. 144. N3AFN. **11.** **RSGB 21/28 MHz PHONE** — 11. **11**	**12**	**W1AW QUALIFYING RUN** — 13. **13**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **14**	**15**	**16**	**FIRST ANNUAL BIG RAPIDS FOX HUNT** — Transmit Freq. 146.64, Hemlock Park, Big Rapids, MI. Contact B.R.A.A.R.C., P.O. Box 1073, Big Rapids, MI 49307. **17.** **QRP ARC INTERNATIONAL CW QSO PARTY** — Starts 1200 UTC Sat., Oct. 17, ends 2400 UTC Sun., Oct. 18. For more information contact WA2JOC. **17-18.** **24TH JAMBOREE ON THE AIR** — 001 UTC Saturday to 2400 UTC Sunday. Contact Boy Scouts of America, 1325 Walnut Hill Lane, Irving, TX or Harry A. Harchar, 216 Maxwell Ave., Hightstown, NJ 08520. **17-18.** **27TH ANNUAL VHF CONFERENCE** — Western Michigan University, Kalamazoo, MI 49008. For more information contact (S.A.S.E.) W9UHF. **17.** **17**
PENNSYLVANIA QSO PARTY — Contact 3HDH. **17-18.** **RSGB 21-MHz CW CONTEST** — **18.** **18**	**19**	**20**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **21**	**22**	**23**	**HAMFEST CHATANOOGA** — Chatanooga State Technical College, Chatanooga, TN. Contact WA4ZOK. **24-25.** **24**
FRAMINGHAM ARA 6TH ANNUAL FALL FLEA MARKET — Framingham Police Station Drill Shed. Contact K1YHM for more details. **25.** **W1AW QUALIFYING RUN** — 25. **25**	**26**	**27**	**AMSAT** Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning) **AMSAT** Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning) **28**	**29**	**30**	

W1AW Schedule
April 26-October 25, 1981

UTC		
	Slow Code Practice	MWF: 0200, 1300, 2300; TThSSn: 2000; S: 0200
	Fast Code Practice	MWF: 2000; TTh: 0200, 1300; TThSSn: 2300; S: 0200
	CW Bulletins	Dy: 0000, 0300, 2100; MTWThF: 1400

Code practice and CW bulletin frequencies: 1.835, 3.58, 7.08, 14.08, 21.08, 28.08, 50.08, 147.555 MHz.

For more details see Coming Events

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October, 1981

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World Class Performance and Features

The FT-ONE is the culmination of an all-out design project by Yaesu's top engineering team. Working without the usual cost constraints, Yaesu's design group is proud to unveil the instrument they "always wanted to design," a revolutionary blend of computer and RF technology.

GENERAL COVERAGE, ALL SOLID STATE

The FT-ONE is a full-coverage all-mode transceiver, equipped for reception on any frequency between 150 kHz and 29.99 MHz, with transmit coverage on all nine present and proposed amateur bands. In countries where permitted, the FT-ONE may be programmed to transmit throughout the 1.8-29.99 MHz range.

KEYBOARD FREQUENCY ENTRY

Fully digitally synthesized, the FT-ONE uses a front panel keyboard for initial frequency entry. Frequency change is then accomplished via the main tuning dial or the pushbutton scanner, with tuning in either 10 Hz or 100 Hz steps possible. Truly the contester's dream, the FT-ONE permits extremely fine tuning and instantaneous band change with equal facility.

DUAL VFO SYSTEM

Ten digital VFO's with memory are provided, in conjunction with an A-B selection scheme that allows instant recall of any transmit, receive, or transceive frequency desired. For split-frequency operation, such as on 7 MHz SSB, the operator may select TX on VFO-A and RX on VFO-B, automatically storing the calling and listening frequencies for each pile-up. For net operations, a non-volatile memory board is available as an option, to eliminate the possibility of dumping memory.

FULL CW BREAK-IN

Recent advances in solid-state technology have finally made full CW break-in reliable enough to be incorporated into a Yaesu product. Now you can select traditional semi-break-in (for use with amplifiers not equipped for full break-in) or full high-speed break-in. When using amplifiers so equipped, the keyer output lead may be interrupted via a rear panel jack and routed to the break-in sequencing input on your amplifier.

SWITCHING REGULATOR POWER SUPPLY

Extremely compact and light in weight, the switching regulator power supply reduces substantially the space required to produce the operating voltages used in the FT-ONE. Highly efficient and uniquely stable, the switching regulator supply provides superb reliability in a field of design long neglected by amateur manufacturers.

ELITE CLASS PERFORMANCE FEATURES

In addition to the full break-in and superb receiver filters, Yaesu's design team packed the FT-ONE with subtle virtues that others might have overlooked. Rear panel jacks allow the use of both an external receiver and an independent receive antenna, such as a 160 meter Beverage. While scanning, automatic halting on a received signal may be programmed. . . perfect for watching a band for openings. If you're a DX-peditioner, an optional Curtis 8044 keyer board is available, so you won't need an external keyer that only wastes suitcase space. And if your amplifier fan is louder than it should be, there's even a microphone squelch (AMGC) to reduce background noise pickup between words and sentences!

ONE YEAR FACTORY WARRANTY

Because of the level of attention to design detail, parts selection, and factory quality control, your FT-ONE is backed by a one-year *factory* warranty for the original purchaser at retail. Prompt and meticulous attention to your warranty needs will be provided by our Ohio And California Service Centers. In addition, all units sold in the United States will be inspected and tested after clearing Customs, and will include a Service Manual in the puchase price.

GAIN/INTERCEPT OPTIMIZED RECEIVER FRONT END

Utilizing up-conversion with a first IF of 73 MHz, the FT-ONE RF amplifier stage uses push-pull power transistors configured to produce a typical output intercept of +40 dBm. The first mixer utilizes a diode ring module followed by a low noise post amp, for optimum noise figure consistent with modern day intercept requirements. The result is a receiver with a typical two-tone dynamic range well in excess of 95 dB (14 MHz, CW bandwidth). Additional gain tailoring is provided via a PIN diode attenuator controlled from the front panel.

FILTERS READY FOR COMPETITION

Three filter bandwidths are available for CW operation (two for FSK!), using optional 600 Hz or 300 Hz crystal filters. Filter insertion losses are equalized for constant IF gain. Both IF Shift and Variable Bandwidth are provided, and two CW filters may be cascaded, for competition-grade selectivity. For SSB work, the Variable Bandwidth feature eliminates the need for costly 1.5 kHz or 1.8 kHz filters, as any intermediate bandwidth may easily be programmed using the standard, cascaded SSB filters. To top it all off, a high-performance audio peak and notch filter is standard equipment.

EXPANDED OPERATING DISPLAYS

Digital displays for the VFO Frequency, memory channel, and RIT offset are provided for quick frequency identification. The large front panel meter provides easy viewing of transceiver operating parameters, including final transistor collector current, input DC voltage, FM discriminator center tuning, speech processor compression level, and forward/reflected relative power.

NOT AVAILABLE AS OPTIONS

It's hard to believe that other manufacturers still insist on making such essential items as a noise blanker or speech processor extra-cost options. We find that these are less expensive to incorporate and more reliable in operation when installed on our assembly line. No AC power supply is available as an option for the FT-ONE, either; it's equipped for operation from 100/110/117/200/220/234 volts AC or 13.5 volts DC. And it goes without saying that there will not be an external VFO offered for the FT-ONE — we're confident that ten VFO's are quite enough!

Experience the FT-ONE in your Authorized Yaesu Dealer's showroom today. This may be the last Amateur transceiver you will ever own.

Warranty policy available upon request. SASE, please.

Specifications subject to change without notice or obligation.


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Eimac