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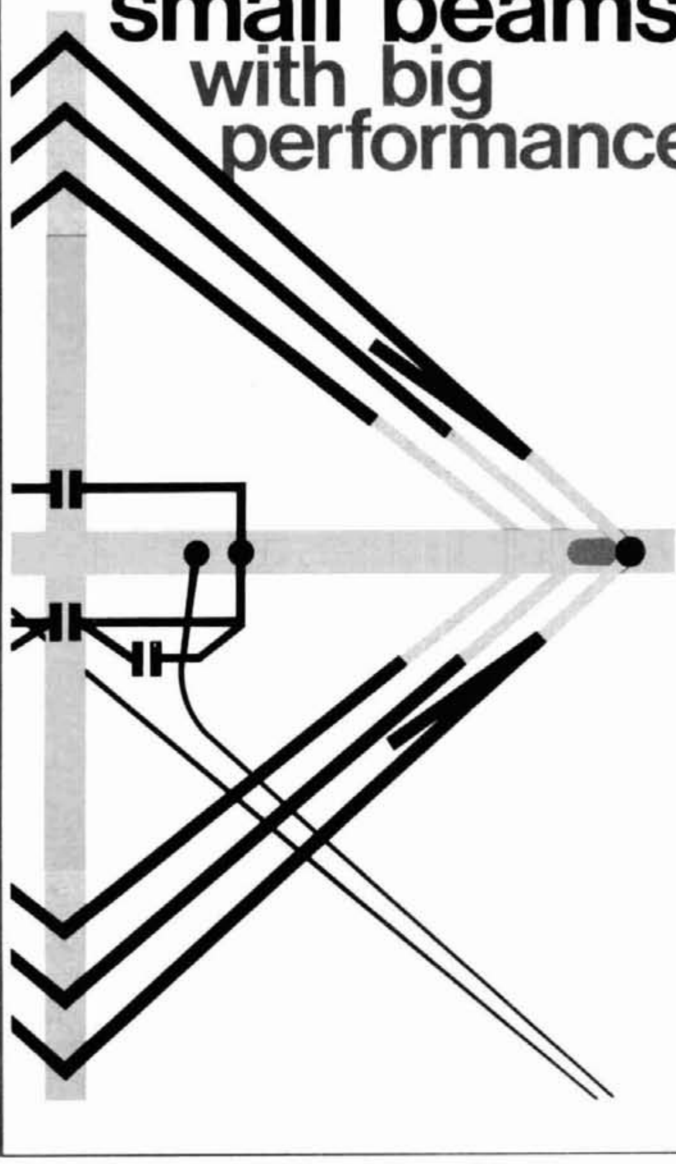
ham radio

magazine

MARCH 1979

small beams with big performance

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MARCH 1979

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contents

a second look

by Jim Fisk

This is the time of year when many high-school seniors are scurrying around, planning their future education, sending applications off to the college of their choice, and taking entrance exams. Seniors who are also Radio Amateurs are probably considering a career in electronics. If they're lucky, they will have a knowledgeable guidance counselor who can steer them in the right direction; if not, they'll probably pick a school with a good reputation and work from there. Sometimes this works out, and sometimes it doesn't — it depends entirely on what the student is looking for.

Electrical and electronics engineers who graduated more than ten years ago would probably not recognize the engineeering curriculum now offered by their old alma mater because, in the past few years, there have been significant changes in engineering education. During the 1960s the classical engineering educational programs tended to become more and more theoretical oriented, with less emphasis on applied engineering. The backgrounds of some electrical engineering staffs changed from being primarily applied electronics to applied mathematics, and attempts to develop practical engineering programs were not all that successful. In recent years, however, some engineering colleges have restructured their curriculums for a better balance between the theoretical and the practical. On the other hand, some colleges have continued to stress the theoretical aspects of engineering science, so the prospective student is faced with a very important, but difficult, choice.

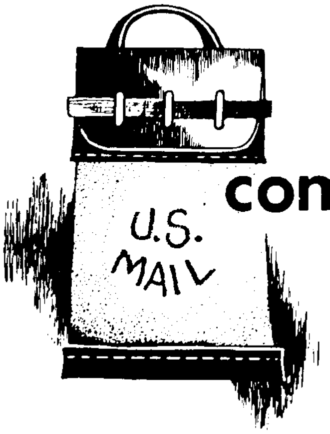
Not too long ago, the prestige of an engineering school was almost always gauged by the theoretical emphasis of its courses; each school tried to outdo the others in the theoretical sophistication of its curriculum. Unfortunately, the majority of jobs within the sphere of electronics engineering does not require such an advanced mathematical sophistication as they do a "gut" understanding of electronics. If you talk to students at a *theoretical* school, you'll find that many of them don't know how to solve a simple steady-state ac problem, although they can invert a matrix and use state-variable techniques.

The difficulty with this type of engineering education is that graduates are not adequately prepared to solve the day-to-day engineering problems they will be presented with in industry. Employers are faced with the prospect of several months of on-the-job training before the newly hired engineer becomes a fully contributing member of the staff. Obviously, a new engineer who can solve problems quickly and practically in the real world is a valuable asset.

In the 1970s several colleges introduced four-year electronic technology programs in an attempt to get back to the old practical engineering concept; the courses at these colleges emphasize electronic hardware and laboratory techniques as well as electrical theory. Although graduates of these Bachelor of Science Technology programs have been pictured as fitting into the occupational spectrum somewhere between the technician and the engineer, many professors see technology graduates as having much wider employment opportunities. In fact, technology graduates now have opportunities in many areas of electronic applications and design traditionally occupied by engineering graduates, jobs vacated because of the change in emphasis in engineering education programs.

Students who are interested in this type of engineering program should be aware that there is a wide difference in B.S. programs parading under the "Technology" banner. Some curriculums are managerially oriented, others are slanted toward applications and design, while still others are little more than two-year electronic technician training programs with added courses in the arts and humanities to fill out four years. Students who wish to enter this area should obviously choose a school carefully to be sure they get exactly what they want.

Jim Fisk, W1HR
editor-in-chief



comments

metric dimensions

Dear HR:

The meter is a widely used unit of length abroad. It is convenient only in that fractions and multiples are decimal. As a specific unit of length it is as arbitrary as the foot; for reference, see the NBS history book *Measures for Progress.* Navigators use the international unit of distance, the nautical mile (based on the earth's equator), rather than the result of two French surveyors' efforts in measuring the distance from Paris to Marseilles.

There are times when metric measurements are useful, other times when other standards are better. Having used so many different standards for so long, I am not really partial to all-metric or all-other. For construction and items used therein it would seem advisable to state the local measurement (depending on the author's location and supply) *first,* then the conversion. For example, the W7DI antenna in the November issue used tubing from a U.S. supplier. It comes in standard diameters in inches. The same for plumbing pipe. One is hard pressed to make a supplier understand millimeters or centimeters. It would seem reasonable to state such dimensions in inches first with cm or mm in parentheses. If DK1AG had written the article it would seem reasonable to expect the local German dimensions first, then inches. I am referring mainly to those dimensions where specific material is widely available.

A sheet of plywood in the United States is going to be 4 by 8 feet for a long while to come. Three-quarter-inch plumbing is going to remain ¾″ for a long time — in fact, any material used in the building trades can be expected to remain in established dimensions for the next ten years — perhaps longer. Many electronic items also remain in the "English" standard. Most numerous are the ICs. They remain rooted on the 0.05-inch (1.27-mm) grid for a simple reason: The United States started it and uses millions of them every year. And many are fabricated in metric countries.

There are a host of other standards. Why the 1¾″ increment on the height of rack panels? Think of how long those have persisted. Some rack panel heights have varied, but the 19-inch (42.3-cm) width is still here. Quarter-inch (6.4-mm) shafts are common. Fasteners are described in threads per inch with roughly arbitrary diameters; both U.S. and foreign types should be differentiated. Consideration should also be given to the enormous number of United States types in use and made each year.

The scientific community remains in both camps and is not certain on a few items. There is increasing use in optics of the nanometer instead of the Angstrom, for example. Seimens has yet to replace mhos. Parsecs, kilometers (why not megameters?), and light-years seem to be interchangeable in astronomical distances. At least to NASA.

We have made the transition from tubes to transistors but tubes are still here. I believe that a double standard can continue, and should do so if certain material is in common supply in the author's country; contemporary literature should reflect that fact.

It is difficult for all to go completely metric, both for editor and author. We will continue to write on 21.6 by 27.9 cm paper using 3.94 pitch, double-spaced. I am awaiting delivery of a new IBM typewriter with a 38.1-cm carriage and dual pitch (4.72 for correspondence). If it bothers me, I'll just pour a glass of milk from the 1.89-liter carton.

Leonard H. Anderson
Sun Valley, California

Mr. Anderson's view of metrification is reasonable and well stated. The response we received to our boxed "metrics only" editorial which appeared with W7DI's article in the November issue was both immediate and loud. Based on the letters which have crossed my desk during recent weeks, ham radio *will be using both metric and English dimensions in our magazine articles for the foreseeable future.* **W1HR**

zip-cord feedlines

Dear HR:

The article on zip-cord feedlines in the April, 1978, issue and the follow-up comments in October brought back some old memories. I first heard of lamp-cord around 1930 (twisted-pair in those days) from the Globe Wireless operators who used it for transmission line to their "noise reducing" receiving antennas. Later there were a number of articles in the Amateur magazines on how to use lamp-cord transmission lines for both receiving and transmitting dipoles; it provided a reasonable match to the feedpoint impedance. Lamp-cord may have been a little lossy, but the early forms of coax which came into use a few years later was not all that good either!

Wayne W. Cooper, AG4R
Miami Shores, Florida

presstop

JIM FISK, W1HR and Editor-in-Chief of ham radio and Ham Radio Horizons magazines, suffered a heart attack in late January. The following week Jim was out of intensive care, with vital signs stabilized and all indications good. He will, however, be in the hospital for two to three weeks and resting at home for another six to eight weeks after that.

NOVICE USE OF 220-225 MHZ was proposed by the ARRL in a Petition for Rule Making submitted to the FCC. In its petition, the League suggests that Novices be authorized A1, A2, and F3 privileges across 220-225 MHz, with a maximum input power of 50 watts. A Novice would not be able to set up and operate a repeater or auxiliary station, although he would be able to use one.

In The Petition, the ARRL noted that the Commission had recently changed the character of the Novice license from a short-term, nonrenewable "learner's permit" to a full-term renewable license. This, they noted, reduced one of the most serious former objections to Novice phone privileges, the tendency of some Novices to operate mostly or entirely on phone until their license expires, putting them off the air — often for good.

FM In The 52.0-52.5 MHz segment of six meters was proposed in mid January by another ARRL Petition for Rule Making. This recommendation stems from a resolution to promote better use of the six-meter repeater sub-band. The resolution was passed unanimously at the board of directors July meeting.

Responding In An unusually short time, the FCC assigned RM-3314 to the 220-MHz Novice proposal and RM-3313 to the six-meter FM petition. Comments on both RMs must reach the FCC before March 1.

BROADCAST INTERESTS MAY THREATEN the U.S. Amateur Radio WARC position far more than the question of sharing 220 MHz with Maritime services. U.S. international broadcasters, not satisfied with the 865 kHz of new hf spectrum proposed for them in the Commission's carefully worked out WARC Report and Order, are now waging a behind-the-scenes battle to double that amount at the expense of other hf users. If they succeed, it will mean cuts for the other services, whose hf expansion was proposed in the U.S. position, and, in the process, it will destroy much of the carefully worked out agreement achieved by various government agencies and industry advisory groups during the past several years.

The Broadcasters Position is supported in a joint separate statement of Commissioners Washburn and Quello that's included in the WARC Report and Order. In it, the two commissioners note that the international broadcasters — specifically the International Communications Agency (Voice of America) and the Board for International Broadcasting (Radio Free Europe and Radio Liberty) — want international broadcasting to have another 800 kHz over and above the new 865 kHz already proposed for it. They also point out that the Executive Branch of the government has yet to make its final decision on the potentially explosive issue.

WILSON ELECTRONICS HAS BEEN bought by Regency. The move puts Regency back into the Amateur Radio business it left early last year, though Regency itself plans to remain in scanners and marine radio while Wilson, operating under its present management, will continue in Amateur and CB products.

FCC'S PERSONAL RADIO DIVISION was abolished as part of a sweeping reorganization of the Safety and Special Services Bureau. In the reorganization, Safety and Special Services has been arranged functionally, rather than by service, into four divisions: Policy Development, Rules, Licensing, and Compliance.

Safety And Special Services previously had three "service" divisions, Personal Radio, Aviation, and Marine; Industrial Safety; and Public Service, all of which went out of existence in the reorganization. In addition, there had also been an Industrial and Public Safety Rules Division, plus a Legal, Advisory, and Enforcement Division.

The Result Of The Change is expected to be an improvement in Safety and Special Services' overall efficiency, with much more flexibility in shifting workloads. What it will mean for the FCC licensees such as Amateurs is less clear. Improvement in such routine matters as license processing seems certain, but getting a question answered or discussing a problem might be more confusing than under the old setup.

THE CHICAGO FM CLUB has just announced its First Annual "Call for Technical Papers Competition." The winning entry will receive $500 plus expenses (less transportation) for the best Amateur Radio oriented paper. To receive the prize, the winner must be present at Radio Expo '79 to present his paper and for the prize presentation ceremony. In addition, ham radio will consider buying and publishing the winning paper. The names of the winner and runner ups will be published in the September issue of ham radio. All entries must be received by June 1, 1979. A detailed set of rules and instructions and application forms are available from Radio Expo '79, Post Office Box 305, Maywood, Illinois 60153, or phone (312) 345-5252.

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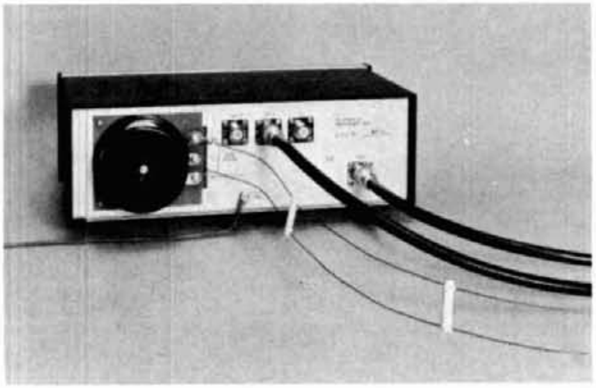

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high performance small beams

For antenna sizes up to that of the quad or three-element Yagi, there is no direct connection between size and gain. This article shows how to design small beams without sacrificing gain.

In view of the urgent need for small beams, the number of them in use is remarkably small. In a recent sample of 14-MHz contacts with Australian amateurs, I found that eighty per cent of the stations worked were using quads or three-element yagis; the remainder, the ones with the biggest signals, had even larger beams, beyond the resources of most of us. There are, nevertheless, some smaller beams, such as the VK2ABQ and the capacitively loaded quad,[1,2] which usually give a good account of themselves. Of particular importance, in the present context, is the fact that some of the most outstanding signals observed during my 50 years as a licensed amateur have originated from stations using driven arrays with only two elements!

The significance of this lies in the ease with which the performance of such beams can be calculated,[3] and the fact that size comes into the calculations *only when estimating the efficiency, which remains high for element sizes and spacings down to approximately 3 meters (10 feet).* Translating this fact into practice has brought to light some interesting problems, in particular the problem of overcoupling. That is so basic a problem that the absence of references to overcoupling in the literature suggests that no serious attempt has, until this time, been made to make beams as small as possible.

To achieve this reduction in size, elements *must* be capacitively end-loaded, without resorting to lossy inductances. This involves large concentrations of metal, which, besides tuning the elements, also couple them very tightly together. Following the normal behavior of coupled circuits, a large secondary (parasitic element) current and a small primary (driven element) current are generated, and there is virtually no beam action. Fortunately, I have found it quite easy to overcome this problem by neutralization similar to that used in push-pull amplifiers.

Another inevitable consequence, when small size is combined with high efficiency, is narrow bandwidth; this makes it essential to use separate feeders for each element so that fine tuning can be carried out in the shack. Also, this arrangement brings with it other important advantages. Since the beam is instantly reversible, less time is wasted in beam rotation, and , because less than 180 degree rotation is required, you can use low-loss, open-wire feed lines as well as simpler and cheaper methods of beam rotation. The direct relationship between the size and performance of large beams is well known, and some readers may find it difficult to accept that a small beam can be as good as a big one, particularly if those readers have experience with typical small beams using large loading inductances. The claim is, on the face of it, improbable, and one might think that it could be dismissed by invoking some general scientific principle, as in the case of perpetual motion. Looking for such a principle we come instead to the surprising discovery that, although the gain of *big* beams is limited, there is absolutely no limit to the *theoretical* gain from an antenna, *provided it is small enough*! You would be justified in some skepticism at this point, since it turns out that gains much in excess of 6 dB are impracticable unless the boom length is increased to half a wavelength or more. It is

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possible, though, to go down in size to about 3 meters square (10 feet square) without dropping below about 4.5 dB gain.

If such statements are found puzzling, it is probably because of the failure in most of the literature to distinguish between two completely different methods of beam formation, additive and subtractive. The subtractive method is typified by the W8JK array, and, as I have shown elsewhere,[3,4] most amateur high-frequency beams can be regarded as derived from or related to this array. The radiation patterns are calculable without using any variable other than the direction. Therefore, the gain is independent of size, provided the efficiency remains high enough to ensure that most of the power is radiated. It is this constraint, allied with the need for adequate bandwidth, which in practice limits the gain of subtractive beams to about 6 dB.

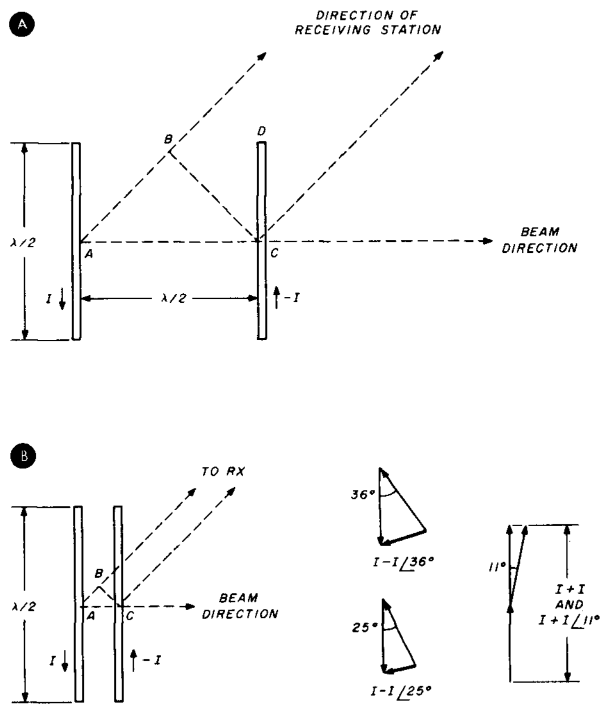


fig. 1. In (A), the elements are fed 180 degrees out of phase so that the fields add in phase along the line at right angles to the elements. A receiver located 45 degrees off the main beam sees a phase difference corresponding to AC-AB, *i.e.*, 54 degrees, causing a drop of 4 dB in signal level in addition to the 3 dB which would be expected for a single element. Thus, the use of two elements has produced a narrower beam by virtue of the wide spacing. For subtractive gain, as shown in (B), the elements are closely spaced. Radiation would be cancelled except for a small phase shift of which the maximum value corresponds to the distance AC, or 36 degrees for a spacing of $\lambda/10$. At 45 degrees to the beam, the phase shift is reduced by the ratio of AB to AC (11 degrees), which translates into a 3-dB drop in signal level. If the fields are additive in the wanted direction, the 11-degree shift is of no consequence and the radiation pattern becomes that of a single dipole.

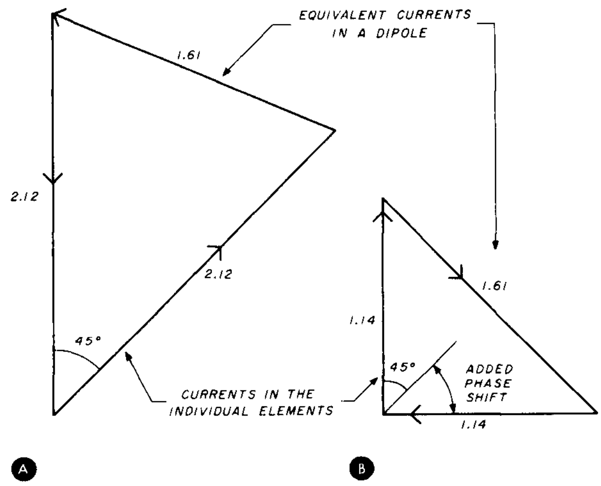


fig. 2. Method for estimating gain from the radiation resistance. Diagram (A), which is drawn to scale, shows how the W8JK element currents of 2.12 amps "add" to give the equivalent of 1.61 amps in a single element. The currents are correct for a radiated power of 72 watts. This would produce a current of 1 amp in a dipole, so that the voltage gain is 1.61, *i.e.* 4.2 dB. (B) shows how if one element is given a phase lead equal to the spacing, only about half as much current is needed to produce the same field strength. In each case, the current is obtained from $I = \sqrt{P/R}$.

The following discussion is intended to provide further insight into the problems of designing small beams, so that you can make your own choice from the available options and then design the "best-possible" beams for the space and facilities you have available. Practical details and some performance data are given for a number of designs, but these are intended as guidelines and not as blueprints. Although the feasibility of the 3 meter square (ten foot square) design has been proved, my own preference, given the space, is a 5.2 meter square (17 foot square) 3-element design, which, besides providing slightly more gain and greater bandwidth, lends itself to a particularly light form of construction and easier methods of achieving multiband operation.

It is a strange paradox that the main advantages of increased size relate to operation at the higher frequencies, to the extent that considerable extra gain can be obtained at 28 MHz by using full-size, 14-MHz elements. For no reason that I can discover, this advantage is usually thrown away by using traps or nesting to "cut the elements down to size" at the higher frequencies.

gain variation vs antenna size

Gain results from concentrating the radiation in one particular direction at the expense of other directions. This can be achieved by arranging more-effective addition or, as with the W8JK, less-effective cancellation of radiation for the wanted direction. Addition requires wide spacing, as in **fig. 1A**, where the elements are arranged so that their fields add in phase for the wanted direction. Viewed at an angle of 45 degrees to the line of fire, the elements are closer together by 0.29 wavelength, which translates into a phase shift of 104 degrees and a corresponding drop of 4 dB in signal level. This drop of course, is in addition to the $\cos \theta$, or "angle to the wire" effect, which applies equally to beams and dipoles and amounts to -3 dB at 45 degrees. But for the wide separation of the elements, there would be no phase shift, no narrowing of the radiation pattern, and hence no gain.

On the other hand, given an array of n elements sufficiently far apart for mutual interaction to be ignored, we can provide each $1/n$ of the power. Since the voltages at the receiver add in phase, there is a power gain equal to the number of elements. Because the antennas have to be separated by at least $\lambda/2$, it turns out, not surprisingly, that gain is proportional to size. During reception, such an antenna collects most of the energy contained in the volume of space which it occupies, thus giving rise to the concept of aperture, for which it is sometimes claimed "there is no substitute." It is perhaps difficult to conceive that a tiny beam can collect as much energy as a big one, but the explanation lies in the high Q of the smaller antenna. Just as tuned circuits couple together more tightly when their Q is increased, so reduction in the radiation resistance is accompanied by "tighter coupling" of the antenna into the surrounding space.

To understand the mechanism of small beams, the W8JK system shown in **fig. 1B** is the easiest starting point. Radiation would be completely cancelled in all directions except for that caused by the phase shift, which results from the elements not being exactly the same distance from the receiver. Field strength is proportional to the apparent separation AB, which, like the radiation from a single element, varies as $\cos \theta$. In simpler language, the field strength, at a given distance and direction, is proportional to the apparent length multiplied by the apparent separation of the elements. The separation factor applies equally in a plane at right angles to the diagram, so that the radiation pattern of a horizontal W8JK array is given by $\cos^2 \theta$ in the horizontal and $\cos \theta$ in the vertical plane. For a single horizontal wire, the pattern is $\cos \theta$ in the horizontal plane and an omni-directional pattern in the vertical plane. The important point to note is that none of these patterns contain any reference to the dimensions, though we are of course assuming them to be small. In fact, the conclusion that gain is independent of size turns out to be accurate within about 0.5 dB for spacing up to $\lambda/4$ and element lengths up to just over $\lambda/2$. Up to these sizes, each element behaves in the same way, *i.e.*, as a "point source" of energy. It is only when an element is very large that appreciable extra gain, or directivity, can

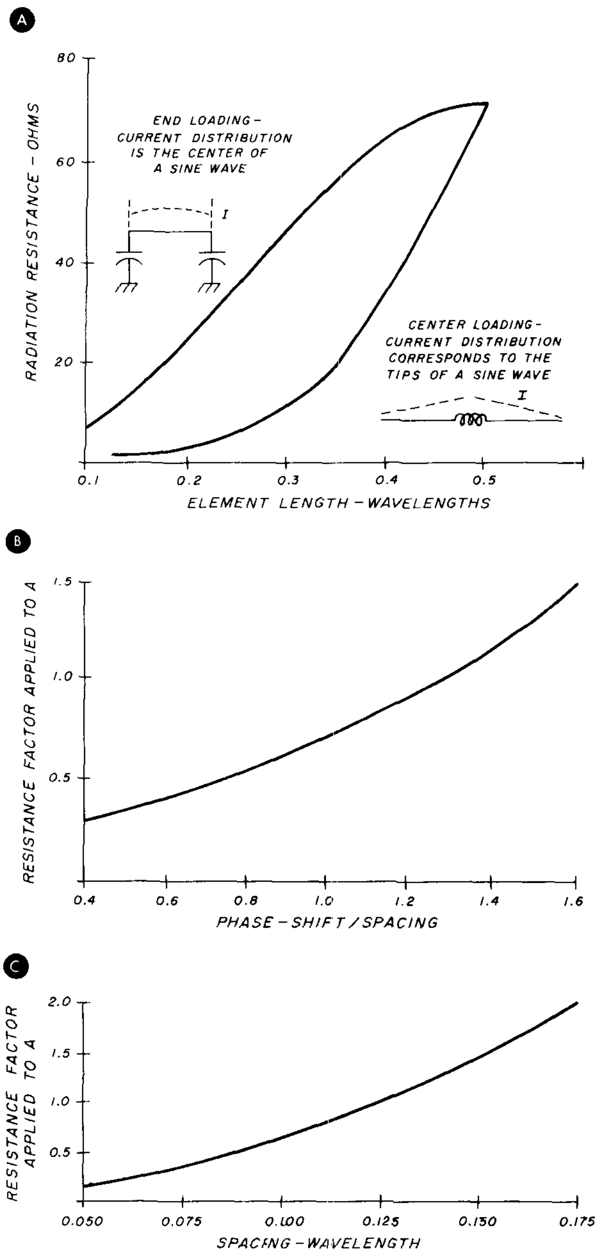


fig. 3. Graphs for determining the radiation resistance of short elements. (A) shows the variation of radiation resistance with both end and center loading. The multiplying factor [see (B)] is used to give the sum of the radiation resistance for a pair of elements with $\lambda/8$ spacing. For miniature beams, such as those shown in figs. 9 and 11, this approximates to the impedance seen by the feeder going to the front element. The value for spacing is converted to the same angular units as the phase shift, which is relative to the condition 180 degrees out of phase. The third chart, (C), is an additional factor which is used if the spacing is other than $\lambda/8$.

be expected, as for example when a 14-MHz element is used as two half-waves in phase on 28 MHz. It should be obvious from inspection that quad loops, even full-sized ones, do not meet this condition.

To prove the point, there is no harm in treating the loops as a pair of stacked dipoles. Various handbooks provide data indicating that the stacking gain for $\lambda/4$ spacing is only 1 dB. However, some of the 1 dB is lost by bending over the ends, since a half-wave dipole has only a small gain (up to 0.4 dB) when compared with shorter dipoles; a further small amount is lost due to radiation off the ends. Even more is lost when parasitic elements are added, since the stacked dipoles then become stacked yagis, and, according to the usual rules, the higher the gain of individual antennas the further apart they have to be placed in order to achieve an appreciable stacking gain.

It is unfortunate that many wild claims have been made for the quad, some of them involving professional journals and computer studies. It needs to be stressed that measurements are very difficult and computers need to be asked the right questions. The habit of accepting figures without checking them against ordinary common sense is not confined to the Novice! In fact, as I have found, better low-angle gain is obtained by omitting the lower halves of quad loops and using the upper halves as inverted V or U elements. This increases the mean height by 2.4 meters (8 feet) at 14 MHz; low-angle gain for a flat, unobstructed site being proportional to antenna height, this more than offsets any slight loss of free-space gain for heights up to about 21 meters (70 feet)!

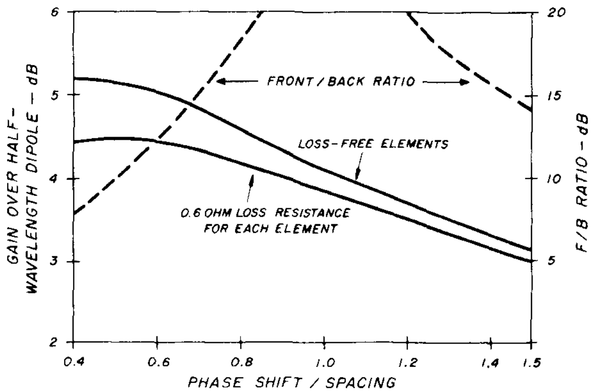


fig. 4. Gain and front-to-back ratio for the two elements, with and without losses. Loss resistance per unit of conductor length is inversely proportional to diameter and directly proportional to the square root of the frequency. The figure of 0.6 ohm is based on a half-wavelength of no. 12 AWG (2.1-mm) wire having a sinusoidal current distribution at 14 MHz. The element currents are assumed to be equal. The upper gain curve is for loss-free elements, while the lower is for 3.7-meter (12-foot) elements spaced at 2.4 meters (8 feet).

The real advantage of the quad is the large amount of extra gain (3-4 dB) obtainable by using the 14-MHz elements at 28 MHz with suitable resonators so that they become a "Bi-Square," but this is rarely exploited. Another frequently made claim, that the quad provides better DX signals by "lowering the angle of radiation", is also without foundation; the lobes of practical antennas are too broad to discriminate between direct and ground reflected waves which must always interact in the same way, resulting in a loss at low angles unless the antenna is very high or the ground sloping. To obtain the effective gain at a low angle of radiation, the free-space gain is multiplied by the ground reflection factor, which, for horizontal antennas, depends only on antenna heights and radiation angle, being the same for a quad, yagi, dipole, small rhombic, or even a minibeam!

The 4-dB gain of the W8JK can be estimated very roughly from the 3-dB widths of the radiation patterns discussed earlier, or, more accurately, from mutual-impedance data. For $\lambda/2$ dipoles spaced at $\lambda/8$, mutual impedance is 64 ohms, which has to be subtracted from the self-resistance of 72 ohms so that for each element the radiation resistance is 8 ohms. If the power available is 72 watts, you would have a current of 1 ampere in an ordinary dipole, or 2.12 amps in each of the W8JK dipoles. The phase difference due to spacing is 45 degrees, and, by "completing the triangle" as in **fig. 2**, you'll see that the distant field is the same as that which would result from 1.61 amps in the dipole, *i.e.*, there is a voltage gain of *1.61/1* or *4.2 dB*.

Now, if the phase of the current in one element is advanced by an amount corresponding to the spacing, the total phase shift becomes zero for one direction and is doubled for the other direction. The resultant unidirectional (cardioid) pattern would require only about half the current to produce a given field strength. It happens (by coincidence) that the gain is unchanged, so that the effective radiation resistance has been multiplied by about four, proving that the beam can be made a lot smaller with the same results. **Fig. 3**, adapted from references 3-6, shows how radiation resistance varies with element length, spacing, and phase angle, from which it can be seen that *provided you shorten the dipoles by sacrificing the ends and not the middle*, the length can be reduced to 37 per cent of a half-wavelength before the radiation resistance drops to its W8JK value, giving a length of only 37 meters (12 feet) at 14 MHz. This reduction in size could be carried out by taking the W8JK beam and folding its ends to fit the available space. Whether or not the example can be improved upon, it does demonstrate that *if* the W8JK beam works properly you could expect to be equally successful at 14 MHz with a 3.7 × 2.4 meter (12 × 8 foot) miniature beam which has been adjusted to give a large front/back ratio.

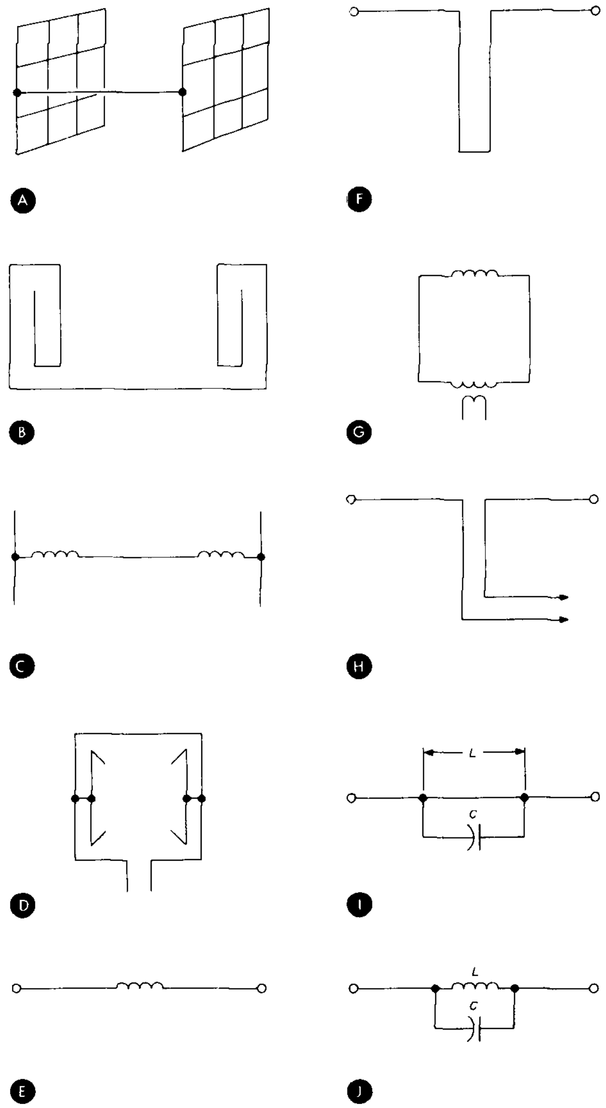
Thus, changing the size does not alter the gain, but, obviously, *if the length or spacing is halved*, the current must be doubled to maintain a constant signal, so that the radiation resistance has been divided by four. In the same way, you could alter the shape to just under 3 meters square (10 foot square) without affecting matters in any way, save that the diameter of turning circle is slightly decreased and it becomes easier to handle the ends.

Whatever shape is selected, radiation resistance may be obtained by multiplying the resistances plotted in **fig. 3A** by the factors obtained from **figs. 3B** and **3C**. This is not quite the full story, since, as demonstrated by **fig. 3** and **4**, an extra dB of gain results from using an intermediate value of phase shift. However, this halves the radiation resistance and doubles any power loss. From the lower gain curves in **fig. 4**, it can be deduced that for a 3-meter-square (10-foot-square) 14-MHz beam, using no. 12 AWG (2.1-mm) wire elements with bent ends, a net gain of 4.5 dB should be obtained after allowing for resistance losses. There may be a slight additional loss due to the "short dipole" effect mentioned, but this is caused by a small difference in the amount of endwise radiation and is much less in the case of a beam.

To put this into perspective, the maximum gain theoretically possible for a three-element parasitic array on a quarter-wavelength boom is 7.5 dB, but in this case , the radiation resistance is only 4 ohms (even less than that of the small beam), and the maximum gain normally found in practice[7] is less than 6 dB. Theory goes on to predict a possible gain equal to the square of the number of elements,[3] but before getting far along this road you're faced with huge currents and voltages, infinitesimal radiation resistances, and microscopic tolerances to the extent that the 6-dB figure is unlikely to be exceeded in practical rotary beams for 14 MHz without increasing the boom length to at least $\lambda/2$, which is sufficient to provide some "additive" gain. Reducing the size below 3 meters square (10 feet square) leads to a similar rapid increase of practical difficulties. And, as I shall point out later, there are substantial advantages, particularly for multiband operation, in an increase to about 5.2 meters square (17 feet square).

Limitations on the reductions possible in antenna size result from the following:

1. Drop in efficiency, *i.e.*, the radiation resistance becomes comparable with the losses. This is basic and imposes a well-defined, practical limit.



A Capacitance plates consisting of wire grids
B Half-wavelength elements with folded ends. The length must be increased slightly to maintain resonance.
C Small capacitance hats — the effective capacitance is enhanced by near resonance with the inductors
D A loop with capacitance hats. This is equivalent to a stacked pair of **B**-type elements with their ends in contact.
E Center loading with an inductor
F A half-wavelength element with a folded center. This is similar to E with a stub instead of the coil. However, the R values from **fig. 3A** are transformed by the stub to give an even lower value at the closed end of the stub.
G Loop equivalent to **E**
H Resonant feeders
I Version of a two-band element as used by DL1FK. The capacitor tunes the inductance of the center of the radiator to increase its effective value at the lower frequency. Series resonance of the capacitor with its connections shortens the electrical length for the higher frequency.
J Lumped circuit equivalent of **I** as used in one form of the G4ZU minibeam.

fig. 5. This figure shows ten different methods for loading short elements. The merits of each type are discussed in the text.

2. Narrow bandwidth — the acceptable lower limit depends on the skill of the designer and the skill plus patience of the operator.

Short elements have to be loaded to bring them to resonance. The aim must be to keep the radiation resistance high, which requires end loading, and the loss resistance low, which rules out the use of lossy devices such as coils or long resonant feeders. **Fig. 5** shows ten methods that have been used, with only **5A** through **5D** meeting the radiation resistance requirement. The others tend to be more convenient, but use the triangular tips instead of the center of a sine-wave current distribution, thus halving the average current and dividing the radiation resistance by four, besides requiring an inductive and therefore relatively lossy loading device in the center. Of these methods, **5F** is open to least objection, since stubs have less resistance than coils; **5H** is particularly bad, since it multiplies the losses of **5F** by the total number of half-wavelength in the resonant system. Methods **5I** and **5J** are used for multibanding,[8] which necessarily adds to the losses because of circulating currents in the resonators. Methods **5E** to **5H** are therefore applicable only for very modest reductions in antenna size.

Of the remainder, **5C** makes use of small end-loading capacitances which have their effective values greatly inflated by near resonance with the inductors. In one typical design, the total inductance is about 14 μH, so that for a Q of 200 the loss resistance would be 6 ohms and more or less comparable with the radiation resistance, the element lengths being 3.7 to 4.3 meters (12 to 14 feet). **Fig. 5A** is ideal insofar as there is negligible loss in the capacitance, but it is difficult to achieve enough loading, so that some inductance on the lines of **5C** is likely to be required; in this case, however, it could take the form of short stubs and the losses would be minimal. Arrangement **5B**, consisting of a half-wavelength dipole with its ends bent over, is very similar, but simpler and equally efficient. The bent ends are not, of course, pure capacitances and there are losses, but, as has been seen, this method allows high efficiency to be maintained down to very small beam sizes. Efficiency can be estimated with the help of **fig. 4**.

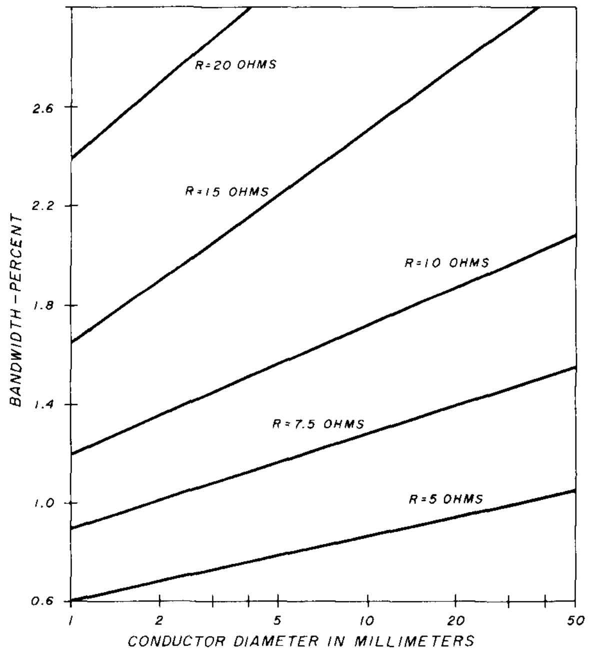


fig. 6. Bandwidth of folded $\lambda/2$ wires at 14 MHz for different values of radiation resistance, plus loss resistance. The curves are calculated for an SWR of 2:1 at the band edges, neglecting any change in Z_a caused by folding. For a coupled pair of elements, the bandwidth for a given R is increased slightly.

Another efficient type of small element is the capacitively loaded loop shown in **fig. 5D**. Loops with 3.2-meter (10.5-foot) sides have been used by G3YDX for a 14-MHz, two-element beam,[2] and a design patented by G3IMX achieves two-band operation by using traps to remove the loading at the higher frequencies. For a single 3.7-meter (12 foot) loop, the radiation resistance is 75 ohms. About 20 ohms could be expected for a 1.8-meter (6-foot) loop, the loss resistance (referred to the feedpoint) probably being about 2 ohms. My own attempt to compress a 14-MHz quad into a 1.8-meter (6-foot) cube was unsuccessful, but I still think it might be achieved with rigid, all-metal construction and inductive loading stubs, plus sufficient ingenuity. The problem is to dispose of enough loading in the space available. In this case, neutralization will certainly be required as the lower physical limit is approached. Neutralization will not be required with 3-meter (10-foot) loops, as sufficient loading can be achieved within the plane of the loops without bringing ends into proximity.

It is important in all cases to arrange the loading so that wires carrying appreciable current are not doubled back in a direction parallel to the driven element, in which case they subtract from the wanted radiation, bringing the radiation resistance "down with a bump!" This constitutes one of the main problems of construction.

bandwidth

The bandwidth of a dipole may be roughly estimated from the radiation resistance (R) and the characteristic impedance (Z), which depends on the ratio of length to diameter. Each per cent of detuning produces a reactance of $0.015 \cdot Z$ ohms; and the 3-dB bandwidth points (corresponding to an SWR of 2:1) may be found by equating this to R. Bandwidths are plotted in **fig. 6** for 14-MHz dipoles of various wire diameters. The figures should be valid, as an approxi-

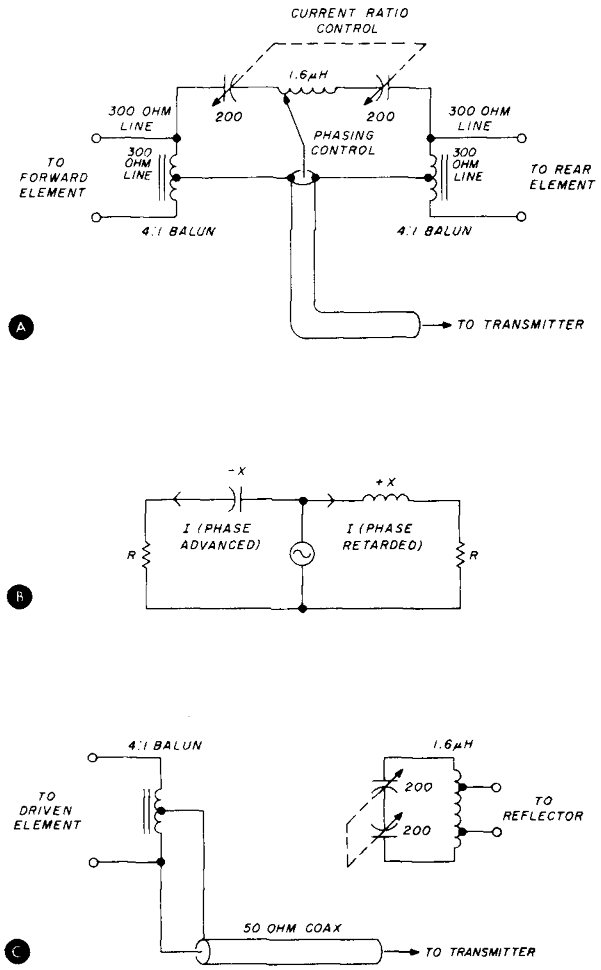


fig. 7. The top illustration shows a practical arrangement for a 14-MHz phasing control. The beam reversing switch, though not shown, interchanges the feeders. This circuit may be usable to 28 MHz, but the inductance should be reduced to about 0.8 μH; some experimentation with values may be needed. The principle of operation is demonstrated by (B); as shown the load currents are equal and the ratio of X/R determines the phase shift. If, as is more usual, the loads are unequal, current equality may be achieved by adjustment of the reactances provided in (A). The components of (A) can also be rearranged as a tuner for a parasitic type of beam [see (C)].

mation, even when the dipoles are folded as in **figs. 5B** or **5F**. When two elements are assembled to form a beam, the bandwidth is reduced because of the drop in R, though, for a given value of R it is increased and could be almost doubled by virtue of the "coupled circuit effect."

It is important to distinguish between three kinds of bandwidth:

1. The pattern bandwidth — the bandwidth over which the radiation pattern and gain are satisfactory

2. The bandwidth for satisfactory SWR

3. The bandwidth over which the antenna is usable subject to adjustments that can be carried out without leaving the shack.

To illustrate, one element of the first version of my small beam had an intrinsic bandwidth (as calculated) of about 450 kHz. The completed minibeam, using a parasitic reflector, had a useful bandwidth of only about 200 kHz; at one edge the front/back ratio had dropped below 8 dB and at the other edge the gain had dropped by 1 dB. In wet weather, due to an inadequately treated bamboo spider, the tuning shifted 200 kHz low, outside the desired range. In contrast, with the second version the useful bandwidth was only 130 kHz. However, it was desirable to keep within about 20 kHz of the tune-up frequency. But, by using separate feeders to each element, the beam was tunable to any frequency in the 14-MHz band either as a driven array or a driven element plus reflector. So, for practical purposes, despite the smaller intrinsic bandwidth, the useful bandwidth was greater.

With the parasitic reflector, the phase-shift is related to the ratio of reactance to the total resistance, R, of the reflector, and, in addition, must meet the requirement for reasonable gain in accordance with **fig. 4**. Although the actual relationship is much more complex, a rough idea of the bandwidth for useful performance can be obtained as follows. Referring to **fig. 4**, we might decide that performance is acceptable for values of phase shift from one half up to one and one half times the spacing, which means from 25 to 75 degrees in the case of a spacing of 3 meters (10 feet). At 25 degrees, the front-to-back ratio is down to 10 dB and the radiation resistance (**fig. 3**) is getting very low, while at 75 degrees the gain is down to 3 dB. Phase shift is partly due to X, and partly to the mutual reactance between the elements, which, in this case, takes care (more or less) of the required mean value of 50 degrees. The maximum allowable shift of ±25 degrees occurs when X/R is roughly equal to this angle (measured in radians), *i.e.*, $X = R/2$. From **fig. 3**, $R = 15$ *ohms* and for $Z = 1000$ *ohms* (a typical value) a reactance $R/2$ results from ±0.5 per cent detuning, *i.e.*, the bandwidth is 1 per cent or 140 kHz, in good agreement with the observed figure of 175 kHz (*i.e.*, 14.300-14.125) from **fig. 10**.

The first version of the small beam was 3.7 meters square (12 feet square), which would be expected to double the radiation resistance and bandwidth; in this case, too, the calculations are in line with the observed performance and there was good agreement in regard to the observed bandwidth for a 20-dB front-to-back ratio. From **fig. 4**, the theoretical 20 dB points correspond to a change of ±18 per cent in phase angle, or 36 per cent in reactance, *i.e.*, 6 ohms, which translates into a bandwidth of 0.4 per cent, or 56 kHz in comparison with a measured figure of 55 kHz; however, this must be regarded as coincidental, since both figures are very rough.

phasing

It is essential for the currents in the elements to be equal (or nearly so), as well as correctly phased. With parasitic arrays there is usually no independent control of these quantities, though equality tends to be achieved in the case of quad reflectors. With $\lambda/2$ dipole elements the inequality, though it degrades the front/back ratio, does not upset gain to a serious extent. In contrast, the small-beam elements behave as overcoupled circuits resulting in large ratios of reflector to driven element currents.

Neutralization allows the coupling to be reduced to any desired extent, so that it can be adjusted in conjunction with the tuning of the reflector to obtain equal currents with any required value of phase shift. In this way, very deep nulls can be obtained in one or more back directions without resorting to driving both elements. This is subject to a number of assumptions: For example, the neutralization, which has to be adjusted at ground level, must remain "right" when the antenna is raised to its full height, at all frequencies, and in all types of weather.

A driven arrangement with provision for adjustment of phases and amplitudes is obviously more versatile and allows compensation for considerable errors in tuning or neutralization, but the methods usually employed for driven arrays are based on false assumptions that are particularly disastrous in the case of small beams with reactively coupled elements. It is usually assumed, for example, that $\lambda/8$ of line provides a 45 degree phase shift — which is true if the lines are perfectly matched. But often there is little attempt at matching, which will, in any case, be upset if the phasing is adjusted. A further difficulty is that for the elements to have equal impedances the mutual coupling between them must be a pure resistance, a condition that applies in practice only for straight $\lambda/2$ elements spaced just over $\lambda/8$. This, incidentally, is an important special case since it is then easy to calculate gain and radiation resistance.[3,5] Having established that gain is independent of size, the numbers obtained can be applied to other sizes on the basis of **fig. 3**.

If there is capacitive reactance coupling, as happens with wider spacing or miniature elements, the radiation resistance of the reflector may be zero or even negative, in which case its feeder returns more power to the transmitter than it receives! Matching is clearly impossible under these conditions. The method I use, which can take various forms,[6,9] is based on resonance; in **fig. 7**, the two feeders are connected through a series-resonant circuit and the complete system, minus the connection to the

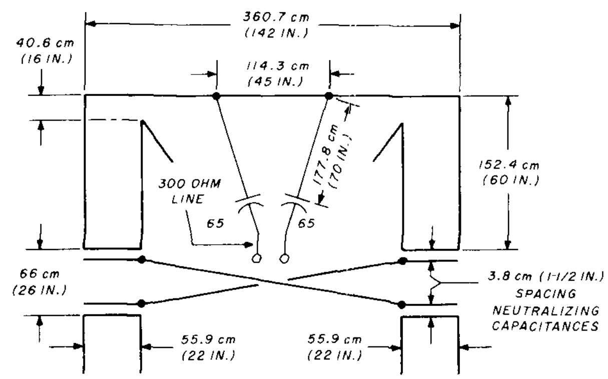


fig. 8. Original version of the small beam showing one element plus the neutralizing wires. The elements are identical, with a wire length of 11.4 meters (37.3 feet). For initial adjustment, one element without the feeder may be tuned as a parasitic reflector, in which case the length is about 10.9 meters (35 feet, 10 inches). The elements and neutralizing capacitors are made from no. 14 AWG (1.6-mm) wire, but the delta match and neutralizing cross connections can be made of a lighter gauge wire. The spider projects beyond the elements, which are suspended by lengths of polyethylene cord.

transmitter, is made resonant. Phase-shift is obtained by off-center connection of the feedline from the transmitter. If necessary, element currents can be made the same by detuning the series circuit so that one element or the other is brought closer to resonance. Matching should be carried out to reduce the SWR in the line to the forward element, a high SWR in the reflector line being of no importance as there is very little power transferred along it. Crossover of the elements as with the W8JK, though normally essential with full-sized elements, is sometimes not required when coupling to highly reactive elements. Using this arrangement, it has been possible to work with different or even unequal lengths of feedline, and to compensate for quite large errors of adjustment, though never to the extent of being able to use it as a substitute for neutralizing. The beam can be reversed either by interchange of feeders or moving the coil tap. It is possible, in principle, to null out from any given direction "off the back." A curious feature of reactive coupling is that, despite the remarkable effect it has on relative impedances, the *sum* of the two radiation resistances is not affected; for **fig. 3** to have universal application, it was therefore necessary to plot the sum and not the individual resistances. The sum is in any case a more useful figure for the present purpose since it is into this value that the feeder for the front element has to be matched (so that the antenna impedance is "repeated" in the shack). It is often possible, particularly if the feeder length is a whole number of half wavelengths, to use the phasing circuit with very little modification as a remote tuner for driven element and reflector operation (see **fig. 7**); this reduces the

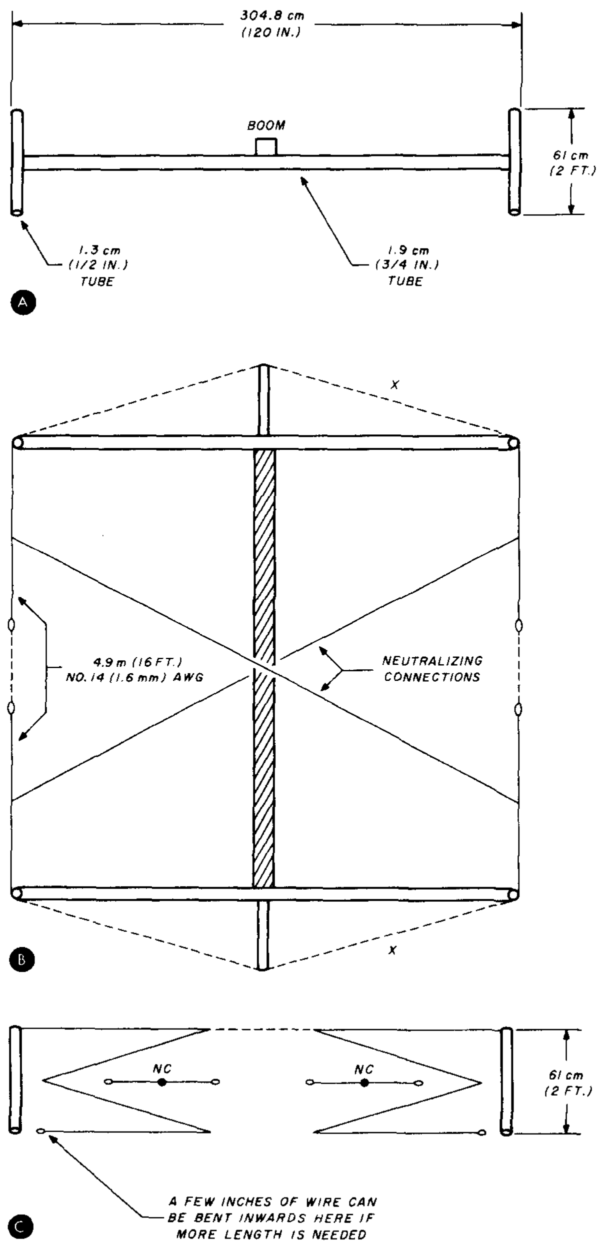


fig. 9. Construction details for a 3-meter-square (10-foot-square) beam for 14 MHz. The front, plan, and side views are shown in (A), (B), and (C), respectively. In (B), the bow-string-type arrangement is used to counter the pull of the loading wires and to allow the use of lightweight elements. Each neutralizing capacitor, as shown in (C), is approximately 0.6 meter (1.9 feet) long. If greater wire length is needed, additional wire can be added as indicated in (C).

number of knobs and has proved more convenient in practice, provided the neutralization is reasonably accurate. It has been found that, although small differences can be compensated, care in making the elements identical pays big dividends in convenience of operation, since it allows beam reversal with no change of tuning or matching. One can tune for a minimum on either the wanted station or an interfering signal from the back direction, using the reversing switch as required.

practical designs

Several construction methods have been used.[10] **Fig. 8** gives the dimensions of my first small beam, the elements being suspended by thin polyethylene cords from a six-armed spider made from bamboo garden canes which extended just beyond the wire. The two central arms were required to counter the inward pull of the folded sections. One element was driven using 300-ohm line with a delta match having series capacitors to tune out the reactance. I tried to tune the other for a null in the back direction, but this was barely perceptible. Current in the reflector was found to be higher than that in the driven element, so the neutralizing capacitance (formed by parallel wires) was increased by reducing the spacing, retuning the reflector, and adjusting the driven element for lowest SWR at each step. Eventually current equality and a good front-to-back ratio was achieved. At a height of 16.8 meters (55 feet) the antenna was compared with a two-element quad at 13.7 meters (45 feet) and appeared to be at least as good.

Mention has already been made of bandwidth and wet weather problems. It quickly became obvious that two feeders would have to be used. To save cost, I used the transparent, plastic-type of 300-ohm line; lacking previous experience with it, I was unprepared for the rapid deterioration, which caused a lot of confusion. Later, good results were briefly obtained using a pair of 600-lines.

However, mechanical problems arose and the next step was a new design using metal construction with 3-meter (10-foot) elements made from 19-mm (0.75-inch) tubing. Short vertical rods at the ends of the elements (see **fig. 9**) act mainly as brackets for supporting wire zigzags. I found that, because of limited space, almost as much wire was needed as in the original design so that the use of tubing provided no electrical advantage apart from getting rid of "wet weather" effects caused by the bamboo. To avoid the need for heavy-gauge elements, their ends were guyed back with polyethylene cord to the boom extensions, thus countering the inward pull of the loading wires. Two open-wire feedlines were used.

Some typical measured performance figures are shown in **fig. 10**. On-the-air performance was down compared with earlier results, on average about 2 dB; this might be due to the smaller size (radiation resistance being halved) in addition to closer proximity to tree branches, the mast being slightly shorter due to breakage and splicing! Another uncertainty arose from loss of the quad as a standard of reference; the 3-element beam, though equal to the quad in performance, was so placed that it tended to screen the smaller beam. I could not be certain that rotation to an end-on position was removing all this effect. From this, I felt that the best test for the small beam would be as a direct replacement for the larger one. Now, however, I used a new multiband version, the disposition and loading of the elements for 14 MHz being as shown in **fig. 11**.

For such tests my yardstick for many years has been another station using a TH6 at 11.6 meters (38 feet) and with a slightly better location for VK (long path) over which most of the tests were made. With the small beam at 14.6 meters (48 feet), I was able, for the first time on record, to equal the signals of the other station on three consecutive days. Normally with a quad at 12.1 meters (40 feet) I should be down in most cases by 1/2 to 1 S-unit. Added to the initial results of the first small beams, this would provide substance for a claim that small beams, given a few feet of extra height, are actually better than big ones! Unfortunately, such a claim could not be supported by theory or common sense, but I was confirmed in my belief that the small beam can be made fully competitive.

Any type of feeder can be used, but, because of its lightness, good-quality 300-ohm line can be recommended as an alternative to open-wire line. I have also used 50- and 75-ohm coax with 4:1 baluns and delta matches identical to the one shown in **fig. 8**.

three-element beam

A starting point for this development was the original VK2ABQ design[1] in which a quad loop lying on its side is converted into a two-element beam by insulators in the sides. The rather wide spacing ($\lambda/4$) unfortunately means that performance is slightly worse than the best that can be achieved with two elements, and it seemed logical to me to put a third element in the middle. No increase in the diameter of the turning circle dictated a maximum element length of 7.3 meters (24 feet). With some end loading by vertical rods and the use of linear resonators, I was able to design a triband element (see **fig. 12**) having almost as much radiation resistance as a full half-wavelength at 14 MHz, higher radiation resistance than a normal element at 21 and 28 MHz, a small amount of extra gain at 28 MHz, and no trap losses.

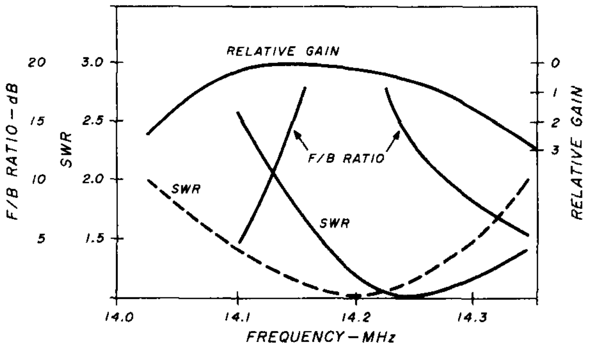


fig. 10. Typical performance of the 1-meter-square (10-foot-square) beam. All parameters were measured with the beam at a height of 2.1 meters (7 feet) and the reflector tuned for 14.2 MHz. The dotted curve shows the improvement in SWR after adding 10 cm (4 inches) to each end of both elements and retuning the reflector for best front-to-back ratio at each frequency. Note: The gain curve is listed as dB down from the maximum.

Tubing was used for this element, but retention of bent wire elements for directors and reflectors made engineering sense, since these elements have less current flowing in them and a lot of cost and weight could be saved. The next step was to eliminate the quad spider by using the driven element as one diagonal of a square and making it support the ends of the parasitic elements which were now V shaped instead of U shaped and filled in the sides of the square as shown in **fig. 12C**. The other diagonal became the "boom" and consisted of two 2.4-meter (8-foot) bamboo garden canes joined by a length of aluminum, supporting the apex of the Vs.

V-shaped elements are not suitable for multibanding by the methods used for the driven element, and ordinary traps would be unsuitable for suspension in wires supported by such a light framework, as well as being too lossy. I therefore used separate elements for each band with their ends strung out to different points on the vertical loading rods of the driven elements in the hope that this way they might not get entangled! Though somewhat haywire, this arrangement has unexpectedly survived two severe storms and, although it needs a lot of tidying up mechanically, comes fairly close to the ultimate in lightness combined with high performance. Details in **fig. 12** should assist any reader wishing to experiment on similar lines. Despite the larger size, the overcoupling problem was not completely avoided and there was some slight difficulty in adjusting the 14-MHz reflector, but this was overcome by increasing the spacing slightly as indicated in fig. 12C.

The linear resonators work as follows.[9,11] The inductance L_{AB} of the central portion (AB) of the element is tuned to resonance by C1 so that it acts as insulator for 28 MHz, making the element two half-waves in phase. At 21 MHz, about half of C2 serves to eliminate the inductance by tuning it to parallel resonance, with the remainder used to series resonate the inductance (L_O) of the outer portions of the element, L_{AB} and L_O chosen to be roughly equal. At 14 MHz, the capacitors are virtually "not there," their values at 21 and 28 MHz having been inflated by series resonance with their connections, and consequently AB no longer acts as a tuning inductance

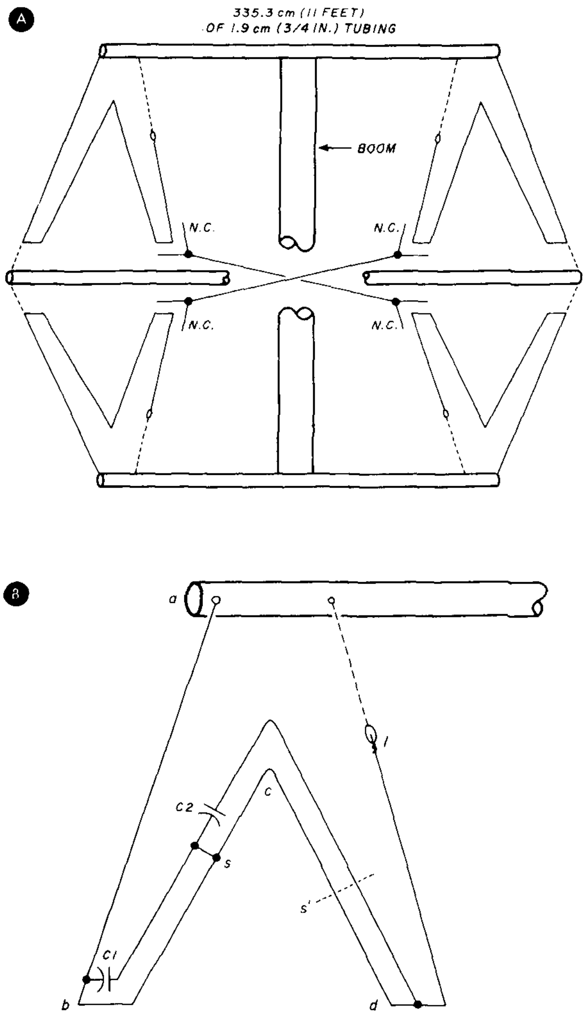


fig. 11. This is an alternative form of the beam shown in fig. 9. In this case (A), the elements have been folded in a horizontal plane to avoid any vertical projections. The metal supporting strut in the center of the boom also serves as a 21/28-MHz driven element in the multiband version. The detail shown in (B) illustrates the arrangement for multibanding with linear traps. Moving the shorting bar from *S* to *S′* results in an improved trap for 28 MHz, but separate parasitic elements must then be used for 21 MHz. For monoband 14-MHz operation, the capacitors are omitted, but extra wire may be needed to obtain sufficient loading. The wire lengths, *a, b, c, d,* and *e,* are all equal and approximately 35.6 cm (14 inches). C1 and C2 use the wire segments *bs* and *sd* to form the linear traps for 28 and 21 MHz respectively.

but reverts to its normal role as the "middle portion of a dipole." This process is accelerated by mutual coupling between the capacitive and inductive branches of the resonators. Values for C1 and C2 are critical and I used selected capacitors slightly lower than the required values (about 10 pF and 20 pF respectively) making up the difference with short, open-wire, adjustable stubs.

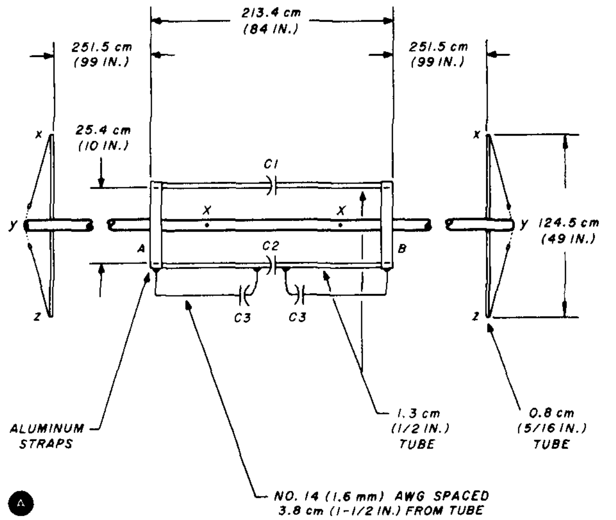
Although linear resonators have little effect at lower frequencies, the 21-MHz resonator in its simplest form has disastrous consequences at 28 MHz, where it looks like a rapidly varying inductance that results in a very narrow bandwidth. This problem is overcome by the capacitors (C3) which form additional linear resonators tuned somewhat above 28 MHz so that the effective inductance at 28 MHz is greatly increased without affecting 21 MHz. C3 is not critical. Using a grid-dip oscillator, the driven element should be tuned by adjustment of C1, C2, and the length of the loading wires to provide the required resonant frequencies, taking care to avoid spurious resonances. Using a pick-up loop with a rectifier and meter as a simple rf current indicator, currents in L and C1 at 28 MHz will be roughly equal and some four times greater than the loop current observed at point D, (see **fig. 12C**). At 21 MHz, currents in C2, L, and just outside AB can be expected to be roughly in the ratio 3:2:1. This is not critical, but any major departure could indicate a spurious resonance. It is important to ensure symmetry and this requires a balanced feed, not a gamma match.

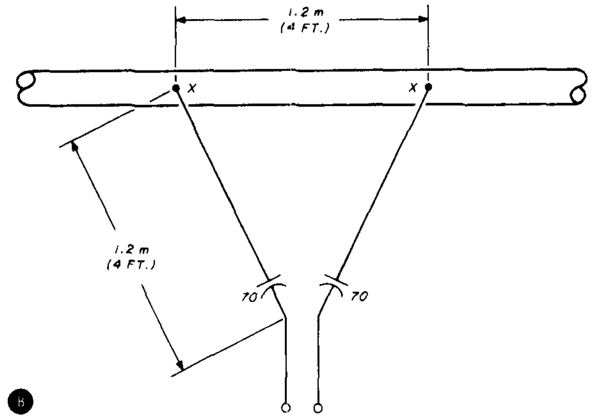
When tuning three-element antennas, there are many performance combinations, but I tended to aim for maximum gain in the 14.1-14.2 MHz region. This yielded the following typical performance figures:

Bandwidth for greater than 9 dB front/back ratio	200 kHz
Maximum front/back ratio	12-15 dB
Bandwidth for less than 1 dB drop in gain	230 kHz
SWR at band edges	2.0:1

Better front/back ratios and bandwidths were obtainable at the expense of gain, thus emphasizing the desirability of remote tuning; in this way it should be possible to achieve effective gains between 6 and 7 dB. I tried to achieve this by using a single pair of additional feeders, attached to coupling loops placed near the centers of each set of parasitic elements, but achieved only limited success. A practical, but rather cumbersome alternative is to use separate feeders to all elements.

At 21 MHz, the SWR was 1.5-1.6 over the whole band; front/back ratio increased with frequency from 13 to 16 dB, but was accompanied by an apparent 2-dB drop in gain. At 28 MHz, bandwidth for an SWR better than 2:1 was 350-400 kHz. Tuning for maximum gain at 28.5 MHz, there was a drop of 2 dB at 28.25 and 29 MHz. The front/back ratio rose from 11 dB at 28.5 to 15 dB at 28.9, but was down to 6 dB at 28.25 MHz. These figures have been selected as fairly typical from a wide assortment and the variations illustrate the degree of improvement to be expected from remote tuning. The linear resonator





	element lengths	
frequency	**reflector**	**director**
14 MHz	11.2 meters (440 inches)	10.8 meters (426 inches)
21 MHz	6.9 meters (272 inches)	6.3 meters (259 inches)
28 MHz	5.1 meters (202 inches)	4.8 meters (188 inches)

boom length from center of driven element to apex of Vs

frequency	reflector	director
14 MHz	4 meters (156 inches)	3.2 meters (126 inches)
21 MHz	2.6 meters (101 inches)	2.6 meters (101 inches)
28 MHz	2.2 meters (86 inches)	2.2 meters (86 inches)

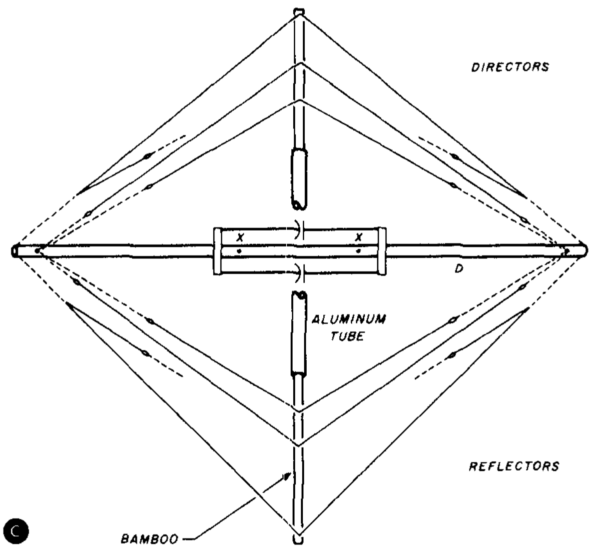


fig. 12. (A) shows the plan view of the driven element made from aluminum tubing, starting with 32 mm (1¼ inch), tapering down to 12.5 mm (0.5 inch) diameter. The feeder is connected to points *x,x* using the delta match shown in (B). Close examination of the end of the element may be necessary to fully understand the loading. Each vertical rod (*x,z*) is not only a help in providing the end loading, but is also used as an attachment point for the ends of the parasitic elements. Also attached to the vertical rods is the other portion of the end loading, short lengths [40.6 cm (16 inches)] of no. 14 AWG (1.6-mm) copper wire. These lengths are run from *x* and *z* to point *y, i.e.*, in the same line as the center element. The delta match detail is shown in (B). For open-wire line, the capacitors are omitted and the spacing is increased slightly. A plan view showing the parasitic elements is shown in (C). The elements are made from no. 14 AWG (1.6-mm) copper wire.

details shown in **fig. 12** are applicable also to "full-size" elements, a reduction in length of about four per cent being required due to the presence of C2.

Earlier I criticized trapped beams, but the situation is quite different with small elements, including the V-shaped parasitic elements of the beam just described. If the folded ends are left in place, at the higher frequencies they degrade performance because of an inefficient current distribution and by radiation from the ends. The only practical way to remove the excess capacitance is by means of traps, but ordinary traps result in appreciable losses even with full-size elements. And, as the radiation resistance drops, the power loss increases in the same proportion so that large losses can be expected. This problem can be resolved with the help of the linear resonator, which, instead of degrading the performance at 14 MHz, actually has a very slight beneficial effect by increasing the total capacitance.

Another problem is caused by excessive spacing between elements at the higher frequencies. This can be avoided by using a separate, centrally placed, driven element for 21 and 28 MHz, a coax feeder with 4:1 balun, and a delta match into a linear resonator, providing two-band operation. To keep within an area 3 meters square (10 feet square), long, vertical, loading rods would have been required, but I thought it was better to increase the element lengths to 3.4 meters (11 feet) and make full use of the 4.7-meter (15.5-foot) turning circle.

Multiband operation, with good front-to-back ratios, was obtained using traps as shown in **fig. 11B**, but on 21 MHz the bandwidth was too narrow to be acceptable. The structure was braced with a lot of cord ties and I was able to use them to support separate (wire) parasitic elements for 21 MHz.

Capacitive coupling from these into the driven element was excessive, however, and the reflector had to be neutralized. Bandwidth was still rather narrow and devious means were needed to achieve even enough remote tuning for band coverage (without beam reversal) on 21 MHz. Despite satisfactory performance, the design became too complicated to be recommended in its present form. It has nevertheless proved that the problem is solvable, and guidelines have been established for further experiments. In particular, I found that proximity between the 14 and 21 MHz parasitic elements (average separation less than 0.3 meter [1 foot]) had no effect on 14-MHz performance. One obvious solution would be the use of separate parasitic elements for the higher bands, stacked about 0.6 meter (2 feet) above and below the 14-MHz elements. Linear traps remain the neatest method, and from inspection of **fig. 11B**, it is obviously possible to increase the trap length (and hence the bandwidth) by using the entire available length for 21 MHz, in which case the 28 MHz traps would have to be accommodated within the 21 MHz traps. Experiments along these lines can be recommended to anyone who feels he has the necessary skill and patience.

Unfortunately, narrow bandwidth at 21 and 28 MHz, *in comparison with a monoband antenna of the same size*, appears to be a price that has to be paid for the multibanding of a "smallest-possible" beam. (It is also part of the price usually, but mistakenly, paid for the multibanding of full-size elements which, when used without traps, have very much higher radiation resistances at the higher frequencies.)

One practical point that must be stressed is the need for accurately maintaining the shape of the linear resonators. With separate feeders to each element, small changes in resonant frequency can, of course, be corrected from the shack, but any asymmetry causes the current maximum to shift toward one end of the radiator. Probably worse, a voltage will exist in the center causing current to flow in a metal boom or dielectric losses in a wooden boom if wet! Insulating a metal element from a metal boom is not a complete cure, because there is bound to be some capacitance, but it has been found preferable to bonding.

future trends

I have tried to cover the subject in all its aspects and find it difficult to envisage a future for small beams outside the guidelines presented here, but perhaps someone will take this as a challenge and come up with something really new! There is room for plenty of ingenuity in finding ways of folding elements to fit them into small spaces, and it should be possible to improve bandwidth by the somewhat mind-boggling process of folding a folded dipole! The mini-quad also has interesting possibilities and appears to lend itself to a number of options for multibanding, of which I favor use of 20-meter loops for 10 meters, and separate, stacked elements for 15 meters.

Better construction methods are needed to improve reliability and achieve closer tolerances. A completely foolproof tune-up procedure, which can be used in all situations, has yet to be evolved. More data is needed on the range over which remote tuning from the shack can be achieved without penalties; further development is needed to find the best methods for remote tuning and reversal of small three-element beams. Perhaps someone may then get around to applying these features to the big beams — which will otherwise find themselves at a disadvantage! For multibanding of beams such as those described here, I believe the future lies in improved versions of the linear resonator trap, which would ease the problem of remote fine tuning and avoid the complications of stacking.

As an alternative to neutralizing, I have tried using the 21/28-MHz element as an electrostatic screen between the 14-MHz elements, but I failed to achieve a viable system. There are difficulties, for example, in specifying exactly what is "earth," and I have found it advisable, even with neutralizing, to insulate elements from the boom and perferably to use a wooden boom.

references

1. Fred Caton, VK2ABQ/G3ONC, *Electronics Australia*, October, 1973.
2. R. G. D. Stone, G3YDX, "Practical Design for a Capacity Hat Loaded 14-MHz Mini-Quad," *Radio Communications*, October, 1976.
3. L. A. Moxon, G6XN, "Supergain Aerials," *Radio Communications*, September, 1972.
4. L. A. Moxon, G6XN, "Evaluating Aerial Performance," *Wireless World*, February and March, 1959.
5. L. A. Moxon, G6XN, "Gains and Losses in HF Aerials," *Radio Communications*, January, 1974.
6. L. A. Moxon, G6XN, "Two-Element Driven Arrays," *QST*, July, 1952.
7. H. P. Williams, *Antenna Theory and Design*, Second Edition, Volume II, Pitman, London.
8. Karl Rothamel, *Antennenbuch*, Telekosmos-Verlag, Berlin, 1968, page 210.
9. L. A. Moxon, G6XN, "The Disappearing Inductance — A New Trick and Some Better Beams," *Radio Communications*, April and May, 1977.
10. Pat Hawker, *Radio Communications*, (Technical Topics), June, 1977 and 1978.
11. L. A. Moxon, "High Frequency Antennae and Propagation Modes in Relation to the Amateur Service," IEE Conference on Aerials and Propagation, 1978.

ham radio

high-performance voltage-tuned mosfet oscillator

One comment often heard on the amateur bands is that the art of homebrewing is a thing of the past. Nothing could be further from the truth. The amateur fraternity has acquired new vigor and growth, and more hams now than ever before, are "rolling their own." This is happening in spite of the fact that, again as a result of recent amateur growth, commercial manufacturers of ham gear are able to offer greater bargains in terms of performance per dollar. Yet there is a growing number of do-it-yourself amateurs who are dedicated to building all or some of their own equipment. The VTO described here is only one example of this trend. I am admittedly a homebrew addict.

concept

The constantly changing state of the art has provided a diversity of methods and circuits applicable to today's requirements. The VTO described in this article is more than just another of the garden variety. It was deliberately designed to perform well under the most demanding conditions. You may be interested in duplicating the design, or in using the basic concept to build one to suit your own particular needs.

This article is intended to provide sufficient specific information so that the design can be easily duplicated. If you need a VTO possessing superior performance characteristics, scrutinize the following checklist and decide if this construction project is for you.

1. Adjustable tuning range
2. Exceptionally clean spectrum — like that of a VCXO
3. Frequency essentially independent of load
4. A temperature compensation adjustment to cancel drift
5. Power output + 10 dBm in a 50-ohm load
6. Remote tuning capability
7. Frequency independent of line voltage
8. Excellent short-term frequency stability
9. Excellent long-term frequency stability
10. Fast warm-up

After reading this article, you may wish to modify the design to fit your own needs. If so, there are certain things you should not do or need not do:

Don't use powdered-iron tuning slugs in the oscillator coil. It is particularly important to stay away from pot cores, bobbins, sleeves, toroids, and other ferromagnetic materials. Not only do these devices generally have relatively high temperature coefficients, but they possess a characteristic called hysteresis, which may cause the VTO frequency to wander from time to time for what appears to be no good reason. The permeability of powderded iron and ferrite materials is relatively sensitive to even weak magnetic fields.

Don't use a clamping diode on the MOSFET oscillator gate. It isn't necessary and only adds to the complexity. Note that the gate is grounded through the coil winding and therefore bias shift on gate 1 cannot occur.

The VTO described here should be operated at the fundamental, not a subharmonic. With the source bias used, the waveform on gate 1 is very nearly a pure sine wave, as is the waveform at the output. The circuit does not work well as a multiplier.

Don't operate the varicaps with too little bias. If the peak rf voltage exceeds the bias, rf rectification may occur which will generally disrupt performance. In the present design, varicap bias varies between 7 and 10 volts, although bias as low as 4 volts may be used if a wider band is to be covered.

Don't use a zener to provide voltage regulation for gate 2 or the drain of the MOSFET oscillator. (See **fig. 1**.) Use an integrated circuit regulator such as the μA723. Gate 2 voltage should be provided from a resistor divider network fed from the 723 output.

Don't mount the oscillator on a printed circuit board, since flexing or warping can cause serious stability problems. It is much better to assemble the entire oscillator on a brass or copper plate that can be mounted firmly to a shield box. Copper is preferred

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because is has higher heat conductivity, which helps to keep all circuit components at the same temperature. Use a small plate not less than 0.8 mm (0.032 inch) thick.

Don't use plastic, phenolic, or fiber coil forms. The coil forms used in this VTO are Cambion part number 1536-3-1. Only the amplifier circuit coil uses the tuning slug, which is carbonyl J (green).

Do not use ceramic trimmers in the oscillator circuit. The glass-piston trimmers specified possess a low temperature coefficient and are mechanically rugged.

Do not locate the VTO circuit near heat-generating components such as power supply regulators or transformers. Remember, since the oscillator is voltage tuned, it can be located at any convenient location because it does not require mechanical linkage with the front panel. You may want to take advantage of this feature and locate it next to the mixer where it belongs.

application

This particular VTO was designed as the local oscillator for the second mixer in a communications receiver. The design requirements were very exacting. It had to operate above 30 MHz and also drive a counter to provide a digital readout. The readout constantly monitors the frequency, which means that any drift exceeding 50 Hz would be particularly annoying, not to mention the problem associated with copying sideband signals. Furthermore, the tuning range was to be adjusted to cover exactly 100 kHz plus 100 Hz overlap at each end. The drift after warmup turned out to be considerably less than originally expected, in spite of the higher-than-normal operating frequency and the use of varicaps for tuning.

tuning mechanism

Although the circuit values can be modified so that the VTO covers other frequency ranges, this particular unit tunes 30,250 to 30,350 kHz. A five-turn, linear-taper, Bourns precision potentiometer (part number 35205-417-453) is used for frequency tuning. A 6.4-mm (2.5-inch) diameter Millen fluted knob provides approximately 20-kHz per revolution, permitting ssb signals to be tuned in with relative ease. This amounts to 18 degrees per kHz. A ten-turn potentiometer can be substituted if greater tuning resolution is desired. In any event, avoid the use of a gear train to increase resolution if backlash is to be avoided.

Originally, there was considerable concern regarding the ability of the of the potentiometer to stand up

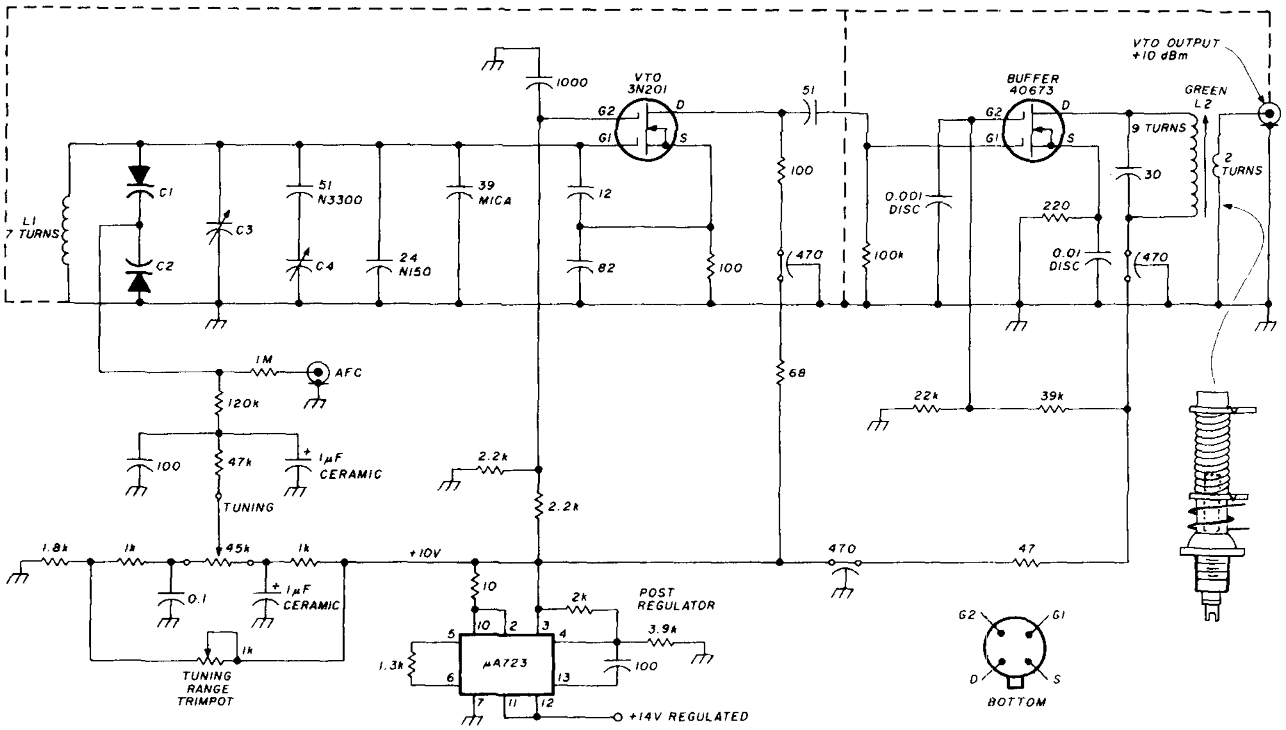


fig. 1. Schematic diagram of the voltage-tuned oscillator. All fixed resistors are 1/4-watt composition, and all capacitors are dipped silver mica unless otherwise indicated. The 470-pF feedthrough capacitors are from Spectrum Control (part number 54-794-002-741M). The varactors are TRW 4808s. Capacitor C3 is an Erie 0.7-12 pF piston trimmer, while C4 is a 1-18 pF Erie piston trimmer. L1 is wound on the Cambion 1536-3-1 coil form; L2 uses the same form with the carbonyl J tuning slug inserted as shown in the diagram.

to abuse day after day. However, the original unit showed no indication of wear after two years of almost daily and often grueling use.

circuit details

The VTO includes a 3N201 dual-gate MOSFET oscillator driving a low-cost 40673 MOSFET buffer amplifier. A high degree of isolation is achieved by use of the 100-ohm resistor in the oscillator drain circuit. As a result, pulling of the oscillator as the buffer coil is tuned through the oscillator frequency is less than 200 Hz. Since the buffer circuit is broadband and therefore fixed tuned, this effect has insignificant effect on drift. If the load terminals are opened or short-circuited, the change in the oscillator frequency is less than 100 Hz. Power output over the 100-kHz range is essentially constant at 10 milliwatts under load.

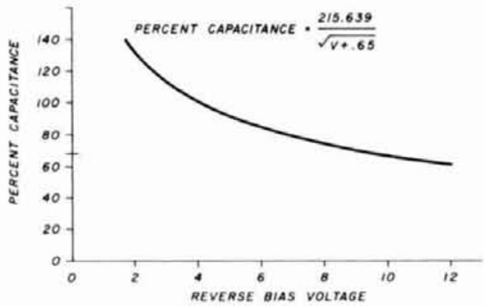


fig. 2. Manufacturer's specifications for the TRW 4808 varactor.

The coils are wound on ceramic forms with no. 26 (0.4-mm) AWG enameled copper wire and heavily doped with polystyrene Q dope. The 50-ohm output winding on the amplifier coil consists of two turns of no. 26 (0.4-mm) AWG enameled copper wire, pushed up tight against the bottom (cold) end of the tuned circuit coil. It is important that the tuning slug be positioned at the 50-ohm output end of the coil, partly overlapping both the tuned circuit and the output winding.

power supply considerations

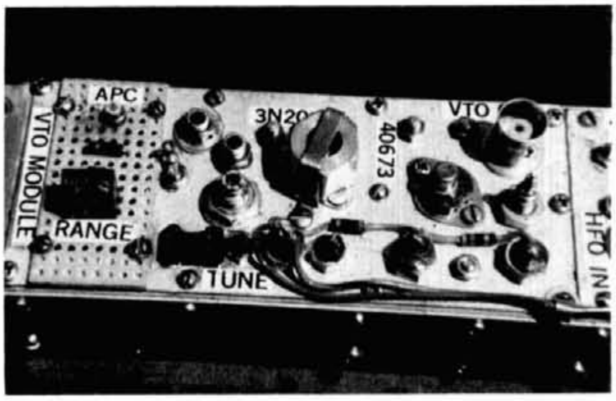
Both the oscillator and its buffer are powered from a μA723 integrated circuit regulator which accepts current from a regulated 14-volt supply. The 723 reduces the 14 volts to 10 volts. The importance of this additional regulator cannot be overemphasized. Not only does it provide the required tight voltage regulation, but by its nature the output voltage is extremely well filtered. For example, when the spectral purity of the VTO was compared while using a battery supply and then the 723 post regulator, there was no noticeable difference. By contrast, without the post regulator, there was considerable hum modulation. Small changes in supply voltage cannot be tolerated because the same supply is applied to the tuning varactors.

A pair of TRW 4808 voltage-variable, varactor diodes (varicaps) are used to control the VTO frequency. These 27-pF tuning varactors are connected in the conventional back-to-back manner with the tuning voltage fed to their junction through an RC filter. The 1000-ohm tuning range trimpot is set near its midpoint so that the voltage across the 45k-ohm tuning potentiometer is approximately 3 volts. Under these conditions, the tuning potentiometer provides the varicaps with between 7 and 10 volts. Long life and reliability is assured since the potentiometer carries only 64 microamperes while the current carried by the moving arm is essentially zero. Data on the varicap is shown in **fig. 2**.

The varicap tuning sensitivity is 30 μV/Hz. If the spectral purity of the oscillator is to be high enough for the intended application, power supply noise and ripple must be extremely low. The μA723 is specified at 20 μV rms noise typical. This could cause a random peak-to-peak fm of 1.89 Hz. Most of this noise is eliminated by means of the lowpass filter consisting of the 47k-ohm resistor and the 1.0 μF capacitor. What little noise actually remains should consist of very low-frequency components, since the RC filter has a 20 Hz cut-off frequency. In the author's application, there is no detectable reduction in receiver output noise when a battery is substituted for the μA723 regulator.

Ripple from the 723 is specified as typically 74 dB below the input ripple. Even if the input ripple were 100 mV peak-to-peak, the output ripple would only be 2.0 μV, including the filtering action of the varicap RC filter. This translates to less than a tenth of a cycle fm.

The varactor capacity as seen by the oscillator coil varies from 3.8 to 4.4 pF. Since the total circuit capa-



Since the VTO is dc tuned, it does not have to be located near the front panel. In this case, it has been incorporated into the same module as the HFO buffer.

city is approximately 90 pF, the ratio of high to low end frequencies is as follows:

$$\frac{F_H}{F_L} = \sqrt{\frac{C+\Delta C}{C}} = \sqrt{\frac{90.6}{90}} = 1.0033$$

where

F_H = high-end frequency
F_L = low-end frequency
C = total circuit capacitance

Therefore, if

$$F_L = 30{,}250\ kHz,$$
$$F_H = 1.0033 \times 30{,}250$$
$$= 30{,}350\ kHz.$$

Of course, the tuning range tripot can be adjusted to provide overlap at each end of the tuning range if that is desired.

The frequency ratio formula can also be used for different frequencies and tuning ranges. I suggest that the circuit capacity be scaled in proportion to wavelength. A VTO operating between 5.0 and 5.1 MHz, for example, could use a circuit capacity of about 500 pF. The varicaps would each be 150 pF, while C would be approximately 20.2 pF, which requires a tuning voltage range of about 6.4 to 10 volts.

tuning linearity

While the tuning potentiometer is linear, the varicap *tuning characteristic* is not. As a consequence, the frequency tunes slightly faster at the low end of the range than at the high (see **fig. 3**). However, the departure from linearity is small. Based on the manufacturer's data, and by measurement, the number of kilohertz per revolution at the low end is 22.4 compared with 18.2 at the high end. This nonlinearity might be objectionable if it were necessary to employ a mechanical frequency indicator, such as a planetary mechanism. In my application, the VTO drives a programmable digital counter in which case the small nonlinearity is of no consequence.

temperature compensation

Considerable effort went into developing a variable temperature compensating circuit for this VTO. While the idea is not new, it lends itself well to this particular application. The compensation circuit is simple and easy to adjust.

A piston trimmer is connected in series with a negative temperature coefficient ceramic capacitor. The coefficient was intentionally made larger than needed. The effective circuit coefficient is adjusted by *tuning the piston trimmer*, C4. The change in frequency which resulted is compensated for by adjusting C3. There is a particular setting of these two capacitors which will provide zero temperature coefficient, therefore zero oscillator drift after warm-up.

Based on manufacturer's data, the voltage-tuned varactors have a temperature coefficient of 250 to 300 ppm/degrees C. Of course, most of the other circuit elements exhibit positive coefficients as well, but their coefficient is generally less — in the order of 50

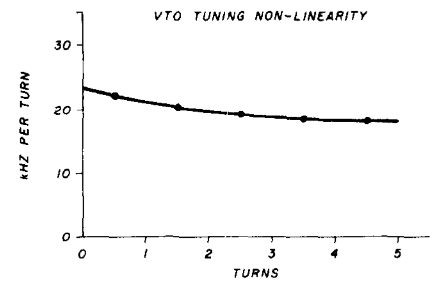


fig. 3. Chart of the voltage-tuned oscillator's linearity as the oscillator tunes from one end of its range to the other.

to 100 ppm/degrees C. Dipped silver-mica capacitors were found to be entirely satisfactory for use in the oscillator and amplifier tuned circuits.

A series of tests was performed using NTC capacitors with various temperature coefficient values. Finally, a 51-pF, N330 capacitor was selected. An additional 24-pF, NTC 150 capacitor was added in parallel to bring the circuit temperature coefficient within range of C4. C4 is a key circuit element because it allows the effective temperature coefficient to be adjusted, and therefore the amount and direction of oscillator drift. The proper setting was found after a number of drift tests were performed over a period of a few hours using different settings of C3 and C4. The results of these tests are shown in **fig. 4**.

After a period of about three months, and again a year later, the drift was checked. It was found that no change in compensation had taken place. The circuit gives you a real good opportunity to check the other fellow's frequency stability!

After two years of drift-free use, and strictly out of curiosity, the original 3N201 oscillator MOSFET was replaced with another made by a different manufacturer. It was found that the frequency was slightly higher and needed trimming. Subsequent drift tests showed the circuit to be over-compensated. A new set of drift tests were run and the overall temperature coefficient quickly brought back to zero.

If the drift that occurs after turn-on from a cold start is annoying, or if the application requires absolutely zero warmup drift, I recommend that the drift correction circuit described by PAØKSB[1] be used. This circuit was built and applied to the AFC terminal shown in **fig. 1**. The performance was excellent.

There was absolutely no warmup drift. It was necessary, however, to include the up-down tuning push buttons recommended to periodically correct for calibration errors inherent in the design. Since this requirement was more of a nuisance than the warmup drift, the circuit was not permanently installed. From a practical standpoint, about the time the 6146s are warmed up and ready to go, the VTO has stabilized! It was also interesting to note that if the VTO design described here were to be modified for operation at 5.0 MHz, the warmup drift would be only about 100 Hz.

dryer will probably prove only that the temperature compensating circuit has a thermal lag.

Short-term drift and low-frequency shot noise effects can be determined by tuning in WWV (assuming the VTO is used as the local oscillator of the receiver). Using the BFO, set the tuning for a convenient heterodyne (500 Hz for example), and then acoustically zero beat an audio oscillator and speaker combination with the receiver output. Listen for any warbling and jumping. If you use a low-beat note, you should be able to hear and detect frequency variations as small as ±2 Hz by reading frequency changes from the audio oscillator dial. If the oscillator is working properly, random variations should not exceed ±5 Hz at 30 MHz, or ±1 Hz at 5 MHz, and there should not be any jumping. It is interesting that the technique described here allows you to detect variations as small as one part in 10^7 or better.

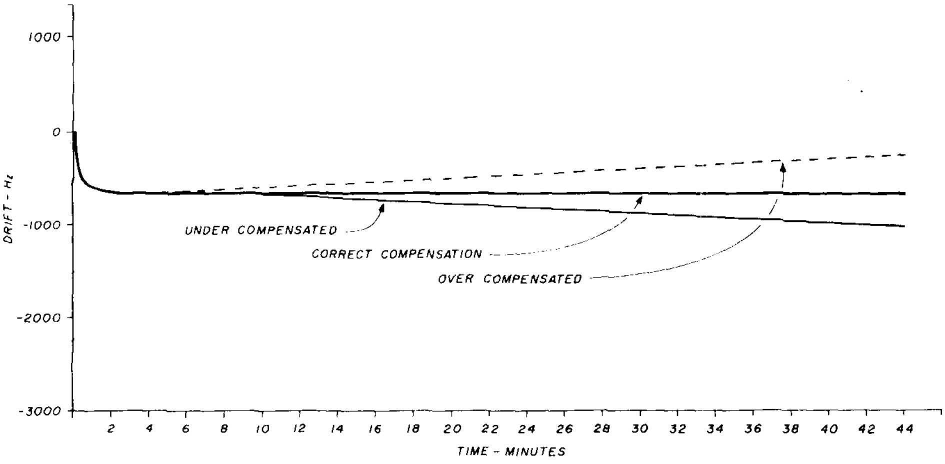


fig. 4. Typical results of the oscillator drift tests. Incorporating the drift correction circuit described by PAØKSB will reduce the frequency change to zero.

Excellent short-time stability was achieved by enclosing the VTO circuit in a metal box. Also, a brass cup heatsinked to the chassis was mounted over the 3N201 transistor and its socket. This protects the transistor from drafts to which it is particularly susceptible, and forces the ambient temperature in the vicinity of the transistor to track that of the entire circuit. This combination was found to be very effective.

One of the most frustrating problems associated with checking out a new oscillator is being able to separate out the various causes of drift. They include the effective temperature coefficient of the overall electrical circuit, the effects of voltage variations, and mechanical effects. If the oscillator varies or jumps when the oscillator chassis is tapped sharply with a screwdriver, you have mechanical problems. Don't try to temperature stabilize the circuit until it is mechanically sound. It is a good idea to run the temperature of the circuit up and down several times using a hair dryer to reduce mechanical strains before checking drift.

If you use the regulator circuit suggested here, you should be able to set the line voltage as low as 100 volts before detecting any oscillator drift. Long-term drift tests should be performed by running the circuit as it would normally be operated. The use of a hair

references

1. Klaas Spaargaren, PAØKSB, "Drift Correction Circuit for Free-Running Oscillators," *ham radio*, December, 1977, page 45.

bibliography

Cromartie, Edmund S., "Synthesis of a Varicap," *QST*, September, 1972, page 44.

DeMaw, Doug, W1CER, "Building a Simple Two-Band VFO," *QST*, June, 1970, page 21.

DeMaw, Doug, W1CER, "VFO Design Techniques for Improved Stabilities," *ham radio*, June 1976, page 10.

Foot, Norman J., WA9HUV, "A Digitally Programmable HF Communications Receiver," *ham radio*, October, 1978, page 10.

Lee, Di Ming, "A VTO for 80 Through 10 Meters," *QST*, November, 1970, page 21.

McDowell, Warren, W2AOO, "Varicap Tune Your VFO," *QST*, April 1975, page 27.

McGraw, Robert W., W2LYN, "A 3- to 4-MHz Franklin VFO," *QST*, August 1971, page 29.

Mather, A.S., VK2JZ, "An External VFO For The SB-100 Transceiver," *QST*, October 1970, page 42.

Schrick, Gerd H., WB8IFM, "Digital Readout Variable Frequency Oscillator," *ham radio*, January 1973, page 14.

ham radio

More Details? CHECK — OFF Page 118

operational characteristics of the 555 timer

Care and feeding of the multi-purpose 555 timer — a closer look at some of the reasons behind the designs

The 555 timer has become *one of the most popular* ICs used by both industry and hobbyists alike. Since its introduction by Signetics Corporation in 1972 (as the NE555), every major IC manufacturer has produced a 555 equivalent. Variations have been developed by Signetics and others, primarily for specific applications (NE556, NE558 quad, XR2250 programmable).

Circuits using the 555 show up in virtually every electronics-oriented magazine. The popularity of the 555 is partly due to its versatility and partly because of its cost (generally less than 50 cents). These published circuits use the timer to generate ramps and time delays, detect missing pulses, act as oscillators, and a host of other applications. The list of specifics can become quite extensive. Most of these applications now appear as "cookbook" circuits with little detail on how the design was accomplished and what variations a builder of that circuit can expect.

This article was written to help you get a better understanding of the 555 and how its eight pins react to external components. With this information, you can get a feel for how most 555 applications work. *For the more creative, I'll outline the basic design* rules for using the 555. (Information on the 555 also applies to the 556 dual timer.)

Fig. 1 shows the block diagram of the 555 timer. The basic components consist of an output driver, a control flip-flop, and two voltage comparators. The flip-flop drives the discharge transistor and output driver. The state of the flip-flop is controlled by the reset pin (pin 4) or one of two comparators. One comparator is controlled by the voltage on the trigger pin (pin 2) and the other controlled by the voltage on the threshold pin (pin 6).

These comparators have separate reference points which are controlled by the three-resistor divider from V_{CC} to ground. The resistors are all of equal value (5-k ohms). The reference voltage for the threshold comparator is thus 2/3 of V_{CC}, and is also available on pin 5, the control voltage pin. The reference voltage into the trigger comparator is set at 1/3 V_{CC} by the divider network (Note: it is also one half of the voltage on the control voltage pin).

The output (pin 3) has the capability of providing *200 mA. Because of the totem-pole structure, this*

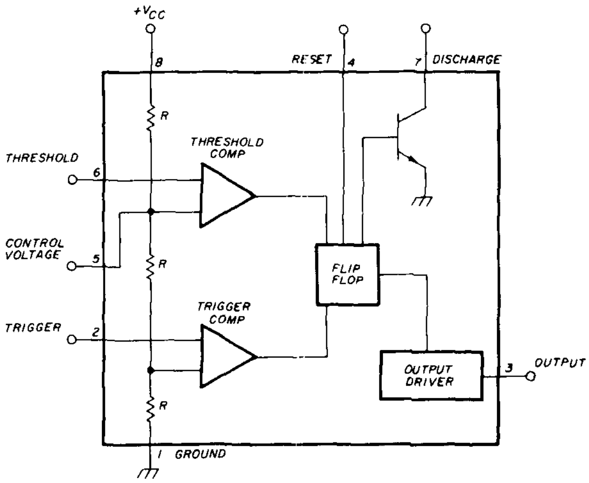


fig. 1. Block diagram of the 555 timer. The three-resistor divider network causes the voltage comparators to work on a ratio, rather than an absolute voltage level. This makes any timing functions relatively insensitive to supply voltage.

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current supply is available whether the output is high or low. Additionally, when the output is high, the discharge transistor is turned off.

monostable operation

To help understand the action of the comparators it is best to show the operation of the 555 in one of the basic timing modes. The monostable configuration of the timer requires only two external components. It is shown in **fig. 2A** (the capacitor on pin 5 is optional).

A resistor (R_A) is connected from V_{cc} to the discharge pin (pin 7) and threshold pin (pin 6). A capacitor is then connected from pins 6 and 7 to ground. The values of R_A and C will determine for how long the output remains high.

Initially, the output is low and the discharge transistor is turned on. This essentially shorts the timing capacitor C. Therefore, the threshold comparator input is at zero volts. When the trigger comparator receives a trigger that is less than 1/3 V_{cc}, it causes the flip-flop to switch. The output goes high and the discharge transistor turns off. When this happens, the timing capacitor starts charging to V_{cc} via R_A. As soon as the charge on the capacitor reaches the threshold voltage level (2/3 V_{cc}), the threshold comparator triggers the flip-flop. This drives the output stage low and turns on the discharge transistor, which discharges the timing capacitor, and the timer is back to its initial condition. **Fig. 2B** shows the waveforms on the timer during this time.

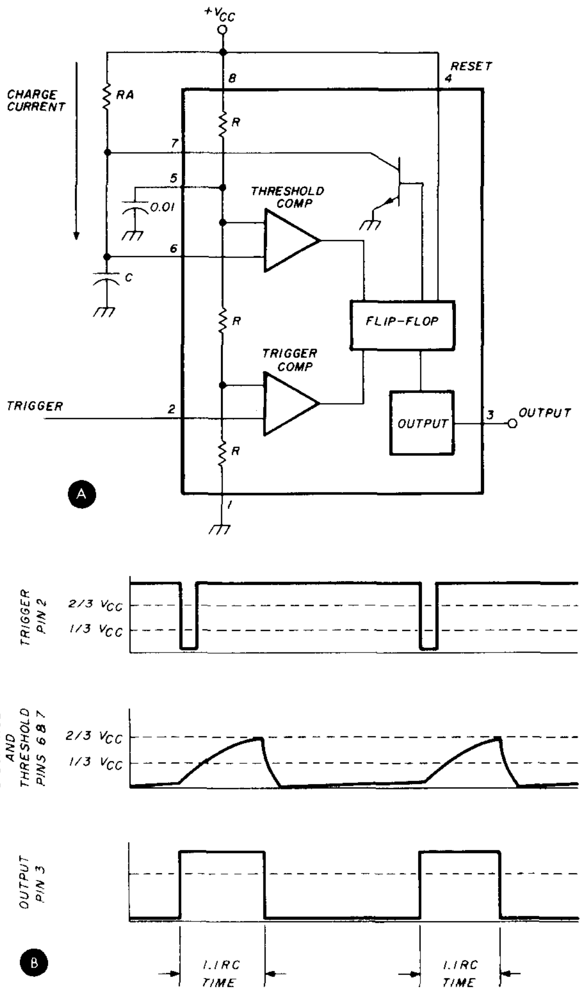


fig. 2. Configuration of the 555 timer for use as a monostable multivibrator and the associated waveforms (B). The negative-going pulse applied to the trigger input causes the internal flip-flop to change states, generating the output pulse.

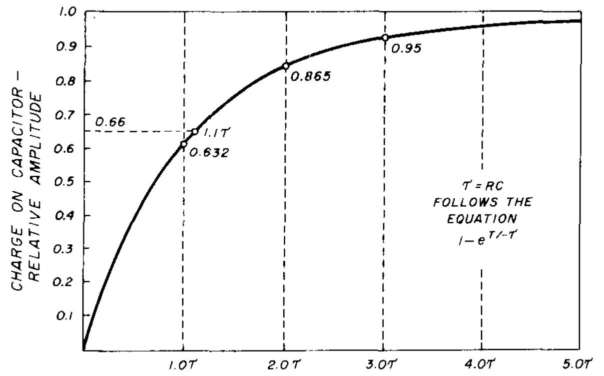


fig. 3. Diagram of the normal RC time-constant curve. When connected as a monostable, the output pulse width from the timer is determined by the time it takes the capacitor to charge between zero and 66 per cent of the full charge.

triggering

Due to the nature of the trigger circuitry, the trigger comparator will trigger the flip-flop whenever the trigger voltage drops below 1/3 V_{cc}. For proper timing, the trigger level must return to a voltage level greater than 1/3 V_{cc}. This is because the trigger comparator has overriding control of the flip-flop. Should the trigger input be held low for a period longer than the timing cycle, the output will remain high, without regard to the voltage on the threshold comparator.

reset function

The 555 has a reset pin for applications that require an abort signal. That is, it may be necessary to interrupt a timing period or to inhibit a trigger. The reset control (pin 4) is normally high. If the reset is held greater than 1.0 volt, the 555 will function normally. However, if pin 4 is held below 0.4 volt the output will be held low. When the timer output is high and the reset goes low, the output will turn off immediately. If the reset pin is between 0.4 and 1.0 volt, the timer is in no man's land; some devices may reset, some may not. When using the reset function, it is important to have the reset less than 0.4 volt. This level is guaranteed to cause the timer to reset. To prevent possible noise spikes from causing an unwanted reset, pin 4 is normally connected to the V_{cc} pin when not being used.

calculating pulse width

When describing the operation of the 555 timer in the monostable operation, I mentioned that the values of R_A and C determined the time the output stayed high. The voltage on C must charge to 2/3 V_{CC}. **Fig. 3** shows the normal RC charge curve. As shown, the voltage rises from 0 to 100 per cent in five RC time constants (τ). The 66.6 per cent (2/3) point occurs at 1.1τ, or

$$T = 1.1\,RC \qquad (1)$$

where

T is in seconds,
R is in ohms
C is in farads

changing the pulse width in the monostable mode

The threshold control voltage on pin 5 is an important feature of the NE555 timer. By imposing a voltage on pin 5, the internal comparator reference levels, the timing can be varied. For example, if one-half the supply voltage were placed on pin 5 (normally held at 2/3 V_{CC}), the timing capacitor would charge only to one-half V_{CC} before the threshold trip level is reached. The time required to charge the capacitor can be found by observing how many time constants it takes for the capacitor to charge to 50 per cent using the equation $T = \ln\left(1 - \frac{V5}{V_{CC}}\right) RC$ or by using **fig. 3**. With the voltage on pin 5 equal to 0.5 V_{CC}, the new timing equation is $T = (\ln 0.5)RC = 0.693RC.$

You must remember that the trigger threshold is also affected by changes on the voltage level at pin 5. In the example above, the trigger threshold is now lowered to one-quarter V_{CC} (halfway below the voltage on pin 5). In order to trigger, the trigger pulse must now go below one-quarter V_{CC}. This feature of the timer opens a multitude of application possibilities such as pulse width modulators, voltage-controlled oscillators, and so forth.

As can be seen, any variations on pin 5 will cause a change in timing. For that reason it is recommended that a small bypass capacitor (about 0.01 μF) be used on pin 5. This will increase noise immunity of the timer to high frequency trash that could cause timing errors by modulating the threshold trip levels.

astable operation

To configure the 555 timer in the astable or oscillatory mode requires only a slight modification to the monostable configuration. **Fig. 4A** is the schematic of a 555 timer in the basic astable mode. It requires two resistors and a timing capacitor. Assume that the charge on the timing capacitor is charging toward V_{CC} through R_A and R_B. The output is high and the discharge transistor is off. When the capacitor charges to the threshold trip level (2/3 V_{CC}) the output goes low and the discharge transistor turns on, shorting pin 7 to ground. The capacitor now begins to discharge through R_B toward ground. But as soon as the capacitor discharges to 1/3 V_{CC} (the trip level of the trigger comparator), the output again goes high, the discharge transistor turns off, and the

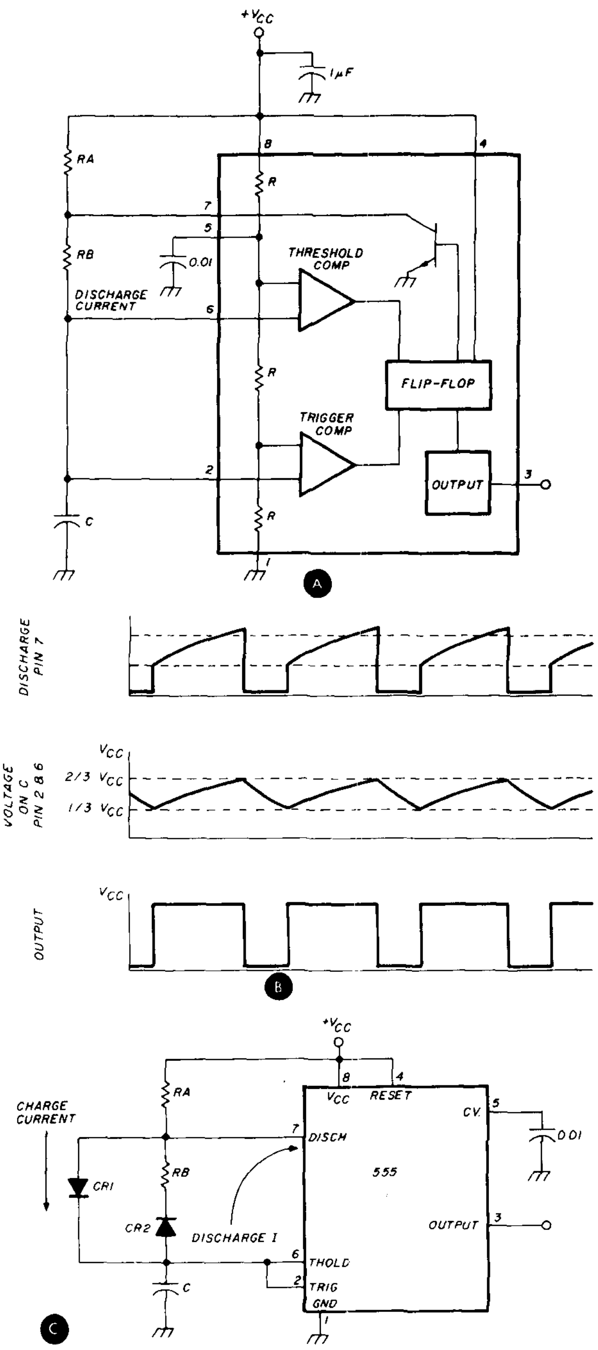


fig. 4. Schematic diagram of the 555 connected as an astable multivibrator and the waveforms at different points in the circuit (B). In applications where a 50 per cent duty cycle is required, the circuit shown in (C) can be used. In this case, CR1 effectively shorts out R_B during the capacitor charge time.

capacitor starts charging through R_A and R_B again, creating an oscillator. **Fig. 4B** shows the waveform in the astable mode.

calculating frequency

The time required to charge from 1/3 to 2/3 V_{cc} is 0.671 RC. The charge path is through $R_A + R_B$. This is the period of time that the output is high, or

$$T_1\,(High) = (R_A + R_B)\,C \qquad (2)$$

During the discharge time the output is low. The time required to discharge from 2/3 to 1/3 V_{cc} is also 0.671 RC. But the discharge path is through R_B only, so

$$T_2\,(Low) = 0.671\,(R_B)\,C \qquad (3)$$

The total period of oscillation is then:

$$T_{TOT} = T_1 + T_2 = 0.671\,(R_A + 2R_B)\,C \qquad (4)$$

and the frequency

$$F = \frac{1}{T_{TOT}} = \frac{1}{.671\,(R_A + 2\,R_B)C} = \frac{1.49}{(R_A + 2\,R_B)C} \qquad (5)$$

The duty cycle is given by:

$$D = \frac{R_A}{R_A + 2\,R_B} \qquad (6)$$

Since the charge and discharge paths are different, the duty cycle cannot be less than 50 percent. In some applications, this may cause a problem. With a slight modification to the basic circuit, the 555 output can be made a square wave. **Fig. 4C** details the circuit configuration for a 50 per cent duty cycle when $R_A = R_B$.

In this circuit, CR1 shorts R_B and the charge time is 0.671 R_AC. The discharge path is still through R_B and does not change. The series diode, CR2 is optional to match the charge and discharge paths. With the diodes in the circuit the formulas for frequency and duty cycle become:

$$F = \frac{1.49}{(R_A + R_B)C} \qquad (7)$$

$$Duty\ Cycle = \frac{R_B}{R_A + R_B} \qquad (8)$$

With this configuration, the timer is capable of generating duty cycles from 5 to 95 per cent.

supply voltages

In selecting supply voltages, note that the 555 timer is guaranteed to operate from 4.5 volts to 16 volts. Because the threshold levels work on a ratio, the supply voltage will not change the timing calculations. The timer has a "totem pole" output structure capable of switching high levels of load current. As a result, large current spikes can develop on the supply line. This momentary loading effect can cause a degree of timing error because of changes in charging current. It can also cause noise glitches and false triggering in TTL circuits. To eliminate this phenomenon, it is necessary to bypass the supply line to ground with a capacitor. The size of the bypass required generally depends on the load to the timer. Values range from 0.1 to 10 μF, or more. The bypass capacitor should be as close to the device as possible.

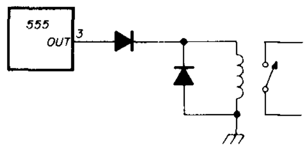


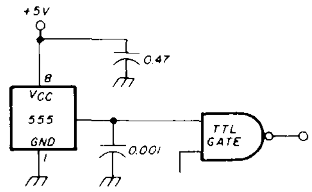
fig. 5. When driving an inductive load, a protective diode is required to prevent the inductive kick from latching up the output of the timer.

Bypassing the control voltage pin (pin 5) is generally considered good design practice. As mentioned earlier, the value is not critical, but the capacitor should be as close to the device as possible. Typically, the bypass capacitor is 0.01 μF.

capacitors

The timing capacitor size is virtually unlimited; but, *the type of capacitor is important.* Ceramic disk capacitors are usually unsuitable. They generally are not stable enough to operate in an RC timing circuit. Electrolitics usually have very high leakage rates and would cause drastic timing errors. The Signetics data sheet lists several acceptable types of capacitors, including silver mica, mylar, polystyrene, and tantalum. The smaller the timing capacitor used, the more

fig. 6. The capacitor on the output of the timer is used to prevent any glitches caused by the cross-over distortion from acting as false triggers to the TTL logic.



apparent effect stray capacitance can have on the timing. The larger the capacitor, the more expensive the capacitor is. This is particularly true of the low-leakage types. For long delays, the capacitor has to be very large, but there are ways of getting long delays without using big capacitors.

resistors

There are certain maximum and minimum values

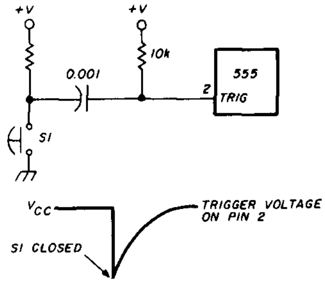


fig. 7. In this example of ac triggering, the trigger pulse must be less than the duration of the output pulse from the timer. The duration of the trigger depends upon the RC time constant of the components.

for the resistors. The threshold comparator requires 0.25 μA of current to trip the output. Considering worst case, the resistor must be able to supply 0.25 μA of current for the comparator and still charge the capacitor to 2/3 V_{cc}. To calculate the maximum resistance, the IR drop must not exceed 1/3 V_{cc} with 0.25 μA current flow, or

$$IR\ drop = V_{cc} - V_{CAP}$$
$$= V_{cc} - 2/3\ V_{cc}$$
$$= 1/3\ V_{cc}$$

The maximum resistance between V_{cc} and pin 6 is defined as

$$R_{MAX} = \frac{V_{cc} - V_{CAP}}{threshold\ current} \tag{9}$$

With a 15-volt supply

$$R_{MAX} = \frac{15V - 10V\ (2/3\ V_{cc})}{0.25 \times 10^{-6}}$$

$$R_{MAX} = \frac{5}{0.25 \times 10^{-6}}$$
$$= 20\ megohms$$

With a 5-volt supply

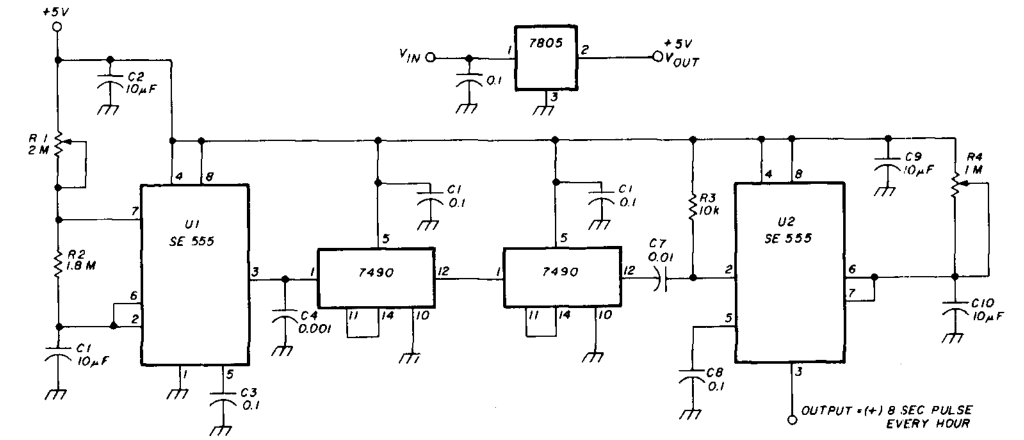
$$R_{MAX} = \frac{5V - 3.33V}{0.25 \times 10^{-6}}$$
$$= \frac{1.67}{0.25 \times 10^{-6}}$$
$$= 6.6\ megohms$$

When using large resistors, capacitor leakage can cause larger timing errors because it represents a larger percentage of the total charge current available. Excessive capacitor leakage current will also cause an IR drop and not allow the threshold comparator to reach 2/3 V_{cc}.

The minimum value of resistance is determined by the current that the discharge transistor can supply. The discharge transistor is internally current limited to about 35 mA. The discharge transistor must supply two loads. The first is the current through R_A. This should be reduced so that the second path into the capacitor (or through R_B) carries most of the load. As a general rule, R_A should not be less than 5k ohms. R_B should not be less than 3k ohms.

control voltage changes

As mentioned earlier, the control voltage pin (pin 5) is normally bypassed to ground by a 0.01-μF capacitor. By imposing a voltage on this pin, it was shown that the timing can be changed since the threshold level is changed. The voltage level on pin 5 can be lowered to about 45 per cent of V_{cc} when operating the timer in the monostable mode. The trigger level is also changed because it will equal one half the voltage on pin 5, and a certain minimum volt-



U1 — *frequency* = 1/36 Hz
$R1 = R2$, let $C = 10\ \mu F$

with $F = \dfrac{1.49}{(R1 + 2R2)C}$

Since $R1 = R2$, $F = \dfrac{1.49}{3R \cdot C}$

therefore $R = \dfrac{1.49 \cdot 36}{10 \cdot 10^{-6}} = 1.8\ megohms$

U2 — 8-second output pulse
let $C = 10\ \mu F$

therefore $R = \dfrac{T}{1.1C} = 0.727\ megohms$

fig. 8. Long time delays can be generated by cascading timers with other count-down devices. In this example, the basic timer, U1, runs at about 0.028 Hz, is divided down by 100, and then used to trigger another timer configured as a monostable. The output is an eight-second pulse, once every hour.

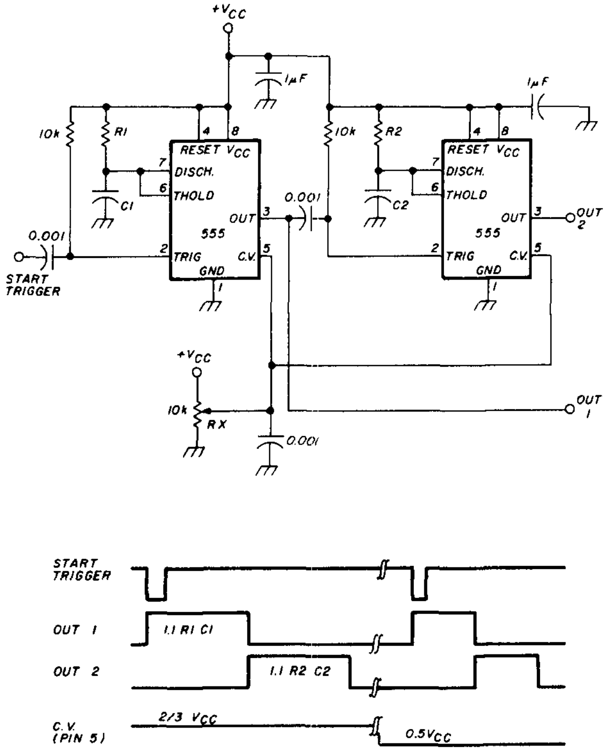


fig. 10. This version of a sequential timer uses the control voltage input to change the pulse width of the output pulses, though they do remain in the same ratio.

age level must be maintained on the trigger comparator reference. If the voltage drops below 45 per cent on pin 5, the timer becomes more sensitive to noise because the trigger voltage nears ground. At the other extreme, the control voltage on pin 5 should not exceed about 90 per cent of V_{CC} since the timing capacitor must charge to V_{CC}. Exceeding this voltage range in the monostable mode may cause timing error, false triggering, or other problems.

In the astable mode, the voltage level changes on the control voltage pin can be used to change the oscillating frequency about ±25 per cent and still remain linear. Changes greater than this will still cause the frequency to change, but linearity decreases due to the RC timing circuit.

Before examining some specific circuits, there are several idiosyncracies of the timers that can cause problems unless you are aware of them.

Temperature. The timer exhibits a small negative temperature coefficient (50 ppm/C°). This can cause small timing changes in the monostable mode and frequency drift in the oscillator mode. In critical applications, R/C values can be selected which have positive coefficients, with the net result a lower drift. Since the astable mode relies on both trigger and threshold levels, the drift from temperature is usually higher than when in the monostable mode. An important point to remember when working with the timer (for that matter any IC) is that power dissipation of the device should never be exceeded. Power causes heat, and excessive heat will destroy the device. The 555 can handle about one-half watt of power at room temperature. This power rating is lower when the device is operated at higher temperature.

Output. If a negative voltage (with respect to pin 1) is applied to the output of the timer, the 555 could latch up. This can happen when the 555 is used to drive an inductive load, such as a relay. To prevent this inductive kick back from latching the timer, a diode in series with the output should be used. **Fig. 5** shows a schematic of a timer being used to drive an inductive load.

The output drive capability of the timer is 200 mA. Because of the output structure's high current capabilities, and fast rise and fall times, the timer exhibits crossover distortion. This glitch can cause false triggering of TTL circuits. By providing a capacitive load, the timer output is slowed to a point that the glitch does not occur. A capacitor of about 1000 pF from the output to ground will eliminate any false triggering of the TTL circuit (see **fig. 6**).

Triggering. I've stated that in the basic monostable mode the trigger must go below 1/3 V_{CC} (or one half

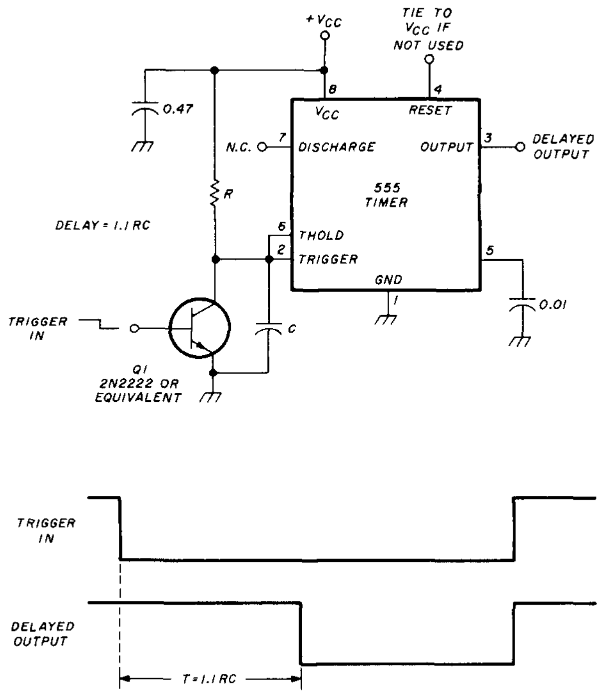


fig. 9. In this time delay circuit, the timing capacitor is effectively short circuited by the normally conducting transistor. A negative-going trigger cuts off the transistor, allowing the timer to operate and provide a pulse after the delay time.

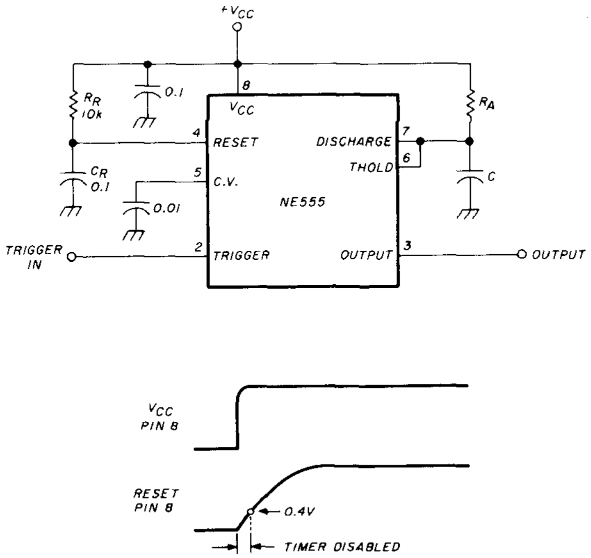


fig. 11. With the capacitor attached to the reset input, the timer cannot produce an output when power is initially applied. After C_R has charged, a trigger will produce the desired output pulse.

the voltage on pin 5) and return high before the end of the timing cycle. One way to generate such a trigger is to ac-couple the trigger. **Fig. 7** shows such a circuit. The duration of the trigger pulse depends on how long the RC time constant is. The switch must return high again before the timer can be retriggered.

example circuit

The following circuits illustrate the use of the 555 timer (or 556 where two timers are used).

Long time delays. Because of the limitations of resistor size, long time delays (times greater than one hour) can be difficult to achieve using the basic circuit. One method of getting long delay times is shown in **fig. 8.** This particular circuit provides a positive 8-second pulse once each hour. U2 receives a trigger once each hour. The output of U2 is set for the desired pulse output by R4 and C10. R3 and C7 provide the ac-coupled trigger. The 7490 counters are set to divide by 100. To provide one cycle per hour, the input must be clocked at a frequency of 1/36 Hz; U2 is then set to oscillate at 0.028 Hz. Note that C4 provides a deglitch filter on the output of U2. Because the timer must interface with TTL counters, the timers and counters use 5-volt supplies. The entire circuit can also be built by using a single 556 dual timer and one 74390 dual-decade counter. By changing the divider network or frequency of U1, it is possible to get an almost infinite combination of pulse outputs.

Simple time delay. Fig. 9 shows a simple circuit that is a modification of the monostable operation. This circuit provides an output after some predetermined time. Initially, the trigger input to the base of Q_1 is high, causing Q_1 to conduct. Pin 2 of the timer is low and the output (pin 3) is high. When the input goes low Q_1 turns off, allowing the timing capacitor to charge. When C charges to 2/3 V_{CC}, the output of the timer goes low. The output will stay low for as long as Q_1 is turned off. The reset pin can be used to keep the output low if required; otherwise it should be tied high.

Sequential timing. Fig. 10 shows another type of delay circuit. This is a sequential timer. The output of the first timer is used to trigger the second. The control-voltage pin is used to vary the sequence time, but the ratios remain the same. The timing diagram shows how the pulse width is reduced as the control voltage pins are lowered.

Delayed triggering. When power is first applied to the circuit shown in **fig. 2** there is a chance that the trigger voltage on pin 2 will be lower than 1/3 V_{CC} and the timer will trigger. This may not be desirable. To prevent this initial trigger when power is turned on, the reset circuit can be modified as shown in **fig. 11.**

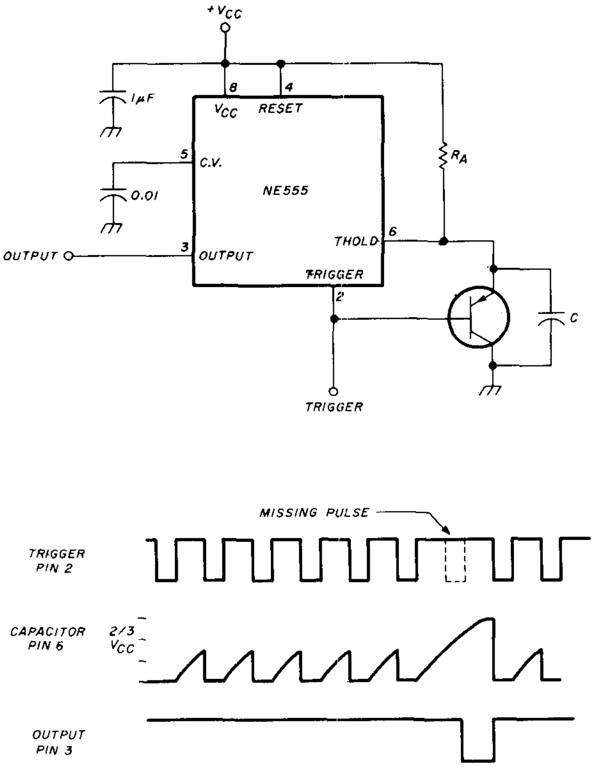


fig. 12. In the missing pulse detector, each trigger shorts the charging capacitor, preventing the output pulse from appearing. If a pulse is missing, the capacitor will charge to the required level, producing the output pulse which indicates the missing pulse.

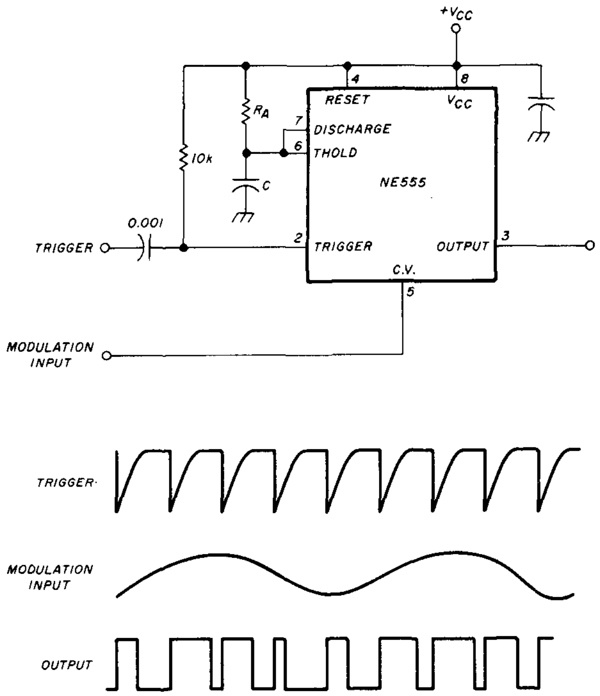


fig. 13. The modulation input is applied to the control voltage input, with the width of the output pulse varying as the amplitude of the modulation.

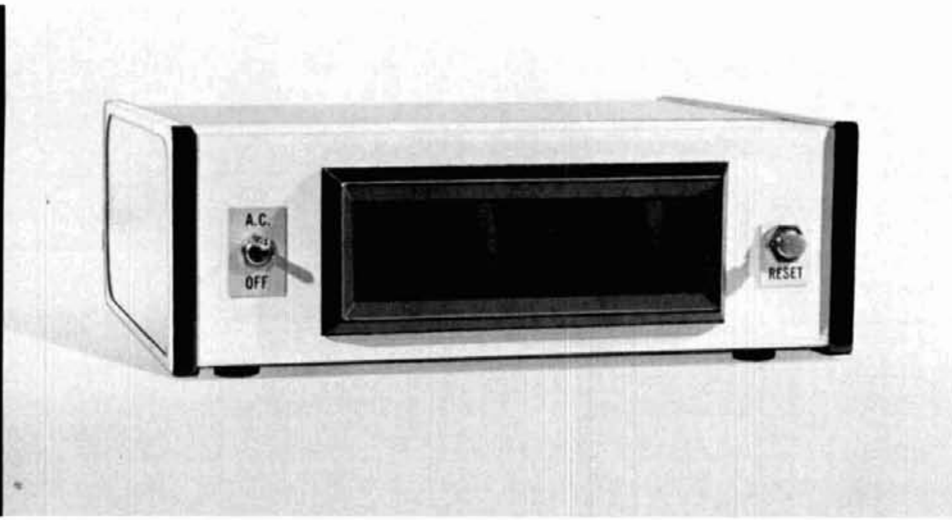
Pin 4 is held below 0.4 volt since C_R is fully discharged. When power is applied, the timer is held reset until C_R charges to above 0.4 volt.

Missing pulse detector. Fig. 12 shows an NE555 timer hooked up as a missing pulse detector. The trigger input also drives the base of a transistor. When a trigger occurs, the transistor conducts and shorts the timing capacitor before the timer can time out. If an input trigger is missing, the timer will time out and pin 3 will go low indicating a missing pulse. The values of R_A and C are set to be slightly longer than the period of incoming pulses.

Pulse width modulator. Fig. 13 shows a circuit which uses the control voltage pin to modulate the pulse width of an incoming clock signal. As the voltage on pin 5 varies, it changes the threshold level of the internal comparator and the pulse width of the output changes.

The examples covered were used to illustrate some of the possibilities of the 555 timer. The uses for this handy little IC could well take a whole book to illustrate. With an understanding of the basic operation, you can analyze timer circuits and design a circuit for your particular need. Who knows, you may come up with an original application and add your name to an evergrowing list of 555 timer circuit designers.

ham radio



receiver digital display

A digital display for your receiver featuring 100-hertz readout, single frequency input, and provisions for forward or reverse tuning VFOs

The addition of a digital frequency display to a receiver goes a long way in enhancing operator convenience. It eliminates squinting at the fine markings found on the usual mechanical dial; and, at the same time, it provides an accurate frequency readout across an entire band without any need for recalibration between band ends. A bright digital display is not only easy to read, it also adds a touch of class to a perhaps otherwise ordinary station.

The circuit described in this article provides a stable, four-digit readout that includes the 100-kHz digit through the 100-Hz digit and will accommodate forward or reverse tuning VFOs at the flick of a switch. The resolution is greater than is usually provided by the typical receiver dial and is handy for returning to a particular frequency in a crowded band. In the interest of economy and simplicity, I did not include the MHz digits; they are easily read from the receiver band switch.

The technique used here[1] requires only a single connection to the receiver's VFO, which, in many modern receivers, is usually available at a connector on the rear panel, making it unnecessary to tamper with the receiver in any way.

theory of operation

In the case of a backward-tuning VFO, the frequency to be displayed is equal to a fixed frequency minus the VFO frequency. All that needs to be done is store the fixed frequency, subtract the VFO frequency, and display the result. In the case of a forward-tuning VFO, store the complement of the fixed frequency (subtract the fixed frequency from zero), add the VFO frequency, and display the result. These additions and subtractions are easily accomplished by using up/down counters and sequentially gating the frequency to be added to the up input and the frequency to be subtracted to the down input, each for the same fixed interval. The fixed frequency is usually crystal controlled and changes very little with time. Thus, measuring and storing it once during an initial calibration is usually adequate.

The price paid for the single interconnection and the simpler circuit is the need to perform a single calibration step each time a new band is used. The operator, using the receiver's internal calibrator, tunes to the bottom edge of the band and presses the calibrate (RESET) button on the display. No further adjustments are necessary. Depressing the

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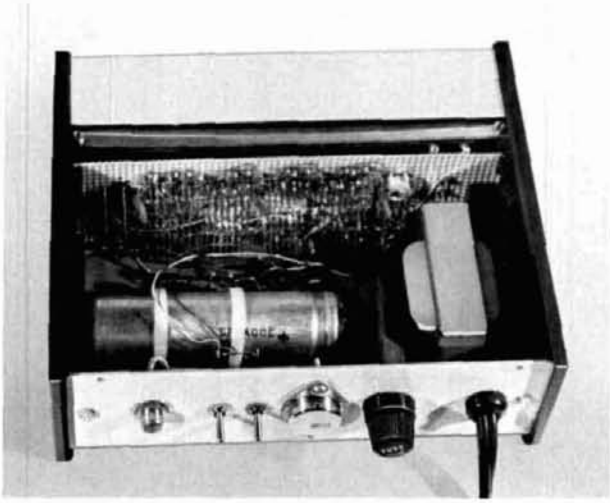
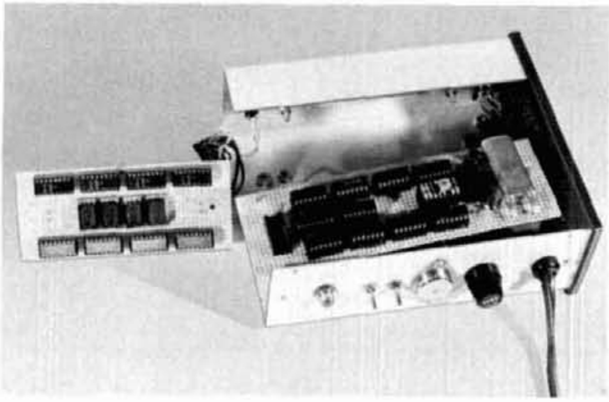
CALIBRATE button stores the VFO frequency and displays all zeros. The operator may now tune up the band in the normal manner and read the display as the frequency above the bottom edge of the band. On the twenty-meter band, for example, 14.0253 MHz would be displayed as 025.3, with the 14 read from the receiver bandswitch. This calibration requires only a few seconds and is something that should normally be done anyway.

The circuit will handle either forward- or reverse-tuning VFOs, but, for the purpose of this explanation, assume a reverse-tuning VFO. Pressing the CALIBRATE button will clear the 74192 up/down counters and cause them to count the VFO frequency in the up direction for 100 milliseconds. The result is then stored in the 7475 latches. All subsequent count cycles will start at the number stored in the latches and count down for 100 milliseconds. Suppose the calibrate button were pressed when the receiver was tuned to exactly 14.0000 MHz. As a result, 5000 would be stored in the latches because the VFO was at 5.5000 MHz. Tuning the receiver to 14.0253 MHz would cause the receiver VFO to be 25.3 kHz lower, or 5.4747 MHz. The display counter would now start at 5000 and count down for a period of 100 milliseconds. The resulting count would be 5000 minus 4747, or 0253. By permanently enabling the decimal point to the left of the least significant digit (LSD), the display would show 025.3. Notice that by counting for 100 milliseconds, 54747 cycles are fed to the counters, but, since it has only four displays, the figure 5 is lost.

For a forward-tuning VFO, the sequence switch is placed in the reverse position. Pressing the calibrate button will then cause the first count cycle to be a down count with all subsequent cycles up counts.

Inside view of the assembled digital display. The smaller perf board is mounted right behind the bezel.





Inside view of the receiver digital display. The displays, up-down counters, and latches are mounted on the small board at the left. All other circuitry is mounted on the board inside the enclosure.

circuit description

One section of U1 serves as a 100-kHz crystal-controlled oscillator (see **fig. 1**). A divider chain, consisting of U2, U3, U4, and U5, drives a 7490 decade counter, U6 with one clock pulse every 100 milliseconds. The output of U6 is decoded by U7, with output pins 1, 3, and 4 each sequentially going low for 100 milliseconds of each measurement cycle. A jumper between pins 2 and 8 of U6 causes it to have only four output states rather than ten.

Assume the sequence switch is in the normal position. Pressing the CALIBRATE button causes the sequence of the next cycle to be *clear, count up, update*. This clears the counters to zero, counts for 100 milliseconds, and stores the final count in the 7475 latches. All succeeding cycles follow the sequence *load, count down, latch*. This loads the number stored in the latches into the counters, counts down for 100 milliseconds, and latches the final count into the displays.

U11 synchronizes the beginning and end of the calibrate cycle with the state of U7. Pressing S1 causes pin 5 of U11 to go high. As a result pin 9 goes high at the end of the current cycle and causes the next cycle to follow the calibrate sequence, in addition to resetting the first half of U11. At the end of the calibrate sequence, pin 4 of U7 goes high, resetting the second half of U11. U10 is the equivalent of a double-pole, double-throw switch and determines the count sequence, either up/down or down/up.

The remaining sections of U11 amplify and square-up the VFO signal. Three 4049 CMOS inverters are used. The first is biased to serve as an amplifier and functions well to above 6 MHz. This is fine for the large number of receivers with 5 to 5.5 MHz VFOs; but if your VFO operates at frequencies above this, a

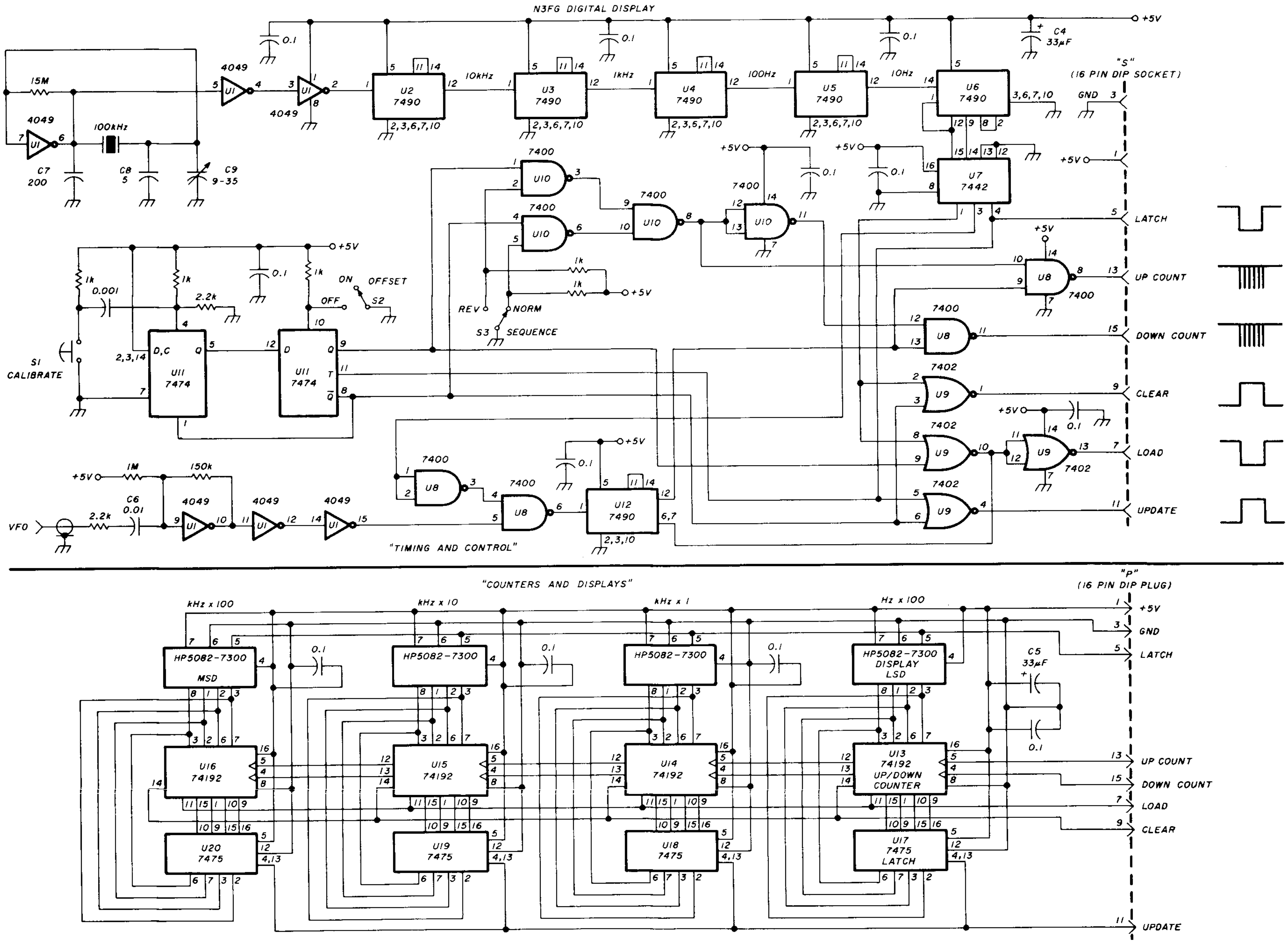
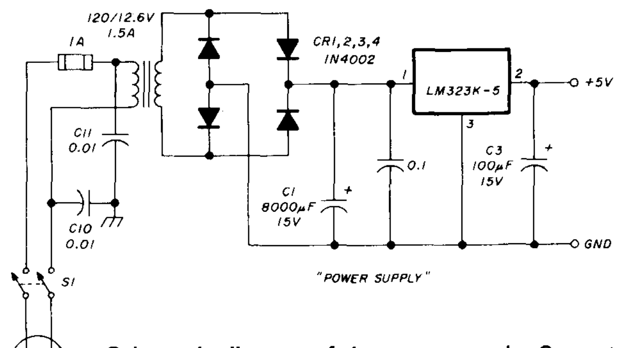


fig. 1. Schematic diagram of the complete digital display. C7 and C8 are silver-dipped micas; C9 is a small ceramic trimmer. Substitution of the LS-series ICs for the 7490s and 74192s will greatly reduce the power supply current permitting the use of a small regulator and transformer.



Schematic diagram of the power supply. Current consumption is such that a small voltage regulator could be used (LM309K).

more conventional frequency counter type of circuit using one or more discrete fets is in order.

U12 operates as a straight decade divider and provides a stable readout with no last digit flicker by acting as an undisplayed counter stage. The display may also be used as a conventional up counter or a straight down frequency counter by merely throwing the offset switch, S2, to the off position.

construction

My display was built in a 6.4 × 18 × 15 cm (2½ × 7 × 6 inch) Ten-Tec enclosure using a commercial bezel assembly available from Digi-Key. No printed circuit board is used. Instead, I used two pieces of 2.5-mm (0.1-inch) grid perf board, one for the counters and displays, and the other for the timing and control circuits. All ICs are mounted in wirewrap sockets which are in turn cemented to the perf board. Most of the interconnections were made using standard number 30 AWG (0.25-mm) wirewrap wire and an inexpensive hand-wrapping tool. The only exception is the power buses, which are number 18 AWG (2-mm) solid bare wire mounted on push-in solder terminals and run on either side of each row of IC sockets. Bypass capacitors (0.01 μF) were used liberally throughout the circuit. The voltage regulator is mounted on the rear of the cabinet using thermal compound, and several vent holes were drilled in the cabinet sides to remove internal heat.

The displays shown in the schematic are very compact and convenient, as they include decoders and latches, but they tend to be rather expensive if they must be purchased new. A functionally equivalent and much cheaper arrangement could be made using 7475 latches, 7447 decoder/drivers, and common-anode, seven-segment LED displays,[2] but a slightly larger cabinet would probably be required (see **fig. 2**).

The 100-kHz crystal I used is of unknown lineage and different crystals may require a slight adjustment of component values in the oscillator circuit. The 8000-μF power supply filter capacitor could probably be reduced to half the value without any problems and a 1.5-amp regulator substituted for the LM 323, as the current requirement at 5 volts is about 900 mA, a bit less than I originally anticipated.

calibration

Clip a piece of insulated hookup wire to pin 2 of U1 to act as an antenna and place it near a receiver tuned to WWV. Zero beat WWV with the trimmer and you're ready to go. If you have a good frequency counter, adjust the trimmers for exactly 100 kHz.

I hope that the ideas and circuits presented here prove to be informative and may perhaps encourage the construction of improved designs using hardware that will appear in the future. Counter latch combinations and dividers with a modulus greater than ten could serve to simplify construction considerably. For anyone attempting construction as shown, I would be pleased to supply advice or answer questions. Please include a stamped, self-addressed envelope with all inquiries. Now that I have had the use of this display for several months, I wish I'd built one years ago.

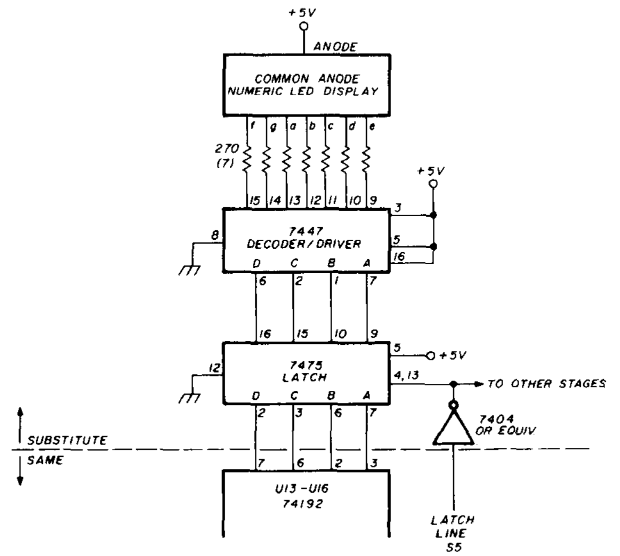


fig. 2. Diagram of a less expensive substitute for the HP 5082-7300 LED display.

references

1. Jon Hagen, W7URZ, "A Simple Frequency Counter for Receivers," *QST*, December, 1972, page 11.
2. Bruce McNair, WB2NYK, "A Digital Frequency Display for Amateur Communications Equipment," *ham radio*, September, 1976, page 16.

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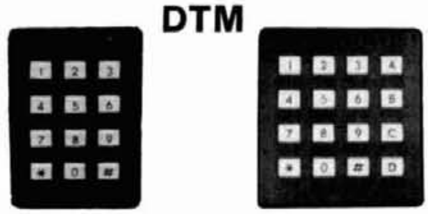

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More Details? CHECK—OFF Page 118

new approach for a 1-MHz oscillator

A reversion to basic oscillator concepts, this oscillator was built with optimized circuitry for each stage

Most of the oscillators built by Amateurs use a single transistor to perform several functions. However, the basic principles of operation are somewhat a mystery. The original analysis of the oscillator, done in the 1920s, showed that it could be divided into separate stages (see **fig. 1**). By actually building separate stages, you can obtain a better understanding of oscillator operation. This article presents an oscillator built using those basic concepts.

circuit description

The RCA CA3028 differential amplifier, shown in **fig. 2**, is used as an amplifier and limiter. Feedback, for the actual oscillator, is the limited sinewave from the pin 6 output. Note that this is a noninverting configuration. The amount of feedback is controlled by the 5-kilohm pot connected to pin 6. Feedback is injected into the quartz-crystal resonator. Because the crystal acts as a bandpass filter, the output will be a sinewave, in this case at 1 MHz. However, the crystal cannot be connected to the limiter without a penalty. The input impedance of a limiting differential pair is nonlinear. To overcome this problem, the crystal must be isolated from the limiter. This is done by connecting a common-base amplifier between the resonator output and the amplifier input. The com-

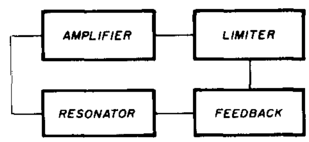


fig. 1. Diagram of the basic stages needed for an oscillator.

By Thomas V. Cefalo, WA1SPI, 29 Oak Street, Winchester, Massachusetts 01890

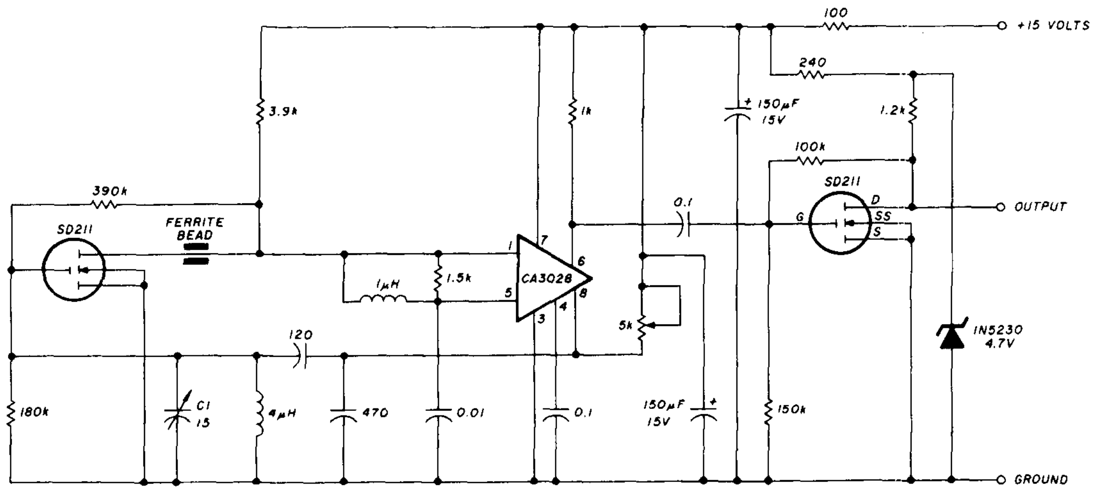


fig. 2. Schematic of the 1-MHz oscillator built using separate stages for each function rather than combining functions into a single device. All resistors, except R1, can be 1/8 watt; R1 is a 1/4-watt resistor. The power requirement is 36 mA at 15 volts.

mon-base amplifier provides a constant impedance load for the crystal. Because the output of the limiter is fixed, regardless of its input, and because the resonator also sees a constant impedance, the sinewave at the collector of the common-base stage has should oscillate. If it does not, increase the feedback until oscillation occurs at 8 volts. After the feedback is correctly adjusted, connect the output to a counter and adjust the crystal frequency with the small trimmer.

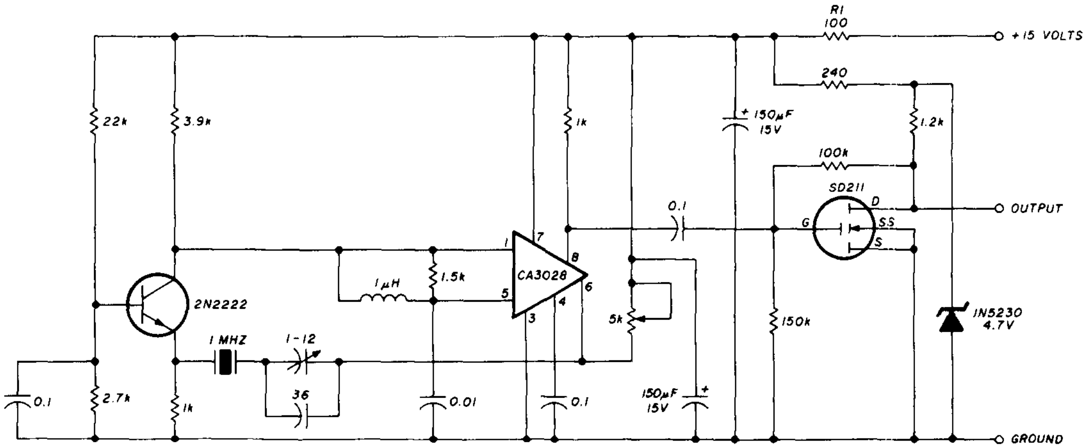


fig. 3. Diagram of a 40-meter LC-tuned VFO built using the same guidelines as the crystal oscillator.

a constant amplitude. This signal completes the loop by driving the limiter. The output is taken from pin 8, the unused inverting output. The output from the CA3028 is a limited sinewave. To make the output a clean square wave, an SD211 DMOS FET was used. The FET is driven into saturation, squaring the signal.

construction and adjustment

The oscillator was built on a piece of perforated board and housed in a 10 × 5.4 × 4.3 cm (4 × 2-1/8 × 1-5/8 inch) mini-box. Adjust the 5-kilohm variable resistor until the circuit goes into oscillation. Next, reduce the power supply voltage to zero and slowly increase the voltage. At 8 volts, the circuit

The output is a 4-volt peak signal with a rise time of 100 ns. The variation in frequency, at 1 MHz, is 0.5 Hz over a 1-second interval. This is due to the quality of the crystal and thermal effects. This variation can be reduced if a higher-quality crystal is used. Also, the environment can be temperature controlled with an oven or the use of insulation. The final frequency error was adjusted to 0.05 Hz. My present application for the oscillator is a time base in a frequency counter. However, you could modify the circuit to act as an LC-tuned VFO (see **fig. 3**). Since the SD211 FET amplifier is inverting, feedback is taken from pin 6, the inverting output.

ham radio

novel method for matching input impedance of grounded-grid power-amplifier tubes

When I was thinking about driving a tube power amplifier with my 20-watt transistorized ssb general-coverage transceiver, I noticed that uniform matching from the 50-ohm output of the transceiver into the amplifier between 1.8 and 30 MHz might present some problems. A circuit with a grounded cathode tube wasn't too attractive, because of the required neutralization and the various voltages needed for a tetrode or pentode. So I decided to use one of the modern grounded-grid tubes of the 8873-8875 series. Their input impedance is in the vicinity of 100 ohms, but since it's a dynamic input, impedance varies as drive level changes.

It's therefore highly recommended to use at least one tuned circuit between the exciter and the cathode connection of the tube to store energy and stabilize the dynamic input impedance. Since this tuned circuit requires retuning when the frequency is changed more than 10 per cent, such an arrangement would be highly impractical.

Note that this energy-storing circuit, although sometimes used in a pi configuration, does not really suppress exciter harmonics. Standard practice is to have enough harmonic suppression already in the exciter, and a 50-ohm output is provided from the exciter.

matching network

With these things in mind, and using a calculator to determine elliptical filters, I constructed a matching network that provides perfect matching and ideal energy storage between 1.8 and 30 MHz (**fig. 1**). This is a bandpass filter, which has Chebishev response in both bandpass and stop-band areas. It provides a constant impedance match over the frequency range of between 1 MHz and 60 MHz. This is important, because even high-order harmonics must be properly terminated, otherwise high transient voltages can be developed in the driver stages.

If you consider the fact that the frequency range between 1.8 and 30 MHz, on the basis of individual filters, must be split into at least seven segments (and assuming three components per segment), the total number of segments would be twenty-one, while here only fourteen are required.

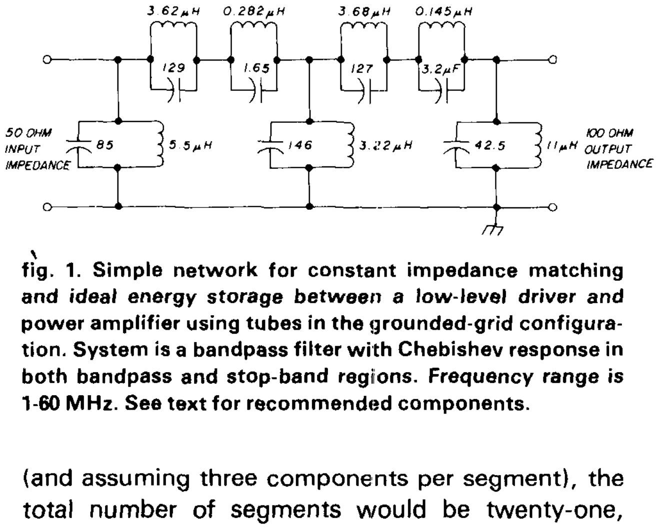


fig. 1. Simple network for constant impedance matching and ideal energy storage between a low-level driver and power amplifier using tubes in the grounded-grid configuration. System is a bandpass filter with Chebishev response in both bandpass and stop-band regions. Frequency range is 1-60 MHz. See text for recommended components.

components

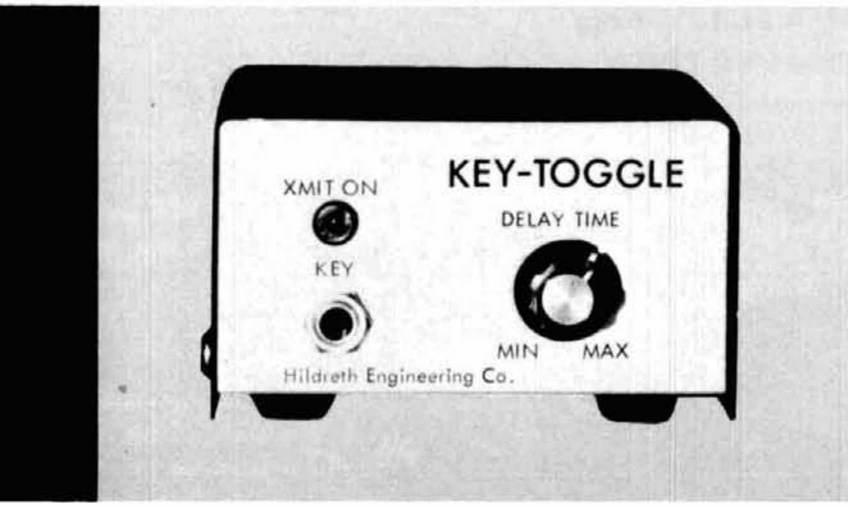
All component values are included in the schematic. You must use 500-volt mica capacitors together with either air-wound coils or coils with suitable ferrite materials, such as toroids. The recommended material for the latter is either Q1 or Q2 (Indiana General), Part no. F625/9 (dimensions in inches: D1 equals 0.375, D2 equals 0.187, and H equals 0.125).

A filter of this design has been successfully used, and no contribution to intermodulation distortion has been measured at a 25-watt drive level.

ham radio

By Ulrich L. Rohde, DJ2LR, 52 Hillcrest Drive, Upper Saddle River, New Jersey 07458

More Details? CHECK—OFF Page 118



the key-toggle

Key-toggle, another form of fast break-in, featuring simple but effective hand-key control of the transmitter

I wonder whether some psychologist won't someday discover that ham radio owes much of its appeal to the fact that you can say your piece in silence and the other guy can't interrupt until you're through. Even in most VOX systems, the other person cannot force interruption. Perhaps this is one of several reasons why "full break-in" CW operation has not yet become prevalent. It is not difficult technically, but there are still those of us who choose not to use it.

For handling commercial traffic on a clear channel, full break-in is perhaps best; but for most other activities, coupled with reasonable and unselfish operating practices, I prefer my key-toggle mode. To come on the air, you just start keying. To switch to receive, you simply hold a dash a little longer than normal (time adjustable). Key-toggle can be just about as fast as full break-in, but the other guy can't break you. For example, when you are winding up a transmission, the last letter normally sent is dah-di-dah. With key-toggle, it's dah-di-*dahah*, click, click. The first click switches your transmitter's plate supply off and the second click, milliseconds later, switches the antenna relay and opens the receiver (optional). You are now in receive mode until you start keying again. When you hit the key, once again: click, click. But this time the antenna relay is switched and the receiver muted first; then, milliseconds later, the transmitter's plate supply comes on and you are ON again. No combination of letters or long pauses will change the relays, switching you back to the receive mode. Only a long dash will toggle your station back to receive.

circuit description

Major components, as seen in **fig. 1**, include a 741 operational amplifier configured as a dual time constant integrator, a 711 comparator, a 7474 TTL flip-flop, a few transistors, and three relays. The KEY UP output of U1 is a nominal +2 volts. Q1 is conducting, which effectively limits the voltage across the 1-μF timing capacitor to near zero volts. With the +1 volt on pin 2, and 3 volts on pin 3, the output of U3 is also low. This places K2 and K3 in the de-energized (receive) state.

When the key is pressed, Q1 is cut off, which lets

By Don E. Hildreth, W6NRW, Post Office Box 60003, Sunnyvale, California 94088

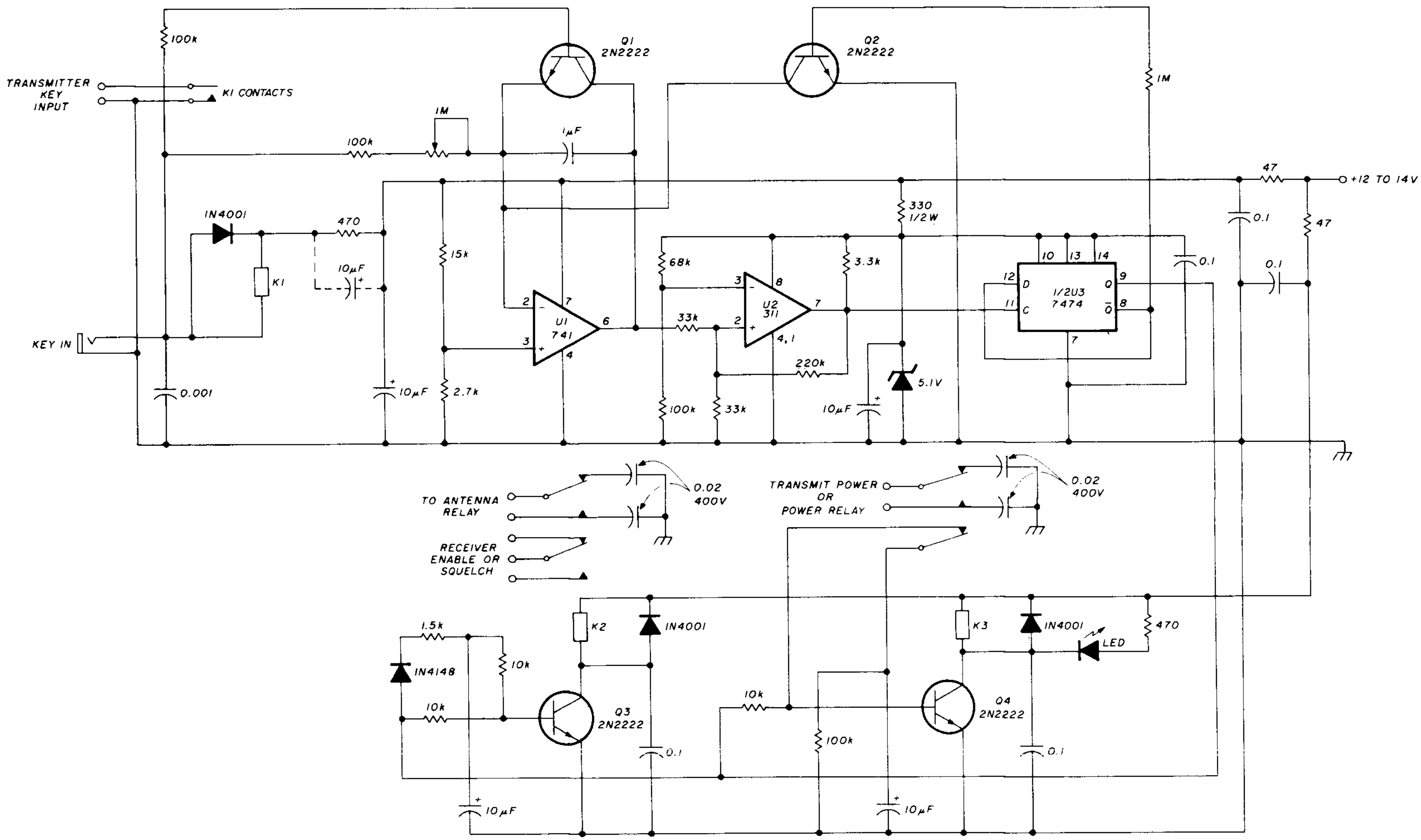


fig. 1. Schematic diagram of the key-toggle system. K1 is a Radio Shack relay (275-004); K2 and K3 are relays 275-206. Ensure that the contact ratings of the relays are not exceeded by the controlled equipment.

the op-amp circuit start ramping positive because of the +2 volts and the *timing* components connected to pin 2 of U1. When the level at pin 2 of U2 just exceeds the voltage at its negative input, the comparator snaps high (with the help of some positive feedback). This toggles the U3, making Q high (pin 9) and $\overline{Q}$ low. With pin 9 of U3 high, a turn-on voltage is fed to Q3 and Q4 through timing control networks. The base network for Q3 comes on first and causes it to turn on very fast and turn off slowly. Q3 operates K2 for antenna control and receiver muting. The RC network connection through K3 to the base of Q4 causes this transistor to turn on after Q3. After K3 is activated, the RC network is removed, allowing Q4 to turn off before Q3. **Fig. 2** shows the timing sequence for K2 and K3. K2 is the basic keying relay and must be able to follow keying speeds. For some keying circuits, K1 may be replaced with a 1-kilohm resistor for direct keying.

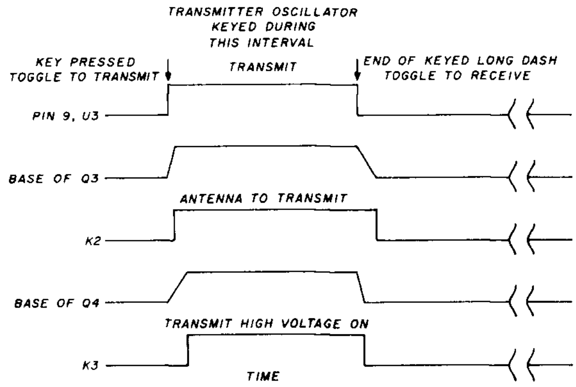


fig. 2. Relay keying sequence when switching from receive to transmit.

By using the $\overline{Q}$ output of U3 and Q2 as a switch, the system provides a short time constant for switching from receiver to transmit and the longer, variable-time constant when switching from transmit to receive.

why key-toggle

Back in May, 1950, Hiele showed a system[1] which, with variations, has been much used. In Hiele's system, the switch-over from receive to transmit is done quickly, just as in key-toggle, but the transmit mode switches to receive after your key is up a selectable time, sort of a "dead man's switch." This system is used in many modern transceivers through an application of the VOX system to CW operation. The relay timing system is simpler with this method because your key must be up in order to switch, but it has its own drawbacks in operation. If you adjust the time delay to allow for reasonable pauses when sending, the time seems like forever when switching over. And, if you adjust the timing for a quick turnover, your receiver blasts you when you pause. With key-toggle, you are in command. In fairness, however, it is recognized that key-toggle is not applicable to any automatic type of keyer.

power supply and construction

I used an inexpensive wall transformer supply system, although the 12-volt units usually supply 14 volts when lightly loaded, this poses no problem to the relays or op-amp. A zener diode is used to obtain +5 volts for the comparator and flip-flop. Maximum current is approximately 150 mA. Since this device is always used where strong rf fields are generated, a metal enclosure is probably mandatory.

connections

Outputs from *Key-Toggle* are contact closures intended to operate existing antenna and transmitter relays. Capacitors have been chosen to prevent switching transients from burning contacts and from false-triggering U3. For low voltage operation, as is the case in solid state equipment, the closures may be applied directly to the equipment.

operating with key-toggle

Assuming you are in receive status, you switch to transmit at the initial touch of your key (the switching process will shave a small piece off of your first dot or dash). Your transmitter will remain active until you hold a dash slightly longer than normal, the exact time determined by the TIME DELAY setting, which may be set between approximately 0.2 and 2.0 seconds. Adjust the time delay pot such that the time required to toggle your system is slightly longer than the time length of the dashes at the rate you intend to send.

One note, however: If you simply press your key and hold it when switching from receive to transmit, your transmitter will remain ON as long as the key is held down. After switching from receive to transmit, your key must be released at least once before a dash can toggle the relays.

This system takes a little time to get used to, but once you get the hang of it you can actually toggle for a quick listen between words, even between letters when you are not sending too fast. And switching will only occur when *you* choose.

reference

1. M. E. Hiele, W2SO, "An Automatic Transmitter Turner-Onner," *QST*, May, 1950, page 56.

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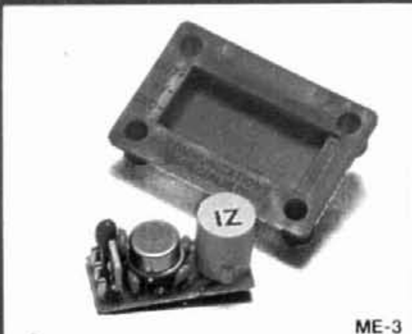
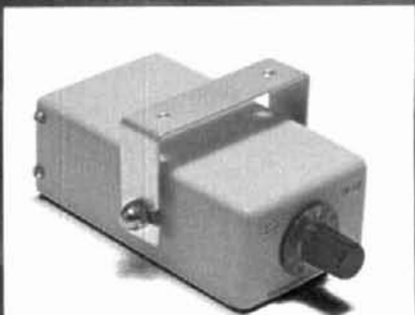


ME-3

TE-8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the weekender

i-f transformers — problems and cures

All serious communications receivers, transceivers, and most transmitters use the heterodyne principle for frequency generation. For receivers, various frequencies are converted to a single frequency called the *intermediate frequency* (i-f), while transmitters, on the other hand, will create the ssb signal at an i-f and then heterodyne it to the ham bands.

An i-f amplifier is a tuned radio-frequency amplifier that operates on a single frequency (*e.g.*, 455 kHz, 3350 kHz, or 9 MHz). In most cases, the tuned circuits in the i-f amplifier are tuned transformers (the primary and secondary coils are resonated by a capacitor) in a shielded can.

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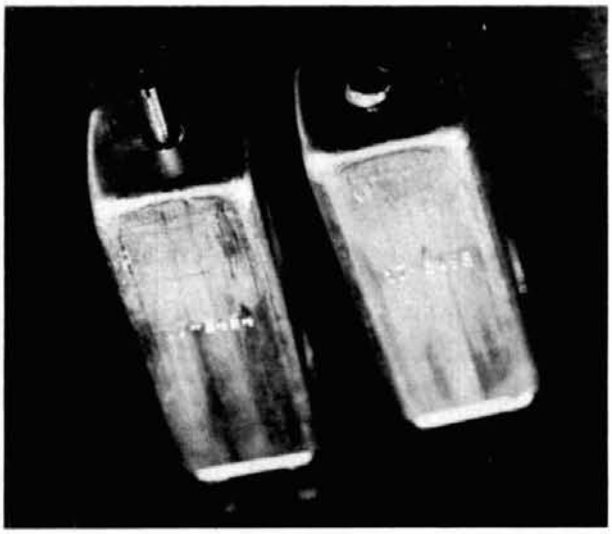
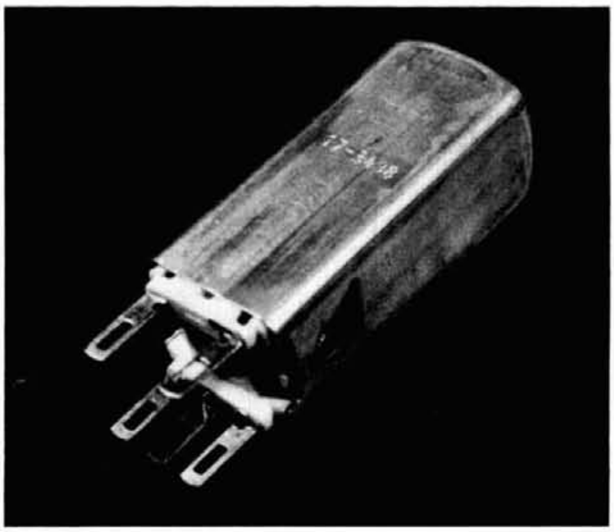
Fig. 1A shows two i-f transformers. Both of these are in the now-standard 1.9-cm (0.75-inch) shielded can. One of the transformers uses a threaded rod attached to the inductor core for tuning, while the other uses just an access hole to admit a tuning tool. In some cases, the inductor core will have a screwdriver slot to permit adjustment, while in others a hexagonal hole is cut through the center of each core. In the latter case, a special insulated hex alignment tool is used. The hex type offers the advantage of permitting adjustment of both primary and secondary tank circuits from the same side of the chassis.

Fig. 1B shows the pins at the bottom of the transformer. For an i-f transformer, at least four pins are required and some may have five or six pins. Some older models used wire leads instead of pins, and, of course, transformers intended for printed-circuit mounting will have solder tails instead of pins.

Fig. 2 shows several of the literally dozens of i-f transformers used in Amateur Radio gear. The transformer in **fig. 2A** uses two tuned coils. In a few early receivers, the tuning of the tanks was accomplished by the adjusting capacitors, the adjustment screws being accessible through holes cut into the shielded can. Most modern transformers, however, use a slug-tuned coil to tune the tank. The version shown in **fig. 2A** is commonly found in vacuum-tube equipment. **Figs. 2B** and **2C** show transformers designed for use in solid-state equipment. The version in **fig.**



A



B

fig. 1. Two versions of the standard 1.9-cm (0.75-inch) i-f transformer, showing the different methods of tuning the inductor. (B) shows the connection pins at the base of the transformer.

2B *uses taps on the primary and secondary windings* to match the low impedances normally found in transistor circuits. In **fig. 2C** the secondary is an untuned link. The transformer in **fig. 2D** is very similar to the one in **Fig. 2A**, except that a *built-in* bypass capacitor is provided to decouple the cold side of the secondary. These i-f transformer circuits are not unusual; they represent those most commonly found in receivers.

Fig. 2E shows a pinout configuration used by many manufacturers; note the odd sequence for numbering the pins. A color dot, usually green, identifies pin number one, with pins two through four occupying the four corners. These pins are usually connected to the tank circuit in the manner shown in **fig. 2A**. Pins 5 and 6 are reserved for such things at taps (**fig. 2B**) or bypass capacitors (**fig. 2D**).

Older units, using wire leads instead of pins often follow *the specific color code:*

blue — plate
red — B+
green — grid or detector diode
black — grid or diode return

transformer failures

Fortunately, i-f transformers are relatively simple devices, with failures limited to a few problems, such as open windings, shorted or open capacitors, windings shorted together, and the inability to resonate.

Open windings rarely occur anyplace except right at the transformer pins. **Fig. 3** shows a close-up view of the wire from one winding that has broken at the pin. Once the signal tracing gets you to the correct stage, this type of problem can be diagnosed with an ohmmeter.

fig. 3. Example of a broken transformer wire at the connection pin.

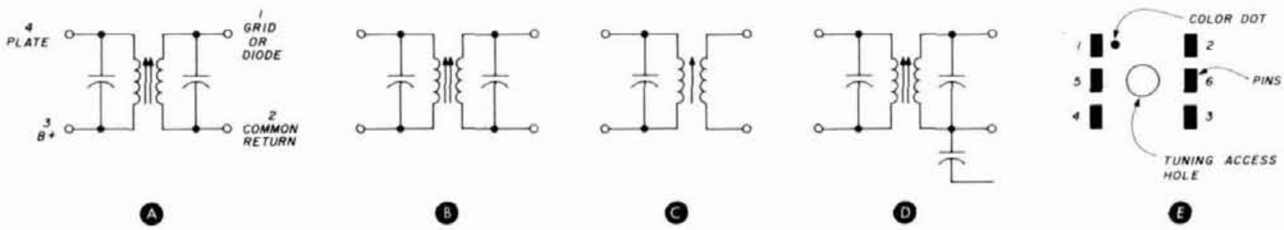


fig. 2. Versions (A) through (D) show different configurations for the i-f transformers. The pin numbering system is shown in (E) (bottom view).

The open winding is also the usual cause of the intermittent i-f. Interestingly enough, I have seen many cases over the years where the wire had never been soldered. The transformer worked nicely for many years, until either corrosion built up or a mechanical jarring knocked the wire loose.

Repairing the open-winding problem is easy in many cases — if you are gentle. Use a small screwdriver to pry open the metal shield. Most of the transformers in use have a coil form mounted on a plastic base, with the entire assembly slid into the shielded can. Tabs on the can are then bent over to form retainers which keep the coil form and base in place. It is a simple matter to pry these tabs loose and then gently pull the base from the metal shell.

Use small long-nose pliers when working on the transformer. In fact, it is best if you use tweezers instead of pliers. Avoid pulling on the wire; it *will* break, and right at the coil form! It is then almost impossible to repair the coil without rewinding it.

The wire should be resoldered to the pin using a small, pencil-type soldering iron, not a gun. There will usually be enough pretinned wire left to allow resoldering to the pin. But, if not, do not try stripping the wire or you will break it. Insulation may be removed by gently scraping the wire with a razor blade or sharp knife. Keep in mind that even this is at the risk of breaking the wire. The best method is to melt the insulation with the tip of the pencil iron.

Ordinarily, there will be enough slack to make the new connection without stretching the wire. If not, bend the pin toward the wire — do not try to stretch the wire. If this is not possible, then solder a short

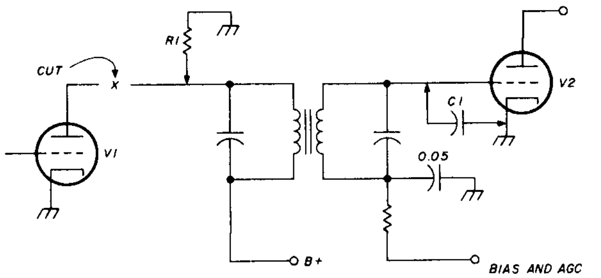


fig. 4. Technique for isolating a noisy i-f transformer. R should be equal to the plate resistance of the tube, with C being 0.01 to 0.1 μF.

piece of wire to the pin for use as a jumper. A single wire removed from a piece of stranded hookup seems about right.

Because of the low coil resistance, it is often impossible to tell if an i-f transformer capacitor is bad. Signal tracing will usually isolate the problem at the correct stage, and then dc measurements and a tube or transistor check will leave you with the fact that there is nothing left except the transformer.

Only one type of problem, the noisy i-f transformer, is easily identified as a bad transformer. This problem produces a crashing, crackling, static-type noise. To isolate the problem, remove the tube from its socket or break the plate lead between the transformer and the plate pin on the tube socket. Temporarily solder a resistor (see **fig. 4**) between the plate and cathode pins (or ground). The value of the resistor should be approximately the plate resistance of the tube. If noise persists, then suspect the transformer. As a quick extra confirmation, shunt a 0.01- to 0.1-μF capacitor across the grid and cathode of the following stage. If the noise disappears, then the i-f transformer is bad.

The i-f transformer is bad if the noise persists when the tube is removed and the resistor is connected to the circuit, or if the noise disappears or is reduced significantly when the shunt capacitor is connected. In a multi-stage, cascade i-f amplifier, each stage may have to be checked separately in succession, beginning with the stage that is closest to the detector.

In many cases, the noise is caused by a bad tuning capacitor inside the transformer can. Some transformers use individual ceramic or silver mica capacitors (which rarely go bad), but in most cases the two capacitors will be as shown in **fig. 5**. In **fig. 5A**, the capacitor is formed from a piece of mica dielectric with the silver plates deposited on both sides. A pair of contact springs connect each plate to its respective pin. This arrangement can cause noise by dc breakdown of the mica or by noisy contacts. In the latter case, cleaning and retensioning often cures the problem. The second arrangement, shown in **fig. 5B**, buries the fixed mica compression capacitors inside of a molded plastic base.

A study by the service department of a major automobile radio manufacturer revealed that, in humid regions of the country, there are roughly two to three times as many trimmer capacitor and i-f transformer problems than in dry areas. The best remedy for this is to replace the transformer. But, if that is impossible or would take too long, try replacing the bad capacitor with a disc ceramic or silver mica capacitor.

If the original capacitor is like the one in **fig. 5A**, it is a simple matter to use side cutters to clip off the top spring clip contact. Then solder a capacitor of the proper value across the terminals (see **fig. 6A**). The proper value can be determined experimentally (check first to see if the manufacturer gives the value in the schematic) using a GDO or signal generator to locate a standard value that will allow the coil to resonate at the correct frequency.

If the bad capacitor is not easily removed or disconnected, there is still a possible cure. Disconnect the coil wire going to one end of the capacitor, and then connect it and one end of the replacement capacitor to an unused pin. Or add a pin in one of the blank pin slots (**fig. 6B**) by forcing a piece of hook-up wire through the slot.

The problem of primary to secondary short circuits comes about because the wires from the upper coil pass by, and may touch, the winding of the lower coil. The problem almost always results in B+ leaking through to the grid of the next stage or the plate of the detector diode.

The cure here may be as simple as moving the wires apart and then patching up the damaged spot using Q-dope, high voltage corona dope, or just glue. Replacement of the transformer, however, may be required.

You'll sometimes find a transformer that is not causing static, passes all dc checks, but signals will

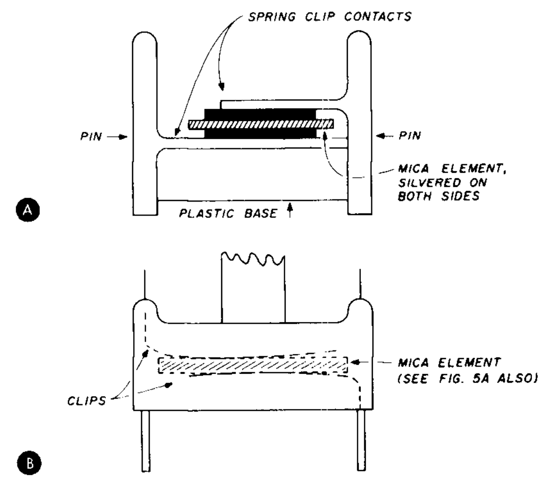
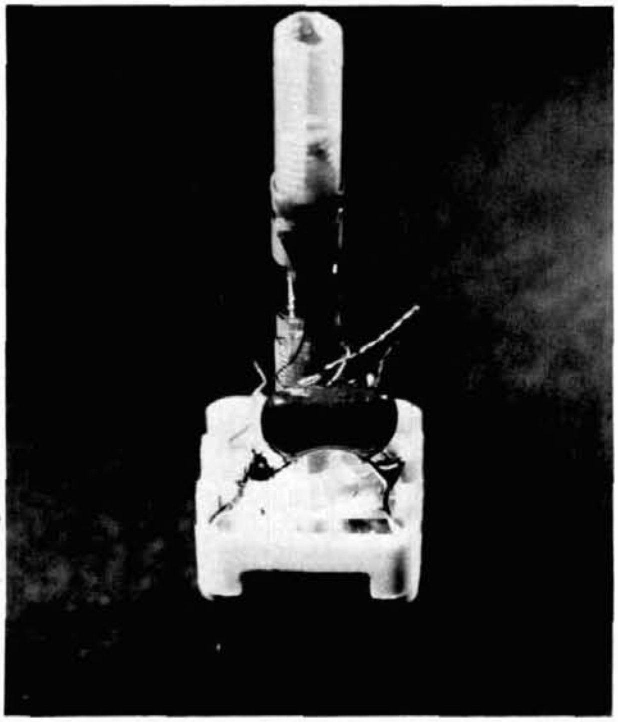
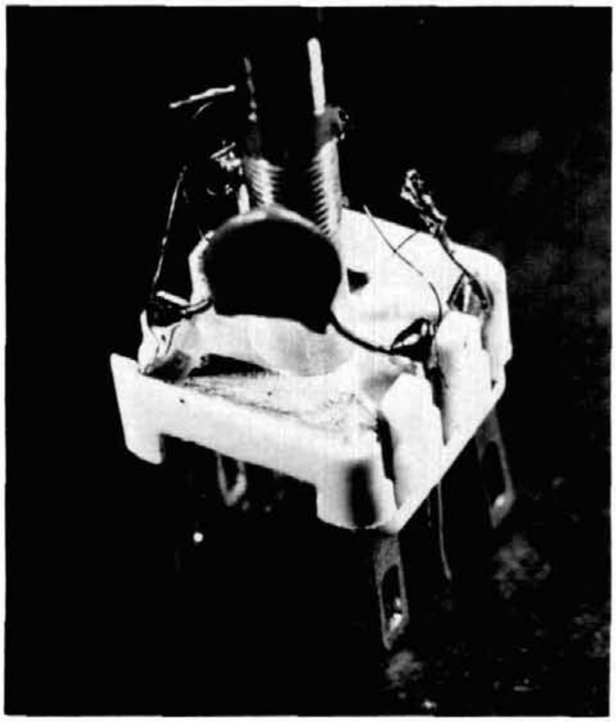


fig. 5. The compression trimmer can be one of two types, either open or enclosed in the plastic base. Cleaning and retensioning the version shown in (A) can cure the problem, though replacement is required for the molded version (B).





A B

fig. 6. (A) shows a replacement capacitor soldered directly across the pins at the base. To replace a molded capacitor, a new pin is inserted in the base of the transformer (see photograph B).

not go through or are severely reduced in strength. Barring such rare problems as shorted windings and open capacitors, it is often the case that one of the tanks is off resonance due to a cracked or broken ferrite tuning slug. To replace the slug, break it into smaller pieces (it rarely will come out by its threads!) and then remove them by shaking. A replacement slug can then be installed. Find an i-f transformer of the same frequency range and with the same type of slug. Salvage the slug and install it in the bad transformer. Some electronic parts suppliers stock small assortments of tuning slugs for just this purpose. Note that 9-MHz ssb transceiver slugs can often be replaced with a slug from a 10.7-MHz fm broadcast receiver.

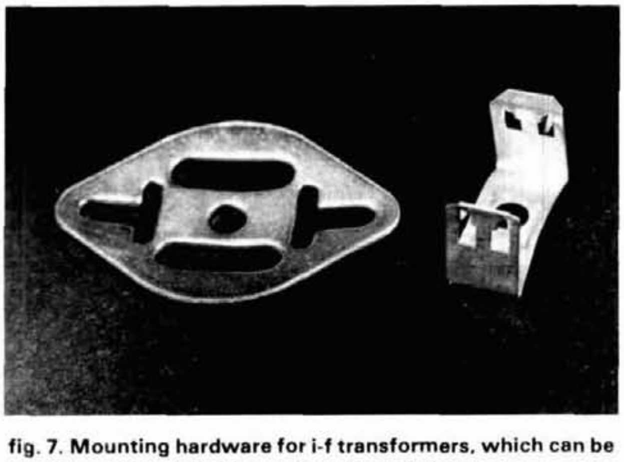


fig. 7. Mounting hardware for i-f transformers, which can be used to replace older 2.5-cm (1-inch) transformers.

Regardless of the problem, except perhaps the open coil repair, the best solution is to replace the bad i-f transformer with a new part purchased from the equipment manufacturer. However, this is not always possible, especially in older gear. Even if the company is still in business, the set may be so old that they no longer support the product. A few years after a model is discontinued, support usually vanishes.

It is possible to buy new i-f transformers. Companies such as J.W. Miller and others still manufacture both direct replacements for many types, and so-called "universal" i-f transformers. Their catalogues should reveal at least one or two currently made models which are good candidates for replacement of the bad unit in your rig. It's unlikely that a cross-reference listing for a piece of ham gear is available, but a careful reading of the specifications and inspection of the circuit diagram will lead to a replacement.

Older 2.5-cm (1-inch) or larger i-f transformers are especially difficult to replace. However, if you are willing to make a few mechanical modifications, the standard 1.9-cm (0.75-inch) transformers can be pressed into service using the adapter plates and mounting clips (**fig. 7**) provided with replacement transformer.

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updating the Heath HW-2036

to the HW-2036A

Modifications to the Heath HW-2036 to provide complete coverage of the new two-meter repeater subband

Now that the two-meter band has repeater allocations in the lower half, people with HW-2036 transceivers are feeling left out in the cold. No longer! With a small parts kit available from Heath, a few additional parts obtained (through Heath or purchased on your own), and these simple instructions, you can update your HW-2036 to cover the entire band. In fact, the transceiver will operate over a six-MHz range, from 143 MHz to beyond 149 MHz, although with reduced output at the extreme edges.

updating early HW-2036s:

Before actually beginning conversion of the HW-2036, check to see that your HW-2036 has all the updates that Heath has added since this model was introduced. There were addendum sheets included with the manual, in addition to several changes in the manual itself to reflect parts values different from those printed on the circuit boards. On the receiver board, R206 and R209 should be 10 kilohms, and C214, C215, and C216 should be 4.7-pF NPO disc ceramics. Also, Q204 was changed from a MPF-105 to an EL-131. If you have to replace these six parts, you will need to realign the receiver i-f. Wait, however, until the rest of the changes have been made.

On the synthesizer board, R419 should be 10-kilohms, C442 a 20-pF NPO disc ceramic, C403 a 100-pF NPO disc ceramic, and R445 220 ohms. These parts changes reduce drive to the synthesizer loop mixer. And finally, on the transmitter board, R141 should be 180 kilohms, ½ watt, which increases the zener bias in the 11-volt regulator. Only very early HW-2036s might need any of these changes. Your HW-2036 is now up to date. **Table 1** lists all the parts needed to convert the HW-2036.

conversion to the HW-2036A

There are changes to be made on each board, and we found it easier to do one board at a time and then do the alignment board-by-board when everything was bolted back together. It is necessary to have some method of removing solder from the double-sided boards before attempting to remove the parts.

Power Amplifier Board. Remove the transceiver top and bottom covers and begin with the power amp board by removing the heatsinks from the back panel. Unsolder and disconnect the ground wires connected to the corners of the transmitter and receiver boards. Carefully pull the molex connector apart, remove the two nuts that hold the power amplifier assembly to the back of the chassis, and swing the board down on its leads. A 12-pF dipped-mica capacitor (C235 in the HW-2036A manual) is added to the output connector on the inside of the board.

Prepare this capacitor by cutting the leads 22 mm (7/8 inch) long and slipping 19 mm (3/4 inch) of spaghetti or insulation over each lead. Bend the exposed 2-mm (1/8-inch) lead at right angles away from the body of the capacitor. Lay the capacitor on the foil of the board and solder one lead to the antenna jack center pin and the other to the foil where the ground wire pokes through the board. This forms a filter across the output. The lead length is the inductance part of the filter. Reassemble the board to the rear apron, but leave the ground wires to the transmitter and receiver boards loose for now. Replace the molex connector.

VCO Board. Heath now supplies a parts kit for modifying the VCO; it consists of two mica capaci-

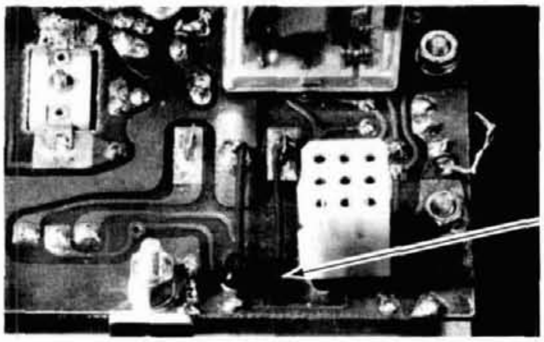
By Mike Miller, WB6TMH and **Ed Fitzgerald, WA6ODR**. Mr. Miller's address is 173 Leveroni Road, Sonoma, California 95476. Mr. Fitzgerald can be reached at Post Office Box 75, Cotati, California 94928.

tors, a coil, and a new varicap diode (parts kit number 830-29, \$3.95). Begin by removing the VCO cover screws and unsoldering the two lugs on the side (a soldering gun may be necessary for this step). Break loose the epoxy bead between the coil and the cover. Remove the nuts and washers and pull the board up on its leads to gain access to the bottom. Cut the epoxy bond between C503 and L501. If C503 is broken it will be necessary to replace it (Heath 21-192 \$1.35).

Unsolder and remove L501, C513, C509, and VD502. Replace each component with the parts supplied in the Heath package. Reglue L501 to the board, C503 to the side of L501, and C513 and C509 to each other. Now, replace the board on its bolts and turn on the power. Set the frequency switches to 146.000 MHz and run the slug of the new coil up and down, checking that the synthesizer lock light on the front panel goes out at some point, indicating the VCO is operational. Install the cover, gluing the coil to the top and soldering the lugs on the side. These changes increase the tuning range of the VCO by increasing the oscillator L/C ratio and making the varicap diode a larger part of the total capacitance. A full alignment of the VCO will be completed later.

Synthesizer Board. First, remove the black wire attached to point C on the power amp board to allow room for the synthesizer board to swing up. Remove the thirteen wires that attach the thumbwheel switches to the front end of the board and the four nuts and washers. Now, swing the board up on its remaining leads and remove R427 and R428, changing the values so that R427 becomes 5.6 kilohms and R428 10 kilohms. Page 61 of the manual can be used to locate these two resistors.

Replace the board on its bolts, attach the black wire to point C on the power amp board, and refer to pictorials 4-10 and 4-11 for color code and wire placement when attaching the thirteen wires to the frequency switches. Again turn on the power and check to see that the synthesizer lock light goes out.



Location of C235 which, in conjunction with its lead length, forms a filter on the output of the transmitter.

table 1. Parts list of components needed to update the HW-2036 to an HW-2036A. Unless otherwise noted, all resistors are 1/4 watt, 5 per cent tolerance.

Designation	value/description	Heath number	Heath price
update parts			
C214, C215, C216	4.7-pF NPO disc ceramic	21-168	\$0.29
C442	20-pF NPO disc ceramic	21-51	0.25
Q204	EL-131 (replaces MPF-105)	417-241	2.10
R141	180 ohms, ½ watt	1-112	0.22
R206, R209	10 kilohms 10 per cent	1-9-12	0.24
R419	10 kilohms	6-103-12	0.25
R445	2.2 kilohms	1-4-12	0.24
C403*	100-pF disc ceramic	21-75	0.25
conversion parts			
C503	0.1-μF monolithic ceramic	21-192	\$1.35
C509*	22-pF 5 per cent dipped mica	20-99	0.40
C513*	125-pF 5 per cent dipped mica	20-117	0.50
C201*	5-pF NPO dipped ceramic	21-78	0.25
C235*	12-pF 5 per cent dipped mica	21-130	0.45
L501*	0.25 μH	40-1855	0.95
VD502*	Motorola MV2110	56-640	1.65
R103*	100 ohms	6-101-12	0.25
R233*	15 kilohms	6-153-12	0.25
R427*	5.6 kilohms	6-562-12	0.25
R428*	10 kilohms	6-103-12	0.25

*Note These parts can be obtained as a kit with instructions (Heath part number 830-29) for \$3.95

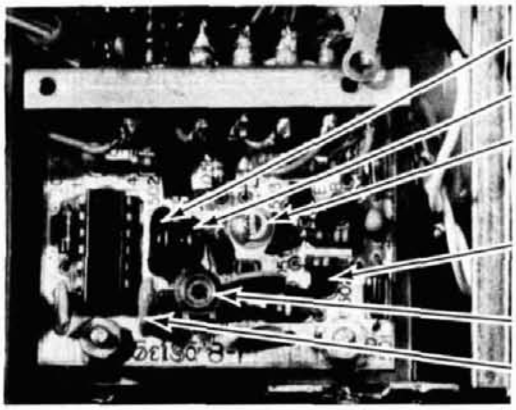
Receiver Board. Remove the four nuts and washers, remove the coax from points A and B, and tilt the board up on its remaining leads. Referring to pages 45-52 in the manual, change the value of R233 to 15 kilohms. This increases the drive to the receiver doubler.

Next, remove C201 and the shield alongside of L201 and L202. Remove 3 mm (1/8 inch) of the paper insulation from the vertical edge nearest L213. Cut a piece of 0.2-mm (0.01-inch) brass shim stock or copper flashing to 22 × 16 mm (7/8 × 5/8 inch), bending 3 mm (1/8 inch) of the long side at right angles to form a tab. Clean the shim stock and shield with steel wool and solder the tab to the existing shield where the insulation was removed. Alligator clips will hold the pieces together during the soldering.

Remove L202 and install the modified shield on its original pins. Solder the shield pin nearest L204 to hold it in place and run a bead of solder along the shield extension, joining it to the board foil behind C203 and L202. Also, run a bead of solder along the back of the shield next to C201. Replace L202, noting the polarity, and change C201 to a 5-pF NPO disc ceramic; solder both components in place, as well as the second shield pin.

Bolt the board down again and resolder the ground lead from the power amplifier board to the corner of the receiver board. Connect the power, turn on the transceiver, and tune in a local repeater to see that everything works properly. Full alignment will be done last.

Transmitter Board. Remove the phono plugs from J101 and J102, and remove the five nuts and washers holding down the board. Disconnect the molex connector to the power amplifier board and also the



This photograph shows the locations of components that were changed on the VCO board.

four large power connections labeled G, P, R, and V. Pull off the three-pin connector on regulator IC1 and unsolder the lead of the 0.001-μF capacitor from ground lug DA (refer to page 106). Carefully tilt up the board on its remaining leads.

Referring to page 74, remove R103 and replace it with a 100-ohm resistor. Remove the connectors on pins B, L, and N and solder the base of these pins to the board foil. These pins are the shield connections for interconnecting coax leads and should be rigidly grounded to both sides of the circuit-board ground plane!

Pull the red wire from pin S. Clip off and discard the 0.001-μF capacitor from the end and remove the two ferrite beads. Strip 3 mm (1/8 inch) of insulation from the end of the red wire and add approximately 7.5 mm (3 inches) of wire of a similar size, covering the soldered splice with heat shrink tubing or spaghetti. Now strip 16 mm (5/8 inch) of insulation from the extended wire and slip on the two ferrite beads just removed. There should be about 3 mm (1/8 inch) of wire sticking out. Solder this end to pin OUT, alongside the yellow wire from regulator IC1. Next, take a 2.5-cm (1-inch) piece of solid wire, bend a 3-mm (1/8-inch) tab on one end, and solder this tab to the circuit board foil next to pin N.

Install the board on its bolts again. Be sure to position the long coaxial cable along the top of the front of the board, as shown on page 106 of the manual. Replace all board connectors, phone plugs, and the connector on IC1.. Don't forget the shield connector to pin B, hidden under the wiring harness. Now, solder the other end of the 2.5-cm (1-inch) wire from the board foil near pin N to solder lug DA on the rear apron. Make this lead as short as possible and trim off the excess. Reconnect the ground wires from the receiver and transmitter boards to the power amplifier board.

Install two ground lugs at stud X on the power amplifier board. Solder one lug directly to the chassis. Remove the coax shield from point B on the power amplifier board and solder it to the second lug on stud X.

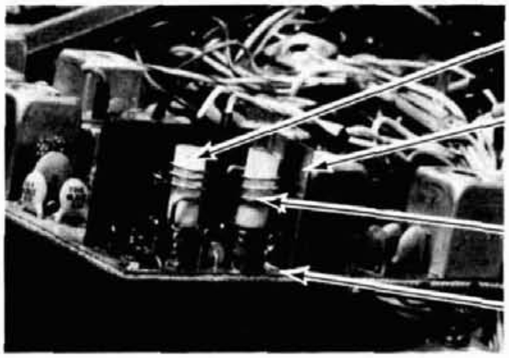
alignment

VCO Board. Set C511 on the VCO board to mid capacity. Attach the dc probe of a VTVM to TP401 on the synthesizer board; set the frequency switches to 146.000 MHz; and set the mode switch on the front panel to SIMPLEX. Turn the slug of coil L501 up until it shows at the top of the coil. Key the transmitter with the dummy load attached and rotate the slug down until the VTVM reads 2.2 volts. The SYNTHESIZER LOCK light should be out at this point.

With the transceiver *not* keyed, adjust C501 until the VTVM again reads 2.2 volts. This completes the VCO adjustments.

Transmitter Board. Since the transmitter strip is already aligned to a center frequency of 147.000 MHz, an abbreviated procedure is used to center the transmitter at 146.000 MHz, providing full output over the entire frequency range. First, install the dummy load. Set the thumbwheel switches to 146.000 MHz and connect the rf probe to TP101. The kit-supplied probe is fine and can be used with the dc scale of a standard VTVM for better sensitivity. Adjust L101 and L102 for maximum output with the transmitter keyed. Several adjustments may be necessary.

Move the rf probe to TP 102, key the transmitter,



The addition to the shield can be seen in this photograph of the receiver board. Part of the paper insulation was removed to allow the addition to be soldered to the original shield. When it's installed, the bottom of the new piece is soldered to the circuit board.

and adjust L103 and L104 for maximum. Remove the probe, and, with the transmitter keyed, adjust L105, L106, and L107 for maximum output as indicated on the front panel's relative power meter. The peak on L106 will be very broad.

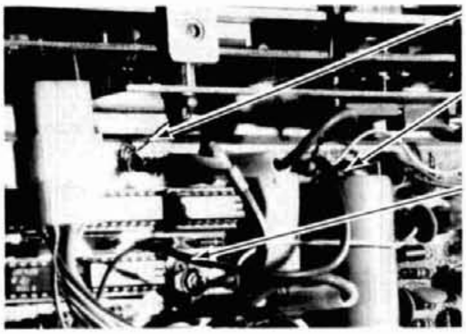
Now, set the frequency switches to 144.500 MHz and adjust L101 for maximum output at this lower band edge. Then, with the frequency set to 147.500 MHz, adjust L102 for maximum. Repeat these two steps, which are designed to stagger the tuning over the full band. Finally, set the frequency to 144.000 MHz, key the transmitter, and check the relative power meter to be sure the transmitter has full output at the extreme band edge. Repeat this step at 147.990 MHz. There may be a slight difference at each end, but not much.

Power Amplifier Board. Set the frequency switches to 145.000 MHz, and, with the transmitter keyed into the dummy load, adjust the power amplifier trimmers in this order: A, B, C, D, E, D, C, A, B. Do not adjust trimmer capacitor A any further clockwise than is necessary for maximum output. This single adjustment series should provide nearly equal output across the entire band. Remember to replace the heatsinks!

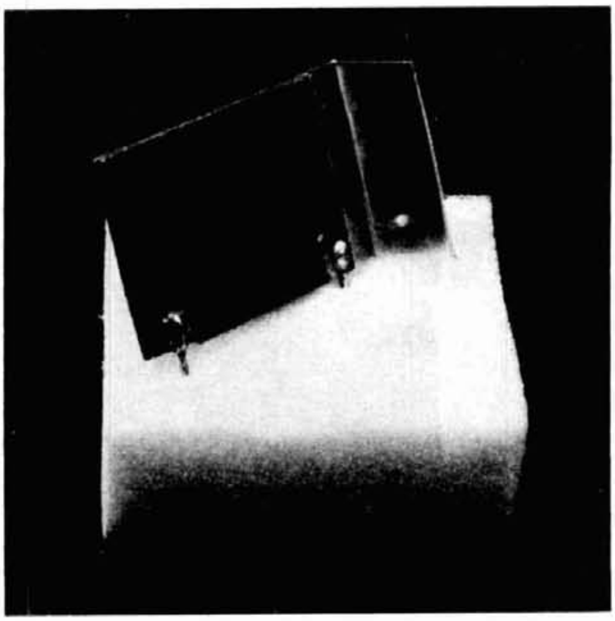
Receiver Board. Set the frequency to 146.000 MHz, connect the rf probe to gate 2 of Q202 on the receiver board, and adjust L402 and L403 on the synthesizer board and L212 and L213 on the receiver board for maximum level. Perform these adjustments in the order listed and repeat at least once. This provides maximum local-oscillator injection to the first mixer.

Next, remove the antenna coax from points A and B on the receiver board and connect the kit-supplied jumper from points A and B to points TP106 and TP107 on the transmitter board. Now, adjust L201, L202, L203, and L204 for maximum S-meter reading with the frequency set to 146.000 MHz. It may be necessary to adjust the frequency up or down slightly to pick up the harmonics of the reference oscillator being used as the alignment signal source. Also, since there is a high signal level, C147 on the transmitter board may be adjusted to maintain the meter reading at half scale or less. If this does not provide enough signal reduction, slightly detune i-f coil L207 on the receiver board. Once L201 through L204 are adjusted properly, L207 can be repeaked by removing the jumper from point A and holding it a small distance from the pin. This will provide enough signal to peak L207 without overloading the i-f strip.

At this point, if you replaced the parts in the i-f strip, refer now to the manual instructions for aligning the i-f stages. Few will need this however, and, if not disturbed, the rest of the i-f will not need attention. This completes the conversion.



Changes to the transmitter board can be seen in this photograph. Note that the wire extension is now soldered to pin OUT instead of pin S.



Close-up of the receiver shield with the addition soldered to the right edge.

remarks and notes

We found that the birdies on 146.000 MHz and 146.520 MHz were slightly decreased in signal strength but not eliminated. The reference oscillator and offset oscillator should not need attention if care was taken not to disturb their trimmers during the modification.

Reducing power consumption. Several ICs can successfully be replaced with low-power Schottky versions (LS series). IC104, IC105, and IC106 (7490s) may be replaced with 74LS90s. IC107 (7492) may be changed to a 74LS92. IC405 (7400) may be changed to a 74LS00, and IC404 (7473) may be changed to 74LS73. IC103 (7400) may *not* be replaced! These changes will reduce current drain about 20 per cent. It may be possible to change these devices to the CMOS series for further power reduction, but we haven't yet tried that substitution.

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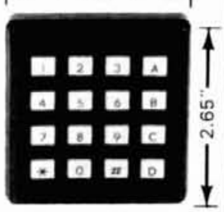

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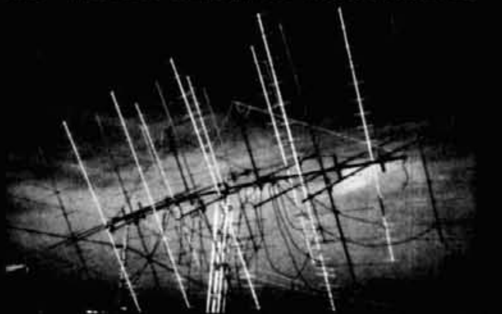

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More Details? CHECK—OFF Page 118

the dasher

Update your Vibroplex bug by using the Dasher — a simple circuit that provides a continuous series of dashes

Back about 1946, during my days as a commercial CW operator, I used to spend an eight-hour shift sending traffic in strings of 40 or more messages. Many of them were weather messages which had groups of five digits and many, many groups per message. I was getting a glass arm doing this at 40 words per minute or better every working day.

I saw a circuit in an Amateur magazine which used two tubes in a multi-vibrator circuit that could be mounted on top of a regular Vibroplex bug and would automatically make the dashes while you still get the dots from the mechanical side of your bug. I built and used one for years, saving my arm a thousand times over. It had the advantage that you could make the dashes much longer than the traditional 3 to 1 ratio. Therefore, you could retain your original sending style, yet send perfect code without fatigue.

Since then I haven't been too active – until recently when I got back into both MARS and CW work. That's when I remembered that silly thing I once built into a cake pan and mounted on top of my old Vibroplex.

Today, however, with all solid-state devices and small parts, one can be built in a small box, using a 9-volt battery for power. I used the 555 IC as a timer and a small 6-volt, dc-sensitive relay.

circuit description

Fig. 1 shows the circuit I used for the *Dasher*. In some circuits, pin 7 on the 555 was keyed. I tried this configuration but it caused a slight "hangover" on the last dash of a train, making it very difficult to handle. I decided to try keying the 9-volt supply to the entire circuit, but this caused the first dash of a series to be stretched. Then, I tried leaving the 9 Vdc connected to all parts of the circuit and keying the lead to pin 8. This got rid of the problems, resulting in perfect dashes.

The two pots permit adjustment of both speed and weight. The only change needed on a Vibroplex bug is to disconnect the lead under the base from the dash contact post. Then, use a two-wire, shielded mike cable to provide three connections from the bug to the input of the *Dasher*. The shield forms one lead from the frame post of the bug, and the other two leads connect to the dot and dash contacts. Inside the *Dasher*, the lead from the dot contact is connected to the output lead, with the dash contact used to control the 555.

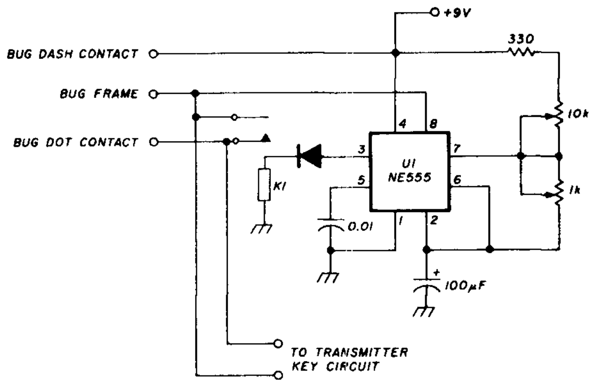

fig. 1. Circuit diagram of the *Dasher*. The relay is a small 6-volt unit available from Radio Shack. The diode can be any small signal switching diode.

Two things I might add for information. I used one of the rechargeable, 9-volt, ni-cad batteries and brought leads from the battery to screw terminals on the side of the box. This way I can connect a charger without opening the box. Also, a note of caution. Do not ground any of the 9-volt points to a ground that is common to the relay output or the bug common lead. When I tried the *Dasher* with my Collins KWM2A barefoot, no problems were encountered. However, when I ran the linear with a full kilowatt, rf was induced into the leads, causing erratic dash length. Putting ferrite beads on the input and output leads cured the problem. So have fun and don't end up with a glass arm; use the *Dasher*.

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By Joseph H. Fenn, KH6JF, 3612 Puuku Makai Drive, Honolulu, Hawaii 96818

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More Details? CHECK—OFF Page 118

formation of passive lumped constant 90-degree phase-difference networks

Construction details for designing equal amplitude, 90-degree, phase-difference networks

A variety of networks, both active and passive, have been used over the years for splitting a signal into two equal amplitude signals while maintaining a quadrature phase relationship between the two components. Roger Harrison's article[1] presented a number of such circuits and rekindled my interest in these devices. I first became interested in these circuits while designing image outphasing systems for sweeping microwave receivers about 20 years ago.[2,3] At UHF and microwave frequencies, 90-degree phasing networks are readily achieved with coaxial or stripline hybrids which can be designed for bandwidths of several octaves. These distributed element hybrids become large and difficult to build for the lower frequencies. Sometimes, it is also desirable to have circuits capable of greater bandwidth.

I have prepared a table (see **table 1**) of prototype values from which passive, lumped-constant, first-order lattice networks (**fig. 1**) may be designed. This table is an adaptation of early work by Darlington[2] and later work by Bedrosian. Darlington's work is basic and requires background in network theory plus a comprehensive table of elliptic functions to arrive at a practical design. Bedrosian's[3] paper included a number of tables of prototype values which can be used to calculate inductances, but you are stuck with the arbitrary bandwidths he chose unless you have access to a table of elliptic functions. Even then, there are several calculations to be done before arriving at a design. I have chosen a number of bandwidths which I believe would be most useful for Amateur Radio users, 2 to 1 through 20 to 1.

network description

The phase-splitting networks consist of two separate lattice networks, a P-network and a Q-network. For a given bandwidth, the amount of phase ripple (deviation from 90-degree phase difference) depends upon the number of lattice sections, the more networks the smaller the deviations. N is the total number of lattice sections in both branches.

Although the first-order networks are simple, they may not be the most practical. This sometimes becomes apparent when you try to produce a pair of networks operating over a relatively broad range.

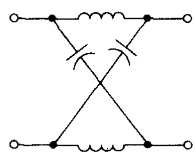

fig. 1. Diagram of a first-order lattice network.

You may discover that the networks, which are operating over the low-frequency end of the band as "all pass" networks, are also behaving at the higher frequencies like lowpass filters with a cut-off frequency within the design bandwidth. The reason for this is the self-capacitance of the inductors, which makes it difficult to place the self-resonance of the coils in the low-frequency lattices outside the design band.

Orchard[4] presented a transformation whereby two first-order networks may be combined in a single second-order network as shown in **fig. 2**.

description and use of the table

Once you have determined the bandwidth required (ratio of upper to lower frequency) and the phase ripple that can be tolerated, you are ready to select the appropriate prototype design from the table. Assume a 3 to 30 MHz 90-degree network is needed, requiring

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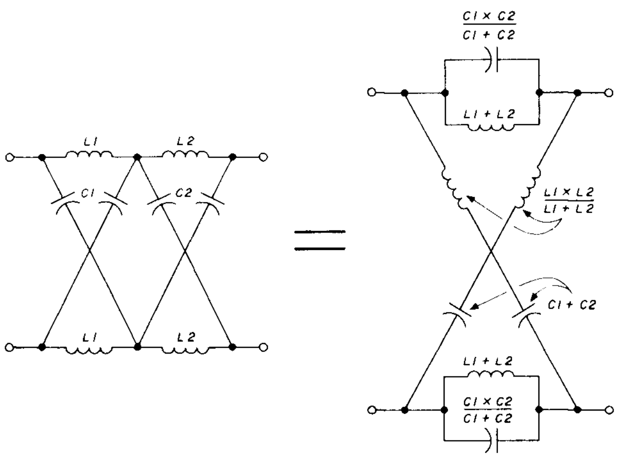

fig. 2. Transformation of a second-order to a first-order lattice network.

a phase deviation of less than two degrees. **Table 1** shows that a network with four lattice sections will yield a 10 to 1 bandwidth with a phase ripple of 1.08 degrees. **Table 1** also has normalized prototype values which are used to arrive at the actual designs.

denormalization and design

The lattice networks are denormalized for the geometric center frequency, in this case $\sqrt{3 \times 30} = 9.487\ MHz$. The inductances for the P network are calculated by:

$$L = \frac{P\,value\,(Z_o)}{2\pi f_o} \qquad (1)$$

where P = value from **table 1**

Z_o = characteristic impedance of network

f_o = geometric center frequency

table 1. Prototype values used for prototype designs.

BW ratio	N	phase tolerance	P1	P2	P3	Q1	Q2	Q3
2	2	1.687	0.405616			2.4654		
3	2	4.12254	0.3933			2.543		
3	4	0.0742	0.1859	1.539		0.65	5.38	
4	4	0.178	0.179	1.564		0.64	5.6	
4	5	0.03	0.142	1	7.04	0.476	2.1	
5	4	0.308	0.173	1.586		0.63	5.787	
5	5	0.06	0.137	1	7.3	0.466	2.15	
6	4	0.455	0.167	1.61		0.622	5.97	
6	5	0.1	0.133	1	7.54	0.456	2.19	
6	6	0.02	0.11	0.731	2.75	0.363	1.37	9.1
8	4	0.77	0.1585	1.64		0.6084	6.31	
8	5	0.184	0.1254	1	7.97	0.441	2.267	
8	6	0.044	0.1038	0.72	2.87	0.348	1.388	9.63
10	4	1.08	0.151	1.675		0.597	6.61	
10	5	0.28	0.1196	1	8.36	0.428	2.33	
10	6	0.07	0.0989	0.711	2.97	0.336	1.41	10.1
15	4	1.91	0.137	1.74		0.573	7.28	
15	5	0.577	0.108	1	9.25	0.403	2.48	
20	4	2.55	0.1285	1.79		0.559	7.78	
20	5	0.829	0.101	1	9.9	0.387	2.59	

You are now ready to complete the design using the P and Q values from **table 1**. For the P network assume $Z_o = 50$.

$$L_1 = \frac{P_1 \bullet Z_o}{2\pi f_o} = \frac{0.151 \times 50}{2\pi \times 9.487 \times 10^6} = 0.1267\,\mu H$$

$$L_2 = \frac{1.675 \times 50}{59.6 \times 10^6} = 1.405\,\mu H$$

$$C_1 = \frac{P_1}{Z_o \bullet 2\pi f_o} = \frac{0.151}{50 \times 59.6 \times 10^6} = 50.7\,pF$$

$$C_2 = \frac{1.675}{50 \times 59.6 \times 10^6} = 562\,pF$$

For the Q network:

$$L_1 = \frac{Q_1 \bullet Z_o}{2\pi f_o} = \frac{0.597 \times 50}{2\pi \times 9.487 \times 10^6} = 0.5\,\mu H$$

$$L_2 = \frac{6.61 \times 50}{59.6 \times 10^6} = 5.54\,\mu H$$

$$C_1 = \frac{Q_1}{Z_o \times 2\pi f_o} = \frac{0.597}{50 \times 59.6 \times 10^6} = 200\,pF$$

$$C_2 = \frac{6.61}{50 \times 59.6 \times 10^6} = 2218\,pF$$

Now the complete circuit can be sketched (see **fig. 3**). An example of an $N = 5$ network for the same bandwidth is shown in **fig. 4**.

The first-order lattice is a balanced circuit whose unbalanced equivalent requires the use of a transformer. Several types of balanced-to-unbalanced transformers, which are suitable for adapting the lattice to an unbalanced circuit, are described in reference handbooks. You have the option of choosing the impedance level of the lattices to effect the desired impedance match at the common junction of the networks.

theoretical and experimental results

The values for **table 1** were obtained from a BASIC computer program (PHASE90) which is capable of designing a wide range of first-order networks with bandwidths up to 100 to 1. Several designs from this program were analyzed using a BASIC (GNET) network analysis program and were found to perform as predicted.

Finally, to prove the usefulness of the theoretical design, a four-section ($N = 4$) network consisting of first-order lattices was built for the 20 to 150 MHz range. The phase deviations from 90 degrees were about 5 degrees, which is greater than the theoretical tolerance of 0.7 degree, but adequate for most requirements. This experimental data shows that the first-order lattices can be used for an 8 to 1 band-

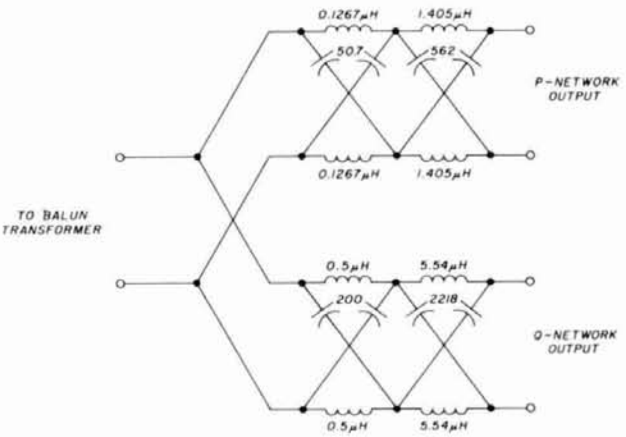

fig. 3. Component values for the 3 to 30 MHz, four-section network.

width. For greater bandwidths you may have to resort to the second-order lattice configuration.

acknowledgments

I am indebted to R. E. Booth, WB6SXV, who wrote the GNET network analysis program, and

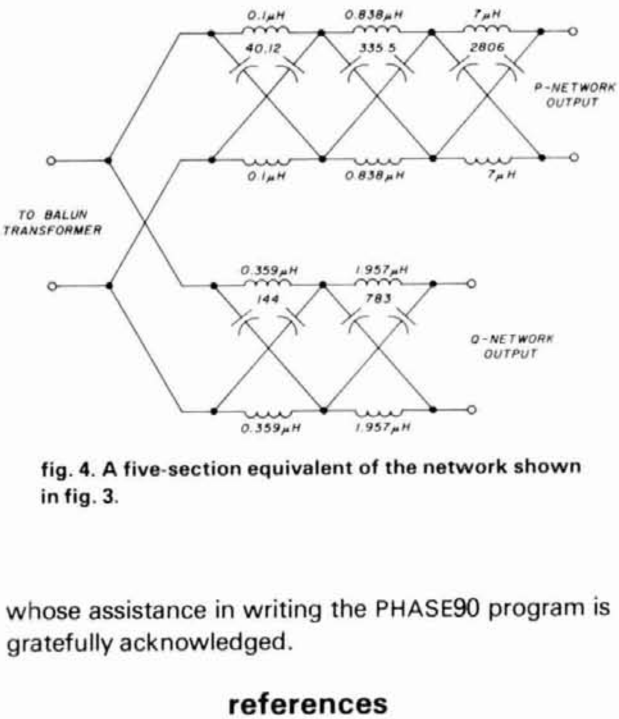

fig. 4. A five-section equivalent of the network shown in fig. 3.

whose assistance in writing the PHASE90 program is gratefully acknowledged.

references

1. Roger Harrison, VK2ZTB, "A Review of SSB Phasing Techniques," *ham radio*, January 1978, page 52.

2. R. B. Wilds, "An S-Band Two-Phase Demodulator," *1958 IRE WESCON Convention Record*, Part I, page 48.

3. R. B. Wilds, "Microwave Two-Phase Converters for Imageless Receivers," *Microwave Journal*, September 1961, page 84.

4. Sidney Darlington, "Realization of a Constant Phase Difference," *Bell System Technical Journal*, January 1950, page 94.

5. S. D. Bedrosian, "Normalized Design of 90-degree Phase Difference Networks," *IRE Transactions on Circuit Theory*, June 1960, page 128.

6. H. J. Orchard, "Synthesis of Wideband Two-Phase Networks," *Wireless Engineer*, March 1950, page 72.

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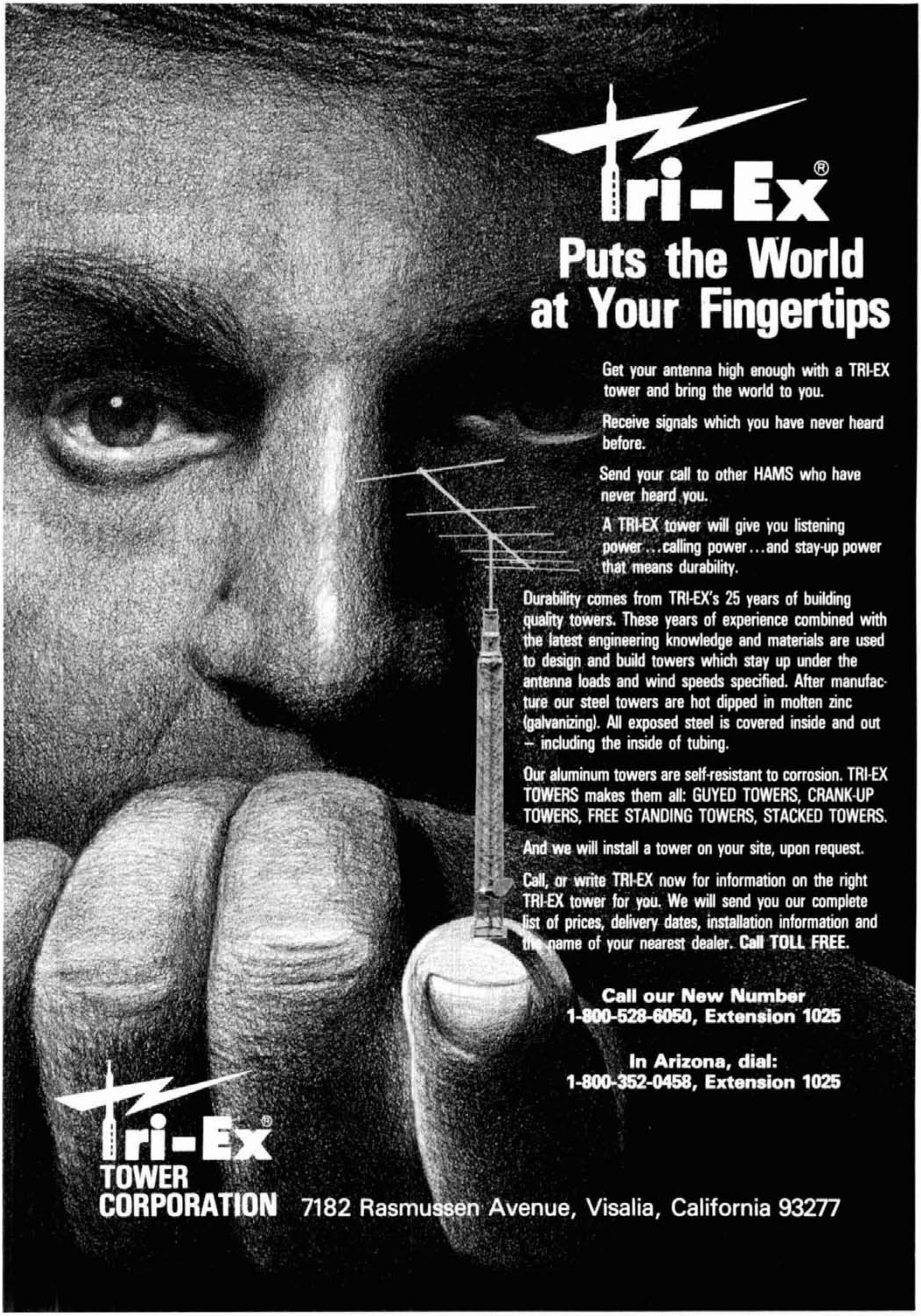
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cabinet construction techniques

A new construction technique which allows the builder to build a cabinet to fit his equipment — rather than fitting his equipment into the cabinet

All builders of electronic devices eventually come up against a continuing problem — what type of cabinet to put their creation in. The magnitude of the problem increases in direct proportion to the dimensions desired. Commercially manufactured answers to the problem are few. If a cabinet is inexpensive, it is usually too small or flimsy; if it is rugged enough it will usually be too expensive. Trying to find a cabinet with the desired size and configuration often seems next to impossible. It has been my experience that few local dealers ever carry a large percentage of a cabinet manufacturer's total line. Therefore, mail order must be resorted to, which takes time.

Many times, the builder must choose "the best of the worst" from stock on hand and then tailor construction of the device to fit the cabinet. This practice usually results in unnecessary work and design trade-offs. Another problem that occasionally occurs is the need to increase or decrease the depth of a cabinet, something not easily accomplished. All of this adds up to what I call the "cabinet frustration syndrome."

What follows is an idea that evolved from attempts to solve these problems. The result is a rugged, inexpensive cabinet which is easy to construct in any needed size. Fabrication materials are universal in that they can be used for most any size cabinet. Most of the pieces from scrapped cabinets can be used again. With this method, the depth of the cabinet can be easily extended or reduced.

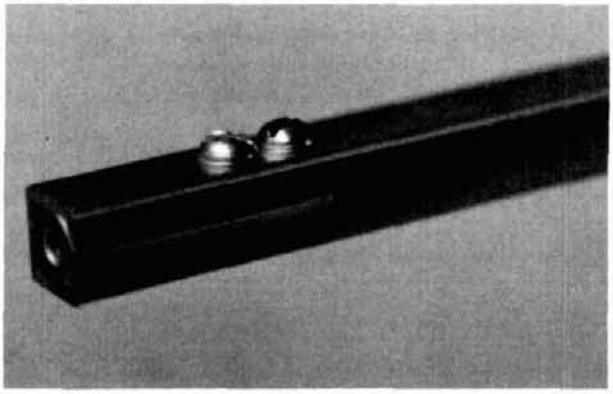
fabrication

The basic cabinet is made of only two items, the end plates and the end-plate support brackets. The end plates can be the front and rear panels of your unit or they can be subpanels, using a method to be described later. The two end plates are simply cut from aluminum sheet stock to the desired front-panel dimensions. A mounting hole for each bracket is drilled in each corner. The end-plate support brackets are the key to this whole method of construction. Bolted between the end plates, they provide cabinet rigidity, while at the same time allowing construction flexibility.

The brackets are made of aluminum U-channel, cut to the desired depth. Aluminum U-channel was chosen because it is light, relatively inexpensive, and readily available at most hardware stores. My first attempt, for which I used 12.5-mm (1/2 inch) U-channel, was acceptable but resulted in a more rugged (and heavier) cabinet than was necessary for that application. Cabinets built of 9.5-mm (3/8-inch) channel proved to be best for most of my uses.

Once the U-channel size is decided upon, the next step is to locate or fabricate something to lay in the channel that will accept the end-plate mounting screws. My junk box yielded some threaded metal standoffs about 5 cm (2 inches) in length. These fit snugly in the channel. The standoffs had a 10-32

By Bob Thompson, W7KDM, 12213 South Oneida, Phoenix, Arizona 85044



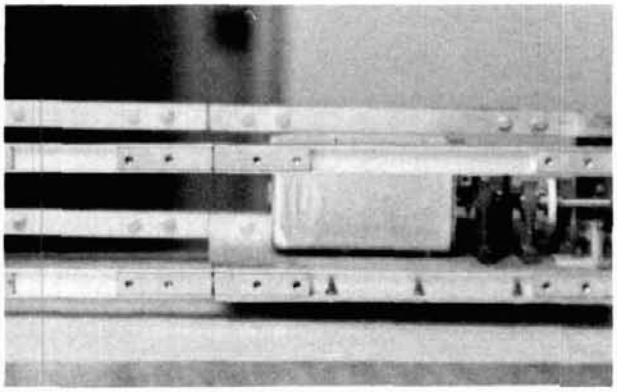
As seen in this photograph, the standoff was drilled and tapped for two additional holes, providing a means of securing the standoff in the channel stock.

(M5) threaded hole through their length. Two other mounting holes were drilled perpendicular to the length and tapped for a 10-32 (M5) thread. These holes are for bolting the standoffs to the U-channel.

If you don't have any standoffs, square aluminum stock is usually sold along with the U-channel. This can be cut to length, drilled, and tapped as necessary. Of course, the square stock can be cut to a length equal to the cabinet depth and used as the entire mounting bracket. In that case, only one hole must be drilled and tapped in each end. However, a solid bracket will have a few disadvantages when compared with the U-channel approach; it will be heavier, and it will offer less flexibility in the mounting of parts to the brackets.

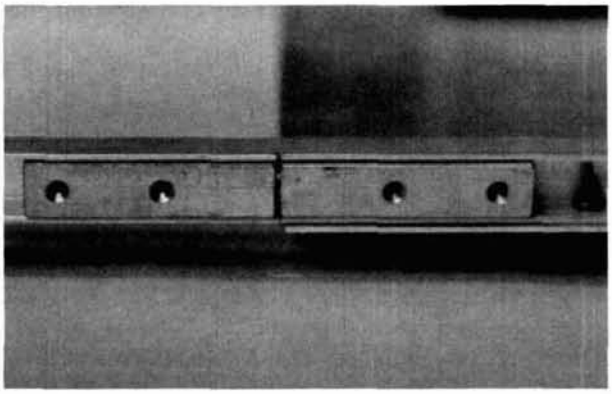
Once each bracket has a standoff mounted at each end, the four brackets are bolted to the end plates, and the basic cabinet is finished! Component mounting plates can be above or below the brackets. If a center mounting plate is needed, this can easily be accomplished with L-brackets. Incidentally, a good source of L-brackets for any project is L-shaped aluminum stock, usually sold in the same place as the other materials. Merely cut the stock to the width of L-bracket desired. The L-bracket will be much stronger than one made by bending a piece of flat stock.

Example of a chassis that has been lengthened by using additional side bracket pieces.



The basic cabinet is essentially a frame that can be covered by cutting and bending lightweight sheet aluminum. The design is such that the cover is not needed to provide the basic structural integrity and strength. This is a big problem with all but the most expensive commercial cabinets. Here again, the lightweight aluminum cover material is usually sold where all the other materials are.

Rather than making a cover by bending, cutting individual pieces of stock and attaching them to their respective sides with small screws is also a possibility. Where a heavier gauge metal will be used for the cover, it is possible to entirely eliminate the brackets.



Close-up of the connection between the two sections of a side bracket.

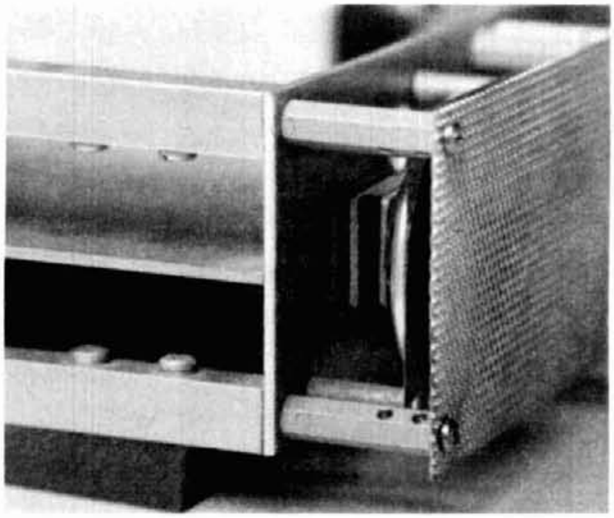
In this case, a central chassis plate is fastened to the end plates with L-brackets. Unless the cabinet is very small, the aluminum sheeting used for the end plates and chassis plate should be heavy enough to provide sufficient rigidity. Most of the aluminum that I use for chassis and end plates is 3 mm (1/8 inch) thick, although I've also used material 1.5 mm (1/16 inch) thick with success.

Aluminum sheeting is used because of its widespread availability and low cost. In the past, I have used some magnesium alloy sheet which provided excellent rigidity and light weight. The problem is, of course, that it is both expensive and difficult to come by.

As mentioned earlier, cabinets made with the U-channel technique can be easily lengthened or shortened. To shorten a cabinet, merely remove the standoffs from one end of each bracket, cut the brackets to the desired length, and remount the standoffs in the ends.

The process of lengthening a cabinet is just a little more involved. If materials are available, just make longer brackets. However, if you don't have a piece of U-channel long enough to make four new brackets you can use four small pieces and add to the length of the existing bracket. This approach will require more work, but could be the most expedient and most economical under certain circumstances.

First, cut and fashion four extension brackets for the desired added depth. Remove one of the end plates. Insert adequate lengths of threaded screw stock (I favor 10-32 [M5]), into the ends of the brackets to be lengthened. Leave about 12.5 mm (1/2 inch) protruding. Screw the extension brackets onto the exposed screw stock. Now comes the only tricky part: when the two brackets are snugged up tight against each other, they should be aligned. If they do not align, insert a piece of metal shim stock or a thin washer between the two pieces and try again until alignment is achieved. Mount the other end plate on the extended brackets. If desired, one end plate can be used as a subpanel for false front panels or speaker grilles. This is accomplished with metal standoffs.



This photograph illustrates a false panel speaker grille using standoffs mounted on an end plate.

The only item which might prove difficult to procure is the aluminum sheet used for the chassis and end plates. Sheet metal dealers will usually sell remnants at scrap value. Scrap metal dealers sometimes have acceptable pieces. Your best bet is to get out and browse around to see what is available.

It's my hope that this article has provided you with a basic method (plus some variations) for relieving "cabinet frustration syndrome."

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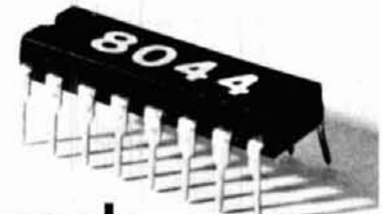

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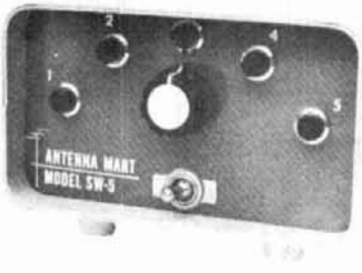

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More Details? CHECK — OFF Page 118

DIGITAL TECHNIQUES

digital circuits — propagation delay and flip-flops

So far, the basic gate has been examined under dc or static conditions. This part will discuss dynamic conditions of switching, propagation delay, and the most simple flip-flop, the latch.

All digital devices have delay from internal charge storage. Input and output may switch rapidly, but the delay between input transition and output transition is usually longer than the transition itself. **Fig. 1** is an example of dynamic conditions in a simple inverter.

The term t_p or t_d is associated with propagation delay and will have a number of different subscript letters to distinguish different types of delay. A table in the front of the Texas Instruments *TTL Data Book* lists most of them. The term *propagation* is used, since the input-to-output path within a device may go through several stages.

The inverter shows only two delays. t_{pLH} is the input transition-to-low delay to output transition-to-high state; t_{pHL} is the opposite. They may occur at different times. Measurement is made at half amplitude between maximum low-level voltage and minimum high-level voltage.

Output-state transition time is also listed, almost always at a specified load of maximum capacity. Load capacity affects output transition delay strongly but has only a slight effect on propagation delay.

Multi-function devices have a number of different delays. Data sheets must be carefully studied to understand the effect of delays on the overall circuit. Lack of understanding of delays can waste a lot of debugging time (most times are too short to measure on inexpensive scopes) and also can cause a circuit to fail entirely. Delay time can't be underestimated!

By Leonard H. Anderson, 10048 Lanark Street, Sun Valley, California 91352

the RS latch flip-flop

Fig. 2 shows the block symbol, waveforms, and an equivalent circuit constructed of NAND gates. The *RS* term comes from reset/set. A flip-flop is a bistable circuit (stable in two conditions) and is either set or reset by an external input. Because it's bistable, it's said to be latched in one state or the other.

The circuit of **fig. 2** has active low set and reset inputs, indicated by inversion bubbles on the symbols. Outputs are not shown with bubbles, since the flip-flop is a bistable device.

Flip-flop terminology sometimes refers to the Q output as true, $\overline{Q}$ as false, or NOT. Output-to-input cross-connection would appear to create an oscillator. This would be true with linear devices, but it's the key to holding a bistable condition with digital devices.

Assume initial conditions of both inputs and Q high, $\overline{Q}$ low. NAND gate G1 is held high by the low from G2. G2 is held low since both inputs are high (the *NAND RULE*). The initial state is stable. Either output could have been high at power turn-on, depending on which gate was the fastest.

The first $\overline{S}$ low input does nothing; G1 is already held high. The first $\overline{R}$ low will force G2 high. G1 then

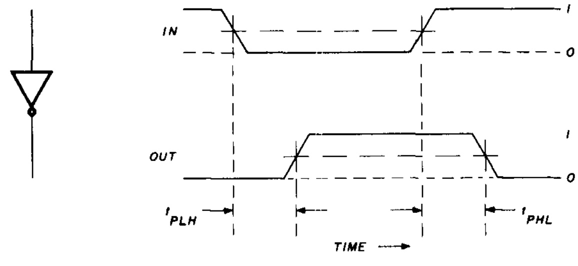

fig. 1. Propagation delay of an inverter.

goes low, since all inputs are high and the latch has flipped to a reset condition (Q low). This is the other stable condition.

Note the exaggerated time delays and sequence of changes. *Each input must hold at a low state long* enough for both gates to change state. Flip-flop spec sheets will give this parameter of time as t_{hold}.

A following $\overline{R}$ low will do nothing: *the latch is* already reset. A second $\overline{S}$ low will force G1 high. G2 will go low since all inputs are high; the latch has *flopped into a set condition.*

What happens if both inputs are low? Both outputs will be forced high as long as that condition persists. The unknown condition occurs when both inputs return high. Either stable condition could occur and, as in power-on, it depends on which gate is the fastest. This is the indeterminate state and should be avoided.

a switch debouncer

All switches and relays, except for mercury wetted types, have contact bounce. Contact bounce is the opening and closing of contacts because of mechanical vibration. It lasts between 0.2 and 50 milliseconds, depending on construction, and can raise havoc with certain digital circuit inputs; a cure is found in **fig. 3**.

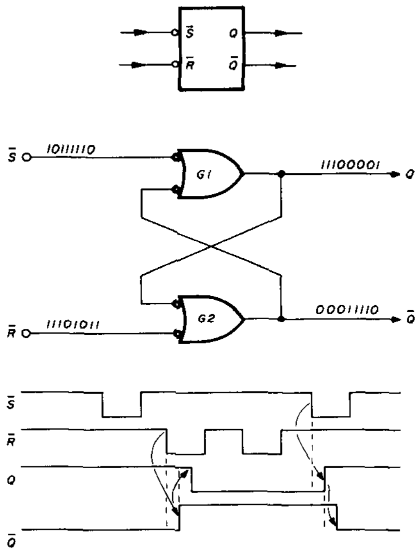

fig. 2. Simple RS flip-flop latch symbol, circuit, and waveform.

The RS latch is an interface between the switch and controlled circuit. The grounded switch arm provides the active low latch input signal. Pull-up resistors provide a high state for open contacts. The 4.7k pull-up is for TTL; CMOS values can range from 56k to 270k.

Contact bounce still exists, but the controlled circuit does not see it. The first contact closure will flip the latch. Subsequent bounce will not affect the latch as long as the switch is break-before-make. Compare this circuit with that of **fig. 2** for full understanding.

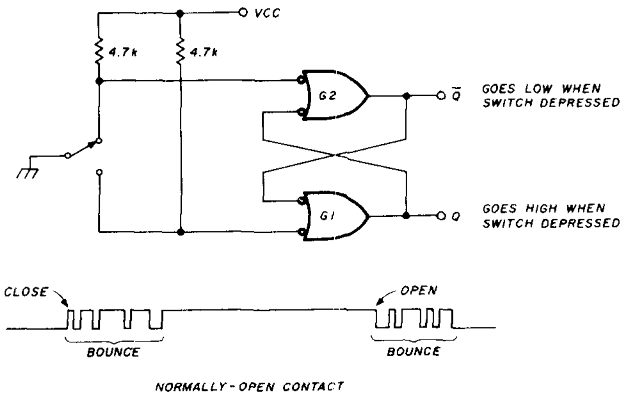

fig. 3. Switch debouncer.

Fig. 3 could be made with CMOS NORgates, switch arm to V_{CC} and pull-down resistors. Try this on scratch paper. A hint: Use the gate truth tables in **Part 1.**[1] The same thing won't work well with TTL. Why?

The difference lies in the high-TTL logic-0 current. Pull-down resistors would have to be 180 ohms or less for 0.4 volt maximum at 1.6 mA. It's fine if you *can afford to waste 28 mA when the pull-down is* connected to V_{CC}. A 4.7k pull-up resistor wastes only 1.1 mA.

Can a single-throw switch be substituted? The thought comes to mind that an inverter could be used for the other latch input. Sorry, this won't work; the same bounce is repeated in the latch. A single-throw switch can be applied only to static switching inputs or those unaffected by bounce.

clocked flip-flops

The term *clock* refers to a timing signal and came from early computer work, when the clock synchronized all functions. Applied to flip-flops, the clock input is really a trigger to initiate a change of state.

Fig. 4 shows the most common clocked flip-flops, the JK and D, in symbolic form with truth tables. Two things should be noted here: These truth tables are time-dependent, and the clock input may or may not have an inversion bubble. The clock edge is the trigger. A positive-going (low-to-high) edge is shown direct as in the D flip-flop. A negative-going (high-to-low) edge is shown with the bubble.

J, K, or D inputs are control or data inputs. Each truth table shows the effect of these inputs on the Q output after receipt of a clock edge. If both J and K are held low, Q of the JK does not change. This is indicated by Q_n. Holding one low and one high will force the 0 and 1 condition. With both high, Q will flip to the state opposite what it was before the clock edge arrived. This is what $\overline{Q}_n$ means.

The D flip-flop is easier to understand. Its Q state takes the D input state after receiving a clock edge.

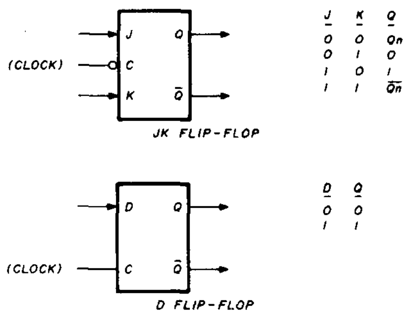

fig. 4. Symbols and truth tables for the basic clocked flip-flops.

Both flip-flops will change Q based on the control input state before a clock edge occurs. Control inputs do not directly affect output.*

Clocked flip-flops require an additional time parameter: setup. J, K, and D states must exist a specific minimum number of nanoseconds before a desired clock edge occurs. Too short a setup time will result in skipping a clock period for a Q state change.

An output state change is sometimes called toggling. A JK with both inputs high will toggle on each clock. Output period will be twice clock period, and the flip-flop becomes a divide-by-two device. Connecting $\overline{Q}$ to D in a D flip-flop will accomplish the same function.

Both flip-flops may have direct set and reset inputs. These override any clock input and may occur at any time. As such they're sometimes called asynchronous. Terms vary and *set* is sometimes *preset*; *reset* is sometimes called *clear*.

The next part of this series will look inside clocked flip-flops, present NAND gate circuits, and discuss timing.

*Some old JK types did flip when both J and K changed together with the same state.

reference

1. Leonard H. Anderson, "Digital Techniques, Basic Rules and Gates," *ham radio*, January, 1979, page 76.

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SN7422N	.39	SN7496N	.65	SN74184N	1.95
SN7423N	.25	SN7497N	3.00	SN74185N	1.95
SN7425N	.29	SN74100N	.89	SN74186N	9.95
SN7426N	.29	SN74107N	.35	SN74188N	3.95
SN7427N	.25	SN74109N	.59	SN74190N	1.25
SN7429N	.39	SN74116N	1.95	SN74191N	1.25
SN7430N	.20	SN74121N	.35	SN74192N	.79
SN7432N	.25	SN74122N	.39	SN74193N	.79
SN7437N	.25	SN74123N	.49	SN74194N	.89
SN7438N	.25	SN74125N	.49	SN74195N	.69
SN7439N	.25	SN74126N	.49	SN74196N	.89
SN7440N	.20	SN74132N	.75	SN74197N	.89
SN7441N	.89	SN74136N	.75	SN74198N	1.49
SN7442N	.49	SN74141N	.79	SN74199N	1.49
SN7443N	.75	SN74142N	2.95	SN74S200	4.95
SN7444N	.75	SN74143N	2.95	SN74251N	1.79
SN7445N	.75	SN74144N	2.95	SN74279N	.79
SN7446N	.69	SN74145N	.79	SN74283N	2.25
SN7447N	.59	SN74147N	1.95	SN74284N	3.95
SN7448N	79	SN74148N	1.29	SN74285N	3.95
SN7450N	.20	SN74150N	.89	SN74365N	69
SN7451N	.20	SN74151N	.59	SN74366N	69
SN7453N	20	SN74152N	.59	SN74367N	69
SN7454N	20	SN74153N	.59	SN74368N	69
SN7459A	.25	SN74154N	.99	SN74390N	1.95
SN7460N	20	SN74155N	.79	SN74393N	1.95
		SN74156N	.79		
		SN74157N	.65		

20% Discount 100 pcs combined order 25% -1000 pcs combined order

C/MOS

CD4000	.23			CD4070	55
CD4001	.23			CD4071	23
CD4002	23	CD4028	89	CD4072	49
CD4006	1.19	CD4029	1.19	CD4076	1.39
CD4007	.25	CD4030	.49	CD4081	23
CD4009	.49	CD4035	99	CD4082	23
CD4010	49	CD4040	1.19	CD4093	99
CD4011	.23	CD4041	1.25	CD4098	2.49
CD4012	25	CD4042	99	MC14409	14.95
CD4013	.39	CD4043	89	MC14410	14.95
CD4014	1.39	CD4044	89	MC14411	14.95
CD4015	1.19	CD4046	1.79	MC14419	4.95
CD4016	.49	CD4047	2.50	MC14433	19.95
CD4017	1.19	CD4048	1.35	MC14506	.75
CD4018	.99	CD4049	49	MC14507	99
CD4019	.49	CD4050	.49	MC14562	14.50
CD4020	1.19	CD4051	1.19	MC14583	3.50
CD4021	1.39	CD4053	1.19	CD4508	3.95
CD4022	1.19	CD4056	2.95	CD4510	1.39
CD4023	.23	CD4059	9.95	CD4511	1.29
CD4024	.79	CD4060	1.49	CD4515	2.95
CD4025	.23	CD4066	.79	CD4518	1.29
CD4026	2.25	CD4068	.39	CD4520	1.29
CD4027	69	CD4069	.45	CD4566	2.25

74C00

74C00	.39			74C163	2.49
74C02	.39			74C164	2.49
74C04	.39	74C85	2.49	74C173	2.60
74C08	.49	74C90	1.95	74C192	2.49
74C10	.39	74C93	1.95	74C193	2.49
74C14	1.95	74C95	1.95	74C195	2.49
74C20	.39	74C107	1.25	74C922	5.95
74C30	.39	74C151	2.90	74C923	6.25
74C42	1.95	74C154	3.00	74C925	8.95
74C48	2.49	74C157	2.15	74C926	8.95
74C73	.89	74C160	2.49	80C95	1.50
74C74	.89	74C161	2.49	80C97	1.50

LINEAR

78MG	1.75			LM710N	79
LM106H	.99			LM711N	39
LM300H	.80	LM340K-18	1.35	LM723N/H	.55
LM301CN/H	.35	LM340K-24	1.35	LM733N	1.00
LM302H	.75	LM340T-5	1.25	LM739N	1.19
LM304H	1.00	LM340T-6	1.25	LM741CN/H	.35
LM305H	60	LM340T-8	1.25	LM741-14N	39
LM307CN/H	.35	LM340T-12	1.25	LM747N/H	79
LM308CN/H	1.00	LM340T-15	1.25	LM748N/H	39
LM309H	1.10	LM340T-18	1.25	LM1310N	2.95
LM309K	1.25	LM340T-24	1.25	LM1458CN/H	.59
LM310CN	1.15	LM358N	1.00	MC1488N	1.95
LM311N/H	.90	LM370N	1.95	MC1489N	1.95
LM312H	1.95	LM373N	3.25	LM1496N	95
LM317K	6.50	LM377N	4.00	LM1556V	1.75
LM318CN/H	1.50	LM380N	1.25	MC1741SCP	3.00
LM319N	1.30	LM380CN	99	LM2111N	1.95
LM320K-5	1.35	LM381N	1.79	LM2901N	2.95
LM320K-5.2	1.35	LM382N	1.79	LM3053N	1.50
LM320K-12	1.35	NE501N	8.00	LM3065N	1.49
LM320K-15	1.35	NE510A	6.00	LM3900N(3401)	49
LM320K-18	1.35	NE529A	4.95	LM3905N	89
LM320K-24	1.35	NE531H/V	3.95	LM3909N	1.25
LM320T-5	1.25	NE536T	6.00	MC5558V	59
LM320T-5.2	1.25	NE540L	6.00	8038B	4.95
LM320T-8	1.25	NE544N	4.95	LM75450N	.49
LM320T-12	1.25	NE550N	1.30	75451CN	.39
LM320T-15	1.25	NE555V	39	75452CN	39
LM320T-18	1.25	NE556N	99	75453CN	.39
LM320T-24	1.25	NE560B	5.00	75454CN	39
LM323K-5	5.95	NE561B	5.00	75491CN	.79
LM324N	1.80	NE562B	5.00	75492CN	89
LM339N	.99	NE565N/H	1.25	75493N	89
LM340K-5	1.35	NE566CN	1.75	75494CN	89
LM340K-6	1.35	NE567V/H	.99	RC4136	1.25
LM340K-8	1.35	NE570N	4.95	RC4151	5.95
LM340K-12	1.35	LM703CN/H	.69	RC4194	5.95
LM340K-15	1.35	LM709N/H	.29	RC4195	4.49

74LS00TTL

74LS00	23			74LS138	69
74LS01	23			74LS139	69
74LS02	23	74LS47	.69	74LS151	.69
74LS03	.23	74LS51	.23	74LS155	.69
74LS04	.29	74LS54	.23	74LS157	69
74LS05	.29	74LS55	.23	74LS160	89
74LS08	.23	74LS73	.35	74LS161	.89
74LS09	.29	74LS74	.35	74LS162	.89
74LS10	.23	74LS75	.49	74LS163	.89
74LS11	60	74LS76	35	74LS164	99
74LS13	49	74LS78	39	74LS175	79
74LS14	.99	74LS83	75	74LS181	2.49
74LS15	.29	74LS85	99	74LS190	.89
74LS20	23	74LS86	.35	74LS191	.89
74LS21	.29	74LS90	49	74LS192	.89
74LS22	29	74LS92	.59	74LS193	.89
74LS26	.29	74LS93	59	74LS194	89
74LS27	.29	74LS95	79	74LS195	89
74LS28	.29	74LS96	89	74LS253	79
74LS30	23	74LS107	35	74LS257	.69
74LS32	.29	74LS109	35	74LS258	1.39
74LS37	35	74LS112	35	74LS260	.55
74LS40	29	74LS123	.99	74LS279	59
74LS42	.69	74LS125	.69	74LS367	.59
		74LS132	.79	74LS368	.59
		74LS136	39	74LS670	1.95

Jameco ELECTRONICS (New) Kits

Digital Stopwatch Kit

- Use Intersil 7205 Chip
- Plated thru double-sided P.C. Board
- LED display (red)
- Times to 59 min. 59.59 sec. with auto reset
- Quartz crystal controlled
- Three stopwatches in one: single event, split (cummulative) and taylor (sequential timing)
- Uses 3 penlite batteries
- Size 4.5" x 2.15" x .90"

JE900 $39.95

6-Digit Clock Kit

- Bright .300 ht. common cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 20 feet
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size 6-3/4" x 3-1/8" x 1-3/4"

JE701 $19.95

ALSO AVAILABLE:

JE200 5v lamp power supply $14.95 — JE2206B Function Generator $19.95
JE730 4-digit clock kit 14.95 — JE747 Jumbo 6-digit clock kit 29.95

DISCRETE LEDS

.200" dia.				**.125" dia.**		
XC556R	red	5/$1		XC209R	red	5/$1
XC556G	green	4/$1		XC209G	green	4/$1
XC556Y	yellow	4/$1		XC209Y	yellow	4/$1
XC556C	clear	4/$1				
.200" dia.				**.185" dia.**		
XC22R	red	5/$1		XC526R	red	5/$1
XC22G	green	4/$1		XC526G	green	4/$1
XC22Y	yellow	4/$1		XC526Y	yellow	4/$1
.170" dia.				XC526C	clear	4/$1
MV10B	red	4/$1		**.190" dia.**		
.085" dia.				XC111R	red	5/$1
MV50	red	6/$1		XC111G	green	4/$1
				XC111Y	yellow	4/$1
				XC111C	clear	4/$1

INFRA-RED LED
1/4"x1/4"x1/16" flat
5/$1

TIMEX T1001 LIQUID CRYSTAL DISPLAY

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4 DIGIT — .5" CHARACTERS
THREE ENUNCIATORS
2.00" X 1.20" PACKAGE
INCLUDES CONNECTOR

T1001-Transmissive $7.95
T1001A-Reflective 8.25

DISPLAY LEDS

TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode-red	.270	2.95	MAN 6730	Common Anode-red ± 1	.560	.99
MAN 2	5 x 7 Dot Matrix-red	.300	4.95	MAN 6740	Common Cathode-red-D.D.	.560	.99
MAN 3	Common Cathode-red	.125	25	MAN 6750	Common Cathode-red ± 1	560	.99
MAN 4	Common Cathode-red	.187	1.95	MAN 6760	Common Anode-red	560	99
MAN 7G	Common Anode-green	.300	1.25	MAN 6780	Common Cathode-red	.560	.99
MAN 7Y	Common Anode-yellow	.300	.99	DL701	Common Anode-red ± 1	300	.99
MAN 72	Common Anode-red	.300	.99	DL704	Common Cathode-red	.300	.99
MAN 74	Common Cathode-red	.300	1.25	DL707	Common Anode-red	.300	.99
MAN 82	Common Anode-yellow	.300	.99	DL728	Common Cathode-red	.500	1.49
MAN 84	Common Cathode-yellow	.300	.99	DL741	Common Anode-red	.600	1.25
MAN 3620	Common Anode-orange	.300	.99	DL746	Common Anode-red ± 1	.630	1.49
MAN 3630	Common Anode-orange ± 1	.300	.99	DL747	Common Anode-red	.600	1.49
MAN 3640	Common Cathode-orange	.300	99	DL749	Common Cathode-red ± 1	630	1.49
MAN 4610	Common Anode-orange	300	.99	DL750	Common Cathode-red	600	1.49
MAN 4640	Common Cathode-orange	.400	.99	DL338	Common Cathode-red	.110	35
MAN 4710	Common Anode-red	.400	.99	FND70	Common Cathode	.250	.69
MAN 4730	Common Anode-red ± 1	.400	.99	FND358	Common Cathode ± 1	.357	.99
MAN 4740	Common Cathode-red	.400	.99	FND359	Common Cathode	.357	.75
MAN 4810	Common Anode-yellow	.400	.99	FND503	Common Cathode(FND500)	500	.99
MAN 4840	Common Cathode-yellow	400	99	FND507	Common Anode (FND510)	500	99
MAN 6610	Common Anode-orange-D.D.	.560	.99	5082-7730	Common Anode-red	.300	1.30
MAN 6630	Common Anode-orange ± 1	.560	.99	HDSP-3400	Common Anode-red	.800	2.10
MAN 6640	Common Cathode-orange-D.D.	.560	.99	HDSP-3403	Common Cathode red	.800	2.10
MAN 6650	Common Cathode-orange ± 1	.560	99	5082-7300	4 x 7 sgl. Digit-RHDP	600	19.95
MAN 6660	Common Anode-orange	.560	.99	5082-7302	4 x 7 Sgl. Digit-LHDP	.600	19.95
MAN 6680	Common Cathode-orange	.560	.99	5082-7304	Overrange character (±1)	.600	15.00
MAN 6710	Common Anode-red-D.D.	.560	.99	5082-7340	4 x 7 Sgl. Digit-Hexadecimal	.600	22.50

RCA LINEAR

CA3013T	2.15	CA3082N	2.00
CA2023T	2.56	CA3083N	1.60
CA3035T	2.48	CA3086N	.85
CA3039T	1.35	CA3089N	3.75
CA3046N	1.30	CA3130T	1.39
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3080T	.85	CA3401N	.49
CA3081N	2.00	CA3600N	3.50

CALCULATOR CHIPS/DRIVERS

MM5725	$2.95
MM5738	2.95
DM8864	2.00
DM8865	1.00
DM8887	.75
DM8889	.75
9374 7 seg. C.A. LED driver	

CLOCK CHIPS

MM5309	$4.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5387/1998A	4.95
MM5841	9.95

MOTOROLA

MC1408L7	$4.95
MC1408L8	5.75
MC1439L	2.95
MC3022P	2.95
MC3061P	3.50
MC4016(74416)	7.50
MC4024P	3.95
MC4040P	6.95
MC4044P	4.50

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin LP	$.17	.16	.15	22 pin LP	$.37	.36	.35
14 pin LP	.20	.19	.18	24 pin LP	.38	.37	.36
16 pin LP	.22	.21	.20	28 pin LP	.45	.44	.43
18 pin LP	.29	.28	.27	36 pin LP	.60	.59	.58
20 pin LP	.34	.32	.30	40 pin LP	.63	.62	.61

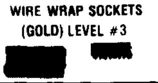
SOLDERTAIL STANDARD (TIN)

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

SOLDERTAIL STANDARD (GOLD)

8 pin SG	$.30	.27	.24	24 pin SG	$.70	.63	.57
14 pin SG	.35	.32	.29	28 pin SG	1.10	1.00	.90
16 pin SG	.38	.35	.32	36 pin SG	1.65	1.40	1.26
18 pin SG	.52	.47	.43	40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3



8 pin WW	$.39	.38	.31	22 pin WW	$.95	.85	.75
10 pin WW	.45	.41	.37	24 pin WW	1.05	.95	.85
14 pin WW	.39	.38	.37	28 pin WW	1.40	1.25	1.10
16 pin WW	.43	.42	.41	36 pin WW	1.59	1.45	1.30
18 pin WW	.75	.68	.62	40 pin WW	1.75	1.55	1.40

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5 ea.	10 OHM / 27 OHM	12 OHM / 33 OHM	15 OHM / 39 OHM	18 OHM / 47 OHM	22 OHM / 56 OHM	50 PCS	$1.75
ASST. 2	5 ea.	68 OHM / 180 OHM	82 OHM / 220 OHM	100 OHM / 270 OHM	120 OHM / 330 OHM	150 OHM / 390 OHM	50 PCS	1.75
ASST. 3	5 ea.	470 OHM / 1.2K	560 OHM / 1.5K	680 OHM / 1.8K	820 OHM / 2.2K	1K / 2.7K	50 PCS	1.75
ASST. 4	5 ea.	3.3K / 8.2K	3.9K / 10K	4.7K / 12K	5.6K / 15K	6.8K / 18K	50 PCS	1.75
ASST. 5	5 ea.	22K / 56K	27K / 68K	33K / 82K	39K / 100K	47K / 120K	50 PCS	1.75
ASST. 6	5 ea.	150K / 390K	180K / 470K	220K / 560K	270K / 680K	330K / 820K	50 PCS	1.75
ASST. 7	5 ea.	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	50 PCS	1.75

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$9.95 ea.**

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ICM7207	Oscillator Controller	7.50
ICM7208	Seven Decade Counter	19.95
ICM7209	Clock Generator	6.95

NMOS READ ONLY MEMORIES

MCM6571	128 X 9 X 7 ASCII Shifted with Greek	13.50
MCM6574	128 X 9 X 7 Math Symbol & Pictures	13.50
MCM6575	128 X 9 X 7 Alphanumeric Control Character Generator	13.50

MISCELLANEOUS

TL074CN	Quad Low Noise bi-fet Op Amp	2.49
TL494CN	Switching Regulator	4.49
TL496CP	Single Switching Regulator	1.75
11C90	Divide 10/11 Prescaler	19.95
95H90	Hi-Speed Divide 10/11 Prescaler	11.95
4N33	Photo-Darlington Opto-Isolator	3.95
MK50240	Top Octave Freq. Generator	17.50
DS0026CH	5Mhz 2-phase MOS clock driver	3.75
TIL308	.27" red num. display w/integ. logic chip	10.50
MM5320	TV Camera Sync. Generator	14.95
MM5330	4½ Digit DPM Logic Block	5.95
LD110/111	3½ Digit A/D Converter Set	25.00/set

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Photo Transistor Opto-Isolator
(Same as MCT 2 or 4N25)
2/99¢

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SOUND GENERATOR
Generates Complex Sounds
Low Power - Programmable
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AY-3-8500-1 and 2.01 MHZ Crystal (Chip & Crystal includes score display, 6 games and select angles, etc.) **7.95/set**

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XR205	$3.40			XR2242CP	1.50
XR210	4.40			XR2264	4.25
XR215	4.40			XR2556	3.20
XR320	1.55	JE2206KA	14.95	XR2567	2.99
XR-L555	1.50	JE2206KB	19.95	XR3403	1.25
XR555	.39	XR1800	3.20	XR4136	1.25
XR556	.99	XR2206	4.40	XR4151	2.85
XR567CP	.99	XR2207	3.85	XR4194	1.45
XR567CT	1.25	XR2208	5.20	XR4202	3.60
XR1310P	1.30	XR2209	1.75	XR4212	2.05
XR1468CN	3.85	XR2211	5.25	XR4558	.75
XR1488	1.39	XR2212	4.35	XR4739	1.15
XR1489	1.39	XR2240	3.45	XR4741	1.47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
				1N4002	100 PIV	1 AMP	12/1.00
				1N4003	200 PIV	1 AMP	12/1.00
1N746	3.3	400m	4/1.00	1N4004	400 PIV	1 AMP	12/1.00
1N751	5.1	400m	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N754	6.8	400m	4/1.00	1N3600	50	200m	6/1.00
1N757	9.0	400m	4/1.00	1N4148	75	10m	15/1.00
1N759	12.0	400m	4/1.00	1N4154	35	10m	12/1.00
1N959	8.2	400m	4/1.00	1N4305	75	25m	15/1.00
1N965	15	400m	4/1.00	1N4734	5.6	1w	28
1N5232	5.6	500m	28	1N4735	6.2	1w	28
1N5234	6.2	500m	28	1N4736	6.8	1w	28
1N5235	6.8	500m	28	1N4738	8.2	1w	28
1N5236	7.5	500m	28	1N4742	12	1w	28
1N5242	12	500m	28	1N4744	15	1w	28
1N5245	15	500m	28	1N1183	50 PIV	35 AMP	1.60
1N456	25	40m	6/1.00	1N1184	100 PIV	35 AMP	1.70
1N458	150	7m	6/1.00	1N1185	150 PIV	35 AMP	1.70
1N485A	180	10m	5/1.00	1N1186	200 PIV	35 AMP	1.80
1N4001	50 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR(2N1849)	$1.95
C38M	35A @ 600V	SCR	1.95
2N2328	1.6A @ 300V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC.	1.95

TRANSISTORS

C106B1	50			2N3904	4/1.00
MPSA05	30	2N3055	.89	2N3905	4/1.00
MPSA06	5/1.00	MJE3055	1.00	2N3906	4/1.00
TIS97	6/1.00	2N3392	5/1.00	2N4013	3/1.00
TIS98	6/1.00	2N3398	5/1.00	2N4123	6/1.00
40409	1.75	PN3567	3/1.00	PN4249	4/1.00
40410	1.75	PN3568	4/1.00	PN4250	4/1.00
40673	1.75	PN3569	4/1.00	2N4400	4/1.00
2N918	4/1.00	MPS3638A	5/1.00	2N4401	4/1.00
2N2219A	2/1.00	MPS3702	5/1.00	2N4402	4/1.00
2N2221A	4/1.00	2N3704	5/1.00	2N4403	4/1.00
2N2222A	5/1.00	MPS3704	5/1.00	2N4409	5/1.00
PN2222 Plastic	7/1.00	2N3705	5/1.00	2N5086	4/1.00
2N2369	5/1.00	MPS3705	5/1.00	2N5087	4/1.00
2N2369A	4/1.00	2N3706	5/1.00	2N5088	4/1.00
MPS2369	5/1.00	MPS3706	5/1.00	2N5089	4/1.00
2N2484	4/1.00	2N3707	5/1.00	2N5129	5/1.00
2N2906	4/1.00	2N3711	5/1.00	PN5134	5/1.00
2N2907	5/1.00	2N3724A	.65	PN5138	5/1.00
PN2907 Plastic	7/1.00	2N3725A	1.00	2N5139	5/1.00
2N2925	5/1.00	2N3772	2.25	2N5210	5/1.00
MJE2955	1.25	2N3823	1.00	2N5449	3/1.00
2N3053	2/1.00	2N3903	5/1.00	2N5951	3/1.00

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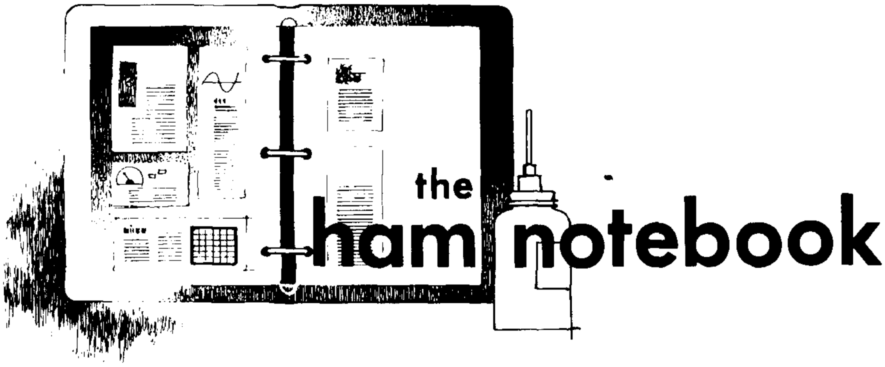
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075
100 VOLT MYLAR FILM CAPACITORS							
.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22
+20% DIPPED TANTALUMS (SOLID) CAPACITORS							
.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/25V	.31	.27	.22
.22/35V	.28	.23	.17	3.3/25V	.31	.27	.22
.33/35V	.28	.23	.17	4.7/25V	.32	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.36	.31	.25
.68/35V	.28	.23	.17	10/25V	.40	.35	.29
1.0/35V	.28	.23	.17	15/25V	.63	.50	.40
MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS							
Axial Lead				**Radial Lead**			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.12	.09	1.0/16V	.15	.13	.10
4.7/25V	.15	.13	.10	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26



integrated circuit tone generator

The MK5085/86 as shown in the February, 1977, issue of *ham radio*, can be used to make a very simple, inexpensive, and reliable tone encoder. In fact, with the exception of the addition of the transmitter keying relay and driver transistor, the circuits shown have been taken directly from the Mostek data sheet.

A couple of additional comments are in order, however. First, it is usually inadvisable to feed the encoder's output into the microphone line as indicated in the article. The pre-emphasis in the audio amplification circuits will distort the level differential between the high and low group tones, which should be on the order of 3 dB. Thus, the levels actually transmitted, *i.e.*, presented to the decoders at the receiver, will not be correct and decoding difficulty may result. In order to use the microphone input, some kind of rolloff circuitry is necessary, and this adds to the complexity of the overall encoder.

A second problem with using the microphone input is that of background noise; the tones receive as much amplification as the ambient noise. Since the output of the MK5085/86 is on the order of 700 millivolts for the low group and 1100 millivolts for the high group, these high-level signals do not need high amplification.

The chip was primarily designed for telephone application, and to feed a load of approximately 600 ohms. In the telephone application, a convenient output load is the telephone line itself. However, the line is also the power source. With this background, it is easy to see that the chip really prefers to deliver its output right into the power line. Using an independent power source, this characteristic can be ignored. Powered from the radio, however, the effect will be to modulate the entire primary power. In short, the tones will wind up in all kinds of places where you don't want them.

A simple solution is shown in **fig. 1**. A large capacitor will swamp the tones, provided the power source impedance is low enough; take power where the 12-volt line enters the rig, and not directly from the rig's power supply. The temptation to do the latter may be great in view of the less-than-10 volts allowed by the MK5085/86. The diode in **fig. 1** is not really necessary if power is taken directly from the car battery, but it should be noted that the MK5085/86 is (mostly) CMOS and can generate appreciable spikes.

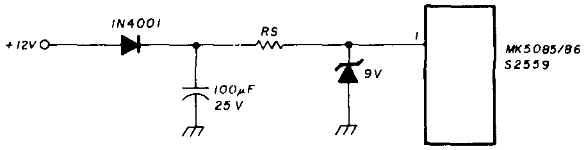


fig. 1. Diagram of the method used to eliminate tones from the power line.

I prefer the AMI S2559 over the Mostek 5085/86 primarily because of its ability to stand power of up to 15 volts, eliminating the need for the zener and dropping resistor shown in **fig. 1**. The S2559 is pin-compatible with the Mostek chips and can direct-

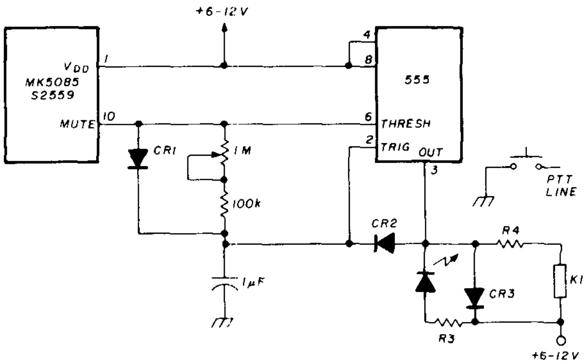


fig. 2. Schematic of a more satisfactory method for generating a variable dropout time. CR1 through CR3 are all 1N914 diodes. R3 is an appropriate current limiting resistor for the LED used. The maximum operating current permissible for the relay is 150 mA. Varying the 1-megohm resistor will change the dropout time from approximately 0.1 to 1 second.

ly replace them. It is also driven from the standard 3.58-MHz color-burst crystal. Aside from the wider power tolerance (down to 3 volts or so), there is yet another advantage: The S2559 can be used with *either* a Class A or 2-of-8 (or 2-of-7) DTMF keyboard. The choice of which Mostek chip to use is dictated by the keyboard key configuration.

A final observation concerns the transmitter keying arrangement shown in the article. It will work, and is simple and inexpensive, but it does have a potential drawback. The two-second time delay is too long (easily changed by choice of capacitance), but it is not very constant or reliable. This could cause problems when the circuit is used with an autodialer or repertory dialer.

In my opinion, a better (and only slightly more expensive) arrangement can be made using the workhorse 555 timer. The circuit, as shown in **fig. 2**, gives an easily adjustable hang time of from 0.1 second, to about 1.1 seconds, by adjusting the 1 megohm pot in series with the 100k fixed resistor. Once set, the hang time is extremely consistent.

The circuit works as follows. With no key pressed, the MUTE output at pin 10 of the MK5085/86/AMIS2559 is low, holding the threshold voltage at pin 6 of the 555 low. The trigger voltage at pin 2 of the 555 is also low, the capacitor having discharged through the timing resistors. The 555 output, pin 3, is high (because trigger went low), charging the capacitor through CR2. This does not change the timer state, even though trigger is now high, because threshold stays low. The 555 is stable in this state: threshold low, trigger high, output high, and capacitor charged. K1 is not energized.

When a key is pressed, the MUTE output from the encoder goes high, tripping the threshold of the 555 and driving the output low. This energizes K1. Full charge is maintained on the capacitor through CR1. When the key is released, the capacitor begins to dischage through the timing resistors. If no key is pressed before the capacitor discharges to 1/3 Vcc (approximately one time constant) the 555 triggers, returning the 555 to its previously stable state. The capacitor recharges virtually instantaneously through CR2. If another key is pressed before the capacitor discharges to 1/3 of Vcc, it immediately recharges to full voltage through CR1 and remains there until the key is released.

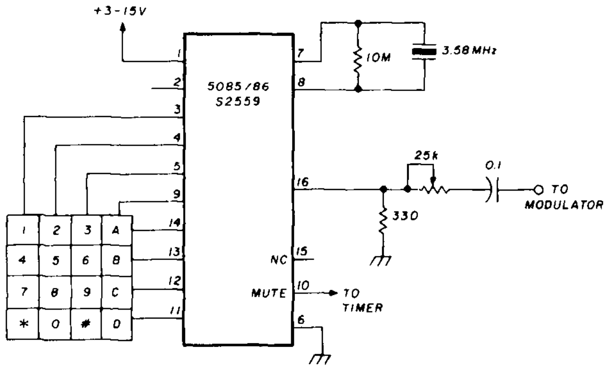


fig. 3. Circuit for a complete tone decoder. The AMI S2559 is a pin-for-pin replacement, featuring the capability of a higher input voltage, 15 *vs* 10 volts. Pin 15 is grounded for dual tones only. When left open, a single tone is generated when two keys in the same row or column are generated. For all practical purposes, the 330-ohm load resistor on pin 16 can remain the same value when Vdd is changed, though the optimum value is 270 ohms for a 12-volt supply and 628 ohms for a 5-volt supply. *If an audible side tone is desired, a 4- to 8-ohm speaker can be inserted in the supply line.*

CR3 is transient suppression for K1. I found it useful to use a relatively low-voltage relay with series resistance because (**a**) *I got a real buy* on 5-volt reed relays and (**b**) by adjusting the resistor the timing circuit will operate down to the lower functional limit of the 555 and the S2559. The LED and its associated series resistor are optional.

If this timing circuit is used with the MK5085/86, an 82k resistor should be used in series with CR1. The MUTE output current is capable of providing 10 μA. (The S2559 will provide a couple of mils.) However, since the capacitor never discharges below 1.3 Vcc and because the majority of charging current comes from the 555, the 82k resistor suggested isn't really required. However, it is cheap insurance to protect an $8.20 IC.

It is preferable to use a pot in series with the encoder output (see **fig. 3**). This provides both level adjustment and isolation concurrently. Taking the output from a pot in the output emitter line (as shown in the article) is not recommended, as it more greatly affects the impedance the chip is working into. I have found a 25K pot to be about the right value, using it in place of the 20k isolation resistor previously mentioned.

One final thought: A useful addition would be to short out the microphone (or open the microphone audio line) when the encoder is active, eliminating background noise. This can be done in a variety of ways, the most obvious being to use another pole on the keying relay connected to the 555 timer.

Concerning the relay, the 10 mA operating current does *not* include the relay current. Care must be taken if a 9-volt battery is used; they're not made to drive current-hungry devices like relays. Also, the 10 mA figure is with Vdd equal to 6 volts, but the circuit shows a 9-volt source. Under these conditions the current will be around 20-25 mA.

Frank Bates, W6IPB

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- **FULLY REGULATED INTEGRAL POWER SUPPLY**: Operating voltage for all 9v circuits independently regulated. Massive Commercial Hash Filter.
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- **ACCESSORY SOCKET**: Fully wired for touch tone, phone patch, and other accessories. Internal switch connects receiver output to internal speaker when connector is not in use.
- **MULTI-PURPOSE METER**: Triple Function Meter Provides Discriminator Meter, "S" Reading on receive and Power Out on Transmit.
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NEW products

For literature on any of the new products, use our *Check-Off* service on page 118.

NDI 800-channel 2-meter transceiver

NDI, Incorporated, of Torrance, California, has announced the HC-1400, a new, high-performance 2-meter fm mobile transceiver of advanced design. This microprocessor-controlled, digitally synthesized unit has 800-channel capability within the Amateur 144-148 MHz band, and offers 5- or 10-kHz channel spacing. A fast-acting, single-knob selector shifts LED digital frequency readout in 10-kHz steps; the HC-1400 also has a 100-kHz "speedup" button.

Transmit frequency offsets are preprogrammed, and are switchable to plus or minus 600 kHz. Simplex operation is also available. The HC-1400 can be programmed to hold three transmit-receive frequency pairs in memory, with the capability of instant recall. The transmitter delivers 25 watts output, and requires 13.8 Vdc for operation.

The receiver is sensitive, selective, and uses an FET front-end with three coaxial resonators. The dual i-f has a crystal lattice filter and multiple tuned circuits.

For more information write to NDI, Inc., 22125½ South Vermont, Torrance, California 90502.

350-watt solid-state amplifier

R.F. Power Labs, Inc., of Kirkland, Washington, is proud to announce their newest amplifier, Model V350. This solid-state vhf amplifier is designed for the Amateur Radio 2-meter band, but can be used (on special orders) over a 5-MHz bandwidth from 135 to 170 MHz. It is capable of producing more than 350 watts of rf output power into 50 ohms when driven with 10 to 15 watts. The amplifier weighs only 23.5 kg (52 pounds), including the built-in ac power supply.

The V350 is priced at $895.00; delivery is one to three weeks. For con-

tinuous-duty operation the **F135** (115 Vac) or F235 (230 Vac) fan kit should be used, priced at $59.00 each.

For more information, contact R.F. Power Labs, Inc., 11013 - 118th Place N.E., Kirkland, Washington 98033.

Cushcraft vertical antennas

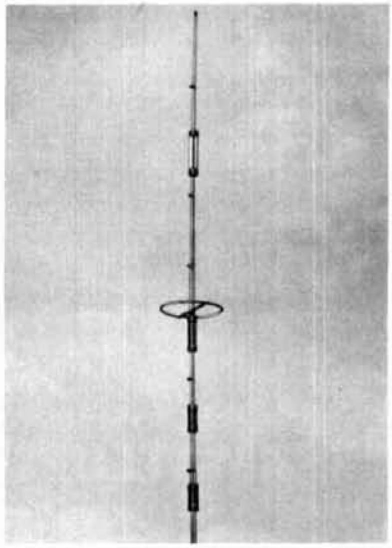
Many hams are convinced that to work a lot of DX they need a couple of thousand watts and a monster antenna array. While that undoubtedly helps, where is it written that the ham suffering from a money or space cramp can't compete for his day in the DXCC sun?

The three new Cushcraft verticals, the ATV-3, ATV-4, and ATV-5, provide a common-sense solution to a commonplace problem. Specifically designed for the DXer, these antennas provide the low angle of radiation necessary for long-haul DX communications, along with the performance and quality long associated with the Cushcraft name. The ATV-3, ATV-4, and ATV-5 operate over the 10, 15, and 20 meter Amateur bands. The ATV-4 has built-in 40-meter coverage, and the ATV-5 is all set for complete five-band operation.

All antennas feature a built-in PL-259 coax connector and stainless-steel hardware for all electrical connections; all are matched to 50 ohms and rated for a full 2000 watts PEP. Factory-marked tubing and plain English instructions make assembly a snap.

Built to withstand the severest weather, the ATVs feature specially designed, high-Q traps employing large diameter enameled copper wire and solid aluminum, air-dielectric capacitors. The trap forms are manufactured from fiberglass for minimum dielectric loss and high strength.

Available from dealers worldwide,



the ATV-3, ATV-4, and ATV-5 retail for $49.95, $89.95, and $109.95 respectively. For more information and a full-color catalog highlighting the entire Cushcraft antenna line, write to Cushcraft, P.O. Box 4680, Manchester, New Hampshire 03108.

B&K model 820 digital capacitance meter

Dynascan Corporation has just announced the introduction of the B&K-Precision Model 820 portable digital capacitance meter. The 820 is a compact instrument capable of measurement over the wide capacitance range of 0.1 pF to 1 farad. Accuracy will greatly exceed the tolerance of most capacitors. The unit features a bright, four-digit LED display for easy reading in laboratories, product lines, or field applications.

The capacitance of virtually any capacitor can be measured quickly and accurately with the 820. Because the accuracy of this unit greatly exceeds the tolerance requirements of most users, required values can be "hand selected." Matched capacitors can also be singled out for use in bridge circuits and other critical applications. Ten ranges cover from 0.1 pF to 1 farad with resolution up to 0.1 pF.

The 820 allows quick measurement of unmarked capacitors or verification that a capacitor is within tolerance. Virtually any type of capacitor can be measured, from miniature

More Details? CHECK—OFF Page 118

discs to pole-mounted power types. Even the small amounts of capacitance encountered in cable or switches can be measured.

For production-line applications, the 820 is an excellent means of pretesting critical capacitors or accurately adjusting trimmer capacitors. The simplicity of operation allows even untrained workers to be quickly instructed in proper operation. To facilitate fast incoming component sorting and selection, slot-type front panel lead-insertion jacks are used. The slot jacks eliminate the time-wasting step of guiding a capacitor lead into the type of small lead insertion holes commonly found on other instruments.

In classroom applications, the 820 can be used to verify capacitor network calculations by measuring the actual value of a network. The operation of a variable capacitor can also be demonstrated, as can the temperature effects on a capacitor.

The B&K-Precision Model 820 comes with a 26-page detailed manual. Optional accessories include the BP-28 rechargeable battery pack, BC-28 charger, and LC-28 carrying case. The 820 is now available for immediate delivery at local B&K-Precision distributors at a price of $130.00. For additional information, contact B&K-Precision, Sales Department, 6460 West Cortland Street, Chicago, Illinois 60635.

Yaesu two-meter transceiver

A new state-of-the-art, two-meter, all-mode transceiver, the FT-225RD, has been added to Yaesu's quality line of Amateur Radio equipment.

The new transceiver covers the entire 4 MHz and provides for USB, LSB, CW, fm and a-m. Power output is variable, 1-25 watts. Squelch, VOX, PTT, semi break-in CW with side tone, and tone burst are standard features of the FT-225RD. A superb noise blanker permits mobile ssb operation, and a discriminator zero-center meter allows precise tuning of

More Details? CHECK—OFF Page 118

fm signals. Repeater splits are the standard 600 kHz; however, any split up to 1 MHz is possible with optional crystal. Provision has been made for up to eleven fixed channels using optional crystals.

The transceiver uses high-quality, plug-in circuit boards throughout, and an optional memory unit enables the storage and recall of any frequency within the range of the unit. This allows instant programmable QSY to a favorite repeater or calling frequency with just a flick of the switch. The digital frequency is accurate to 0.1 kHz or to 1 kHz with the FT-225R, which offers the analog dial readout only and at slightly less cost.

A built-in power supply provides taps for operation on 100/110/117/200/220 and 234 volts 50/60 Hz; dc operation covers 11.5 to 16 volts, negative ground at 6.5 amps on transmit, 1.2 amps on receive.

An attractive, four-color brochure is available at your nearby authorized Yaesu dealer or from Yaesu Electronics Corporation, 15954 Downey Avenue, P.O. Box 498, Paramount, California 90723.

second generation VMOS

Siliconix has introduced the first of a new family of high-current and high-voltage VMOS power fets, serving both analog and digital applications. The VN84GA has a rated output of 12.5 amperes, 80 volts, and 0.4 ohms — about sixfold current increase over previously available units.

The VN84GA, with input power in the microwatt range, produces up to 80 watts output at lower frequencies, or as much as 50 watts at 30 MHz.

More Details? CHECK — OFF Page 118

This input power is several orders of magnitude less than that required by Darlington bipolars of equivalent output power, yet the new VMOS retains the benefits of fast switching, high gain, and high-input impedance that are characteristic of lower power VMOS units. The VN84GA also provides inherent fail-safe operation with no failure from secondary breakdown and no thermal runaway; it has the ability to current limit by controlling the gate voltage.

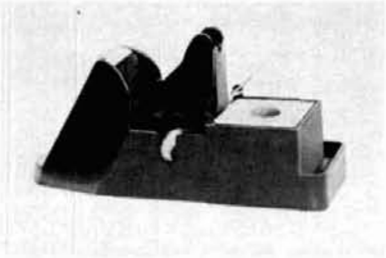
The VN84GA is meant to satisfy a designer's need for a universal high-power device for switching regulators, motor controllers, audio amplifiers, and as an interface for microprocessor logic outputs. It interfaces directly with CMOS, TTL, DTL, and MOS logic families.

The VN84GA is available in a TO-3 package from franchised Siliconix distributors. It is priced at $19.76 in single quantities. For additional information, contact Siliconix Incorporated, 2201 Laurelwood Road, Santa Clara, California 95054.

Newnes Radio and Electronics Engineer's Pocket Book

In this, the latest edition of this handy pocket book first published in 1940, author H. W. Moorshead has succeeded in keeping this standard reference book up to date. Obsolete material has been eliminated to make room for the most current information. The section on ICs, in particular, has been expanded to cover the many recent advances in the field. Among the other topics contained in the book are transistor and diode data and basing diagrams, transistor circuits, transformer data, and many tables of information useful to the working technician and engineer. Pocket-notebook size (5 inches long and 3 inches wide), hard cover, 191 pages. $5.95, plus $1.00 per order for shipping, from Ham Radio's Communications Bookstore, Greenville, New Hampshire 03048; order NR-PB.

soldering-tool holder and mini-soldering station



EDSYN, Incorporated, of Van Nuys, California, announces a low-cost soldering tool holder which also serves as a compact soldering station. Designated the Idle-Rest TL194 General Purpose Holder, the unit holds most available soldering tools due to its specially designed tool cradle. The exterior of the holder remains within safe skin-touch temperature limits because of the low heat transfer characteristics of the molded Bakelite housing. Also, an efficient heat shield and ventilating-grill system helps keep heat concentrated to the soldering tip area.

The holder sits securely on the bench top without tipping. If desired, the integral fastener nut may be used for permanent installation to the bench top.

In addition, the holder contains a supply of desoldering wick and solder (included with purchase), parts or tip-storage tray, and a large tip-cleaning sponge which self-wets at the touch of a finger. The sponge may be removed if desired to obtain an additional storage tray for components or soldering supplies.

For more information, contact an authorized Edsyn distributor; for the *name of the one nearest you, write* Edsyn, Incorporated, 15958 Arminta St., Van Nuys, California 91406.

Mirage MP1, peak-reading wattmeter

Mirage Communications is now offering the *MP1* high-frequency (1.8-30 MHz) peak-reading wattmeter. It is designed to provide the

Amateur Radio operator with a versatile fixed or portable wattmeter, without having to use cumbersome plug-in or add-on accessories.

Three power ranges are available (25, 200, and 2000 watts), providing reading convenience whether you use it for low-power operation or with the biggest DX setup. The wattmeter will read both forward and reverse power at the flip of a switch. The *MP1*, like its vhf predecessor, the *MP2*, has the ability to display either average or peak power reading. The peak-reading feature is a must for ssb transmitters. The *MP1* also will display swr, which is measured directly, without having to use extra charts or graphs. For ease of installation, the *MP1* has a removable r-f coupling unit that may be placed up to 1.2 meters (4 feet) from the indicator.

The *MP1* is portable, containing the latest in low-power ICs and powered by a 9-volt battery. For long-term, fixed-station operation, an optional ac adaptor is available. A low-battery-voltage indicator has been built into the wattmeter to indicate when the battery needs changing.

For more information please contact your local dealer or Mirage Communications, P.O. Box 1393, Gilroy, California 95020.

J. W. Miller catalog

A new 100-page catalog with specifications for more than 5,000 coils, filters, and communications

More Details? CHECK—OFF Page 118

essentials is now available from the J. W. Miller Division of Bell Industries, Compton, California.

Newest additions to their catalog include direct reading SWR/power meters, an rf speech-processor, and coaxial switches. Included also is the broad line of high pass, lowpass, audio, and ac power-line filters.

Catalog 79 gives detailed specifications for rf coils, chokes, filters, and related communication components. To assist in selection, coils are categorized by frequency from 0 through 500 MHz in the table of contents. Schematic diagrams for all shielded and unshielded coils, showing adjustment accessibility, are given.

For additional information, contact Jerry Hall, Operations Manager, Bell Industries, J. W. Miller Division, 19070 Reyes Avenue, P.O. Box 5825, Compton, California 90224.

Astatic amplifying microphone

A microphone designed for repeater-control and phone-patch operations has been introduced by the Astatic Corporation, Conneaut, Ohio. It's the new *Astatic T²M* amplified microphone with touch-pad encoder.

For fingertip convenience, the touch pad encoder is an integral part of the microphone itself. It has a tactile twelve-key keyboard and provides visual feedback through a front-mounted LED.

Priced comparably to a conventional microphone, the T²M is of an advanced design that has such high-quality features as a preamplified electret element with tailored response and integral modulation control; a digital, integrated tone-generator circuit with 3.5795 MHz crystal for stable frequency control; and a mixer amplifier with up to 15 dB gain for impedance matching and audio and tone mixing.

The attractive Cycolac housing resists abusive treatment. It also features shielding to reduce external interference and rf feedback. The T2M operates from filtered 6 to 16 volt dc sources. Included is an eight-foot, three-conductor (one shield) cable and coiled cord.

For additional information on the new Astatic T2M amplified microphone with touch pad encoder, write The Astatic Corporation, Conneaut, Ohio 44030.

communications equipment catalog

Harrison Radio is pleased to announce the availability of the all-new 1979 Harrison Radio Communications catalog. The catalog has 120 pages of illustrations, descriptions, specifications, and prices covering several hundred transceivers, antennas, and accessories for Amateur Radio, marine radio, business-band radio, public-service-frequency equipment, and CB.

The catalog is free and available by writing to Harrison Catalog, 22 Smith Street, Farmingdale, New York 11735.

receiver preamplifier

Telco Products Corporation announces two new mobile in-line receiver preamplifiers. Known as Models VHF 144 and UHF 450, they are specifically designed for amateur, police, emergency, business-band, and Class A CB transceivers.

These new computer-designed preamplifiers boost receiver sensitivity. A unique rf-sniffer circuit allows the preamplifier to sense when the transceiver is keyed, and switches the preamplifier off during the trans-

More Details? CHECK—OFF Page 118

mit cycle. This feature allows the preamplifier to be connected directly into the coax line with no modification to the existing mobile system.

The VHF 144 has 20 dB gain over a 5-MHz band in the frequency range of 140-180 MHz. Model UHF 450 features 10-12 dB gain over any 1-MHz band in the frequency range of 400-512 MHz. The VHF 144 will safely handle transmitter output of 40 watts, and UHF 450 will work with 100-watt transmitters.

Suggested retail price for the VHF 144 is \$49.95; and for the UHF 450 is \$59.95. For additional information, contact Telco Products Corporation, 44 Sea Cliff Avenue, Glen Cove, New York 11542.

solderless breadboards

Continental Specialities Corporation is probably best known for their popular line of versatile and easy-to-use solderless breadboards. One of the best is their Proto-Board model 203A, which is actually more than a solderless breadboard. In addition to offering a very large socket-type solderless breadboard array to work on, Proto-Board 203A has three separate, regulated, power supplies built into the box. They offer 5 Vdc at 1 per cent regulation and up to 1 amp of output current, and ±15 Vdc (nominal) supplies, each good for 0.5 amp and each independently internally adjustable over a 9-18 Vdc range.

The statistics on the Proto-Board 203A are impressive. The whole package measures only 25 × 17 × 8 cm (9.8 × 6.6 × 3.3 inches). It features 2250 tie points for a 24-DIP (14-pin package) capacity. The +5, ±15 Vdc and ground connections are available at four five-way binding posts. The power switch and a power pilot are adjacent to the power supply terminals.

The PB-203A is designed for 117 Vac, 60-Hz operation and carries a suggested amateur net price of \$129.95. For further information, contact Continental Specialties Corporation, 70 Fulton Terrace, New Haven, Connecticut 06509; or phone (203) 624-3103.

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The DF is battery-powered, can be used with accessory antennas, and is 12/24V for use in vehicles or aircraft. It is available in the 140-150 MHz VHF band and/or 220-230 MHz UHF band. This DF has been successful in locating malicious interference sources, as well as hidden transmitters in "T-hunts", ELTs, and noise sources in RFI situations.

Price for the single band unit is $195, for the VHF/UHF dual band unit is $235, plus crystals. Write or call for information and free brochure.

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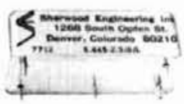

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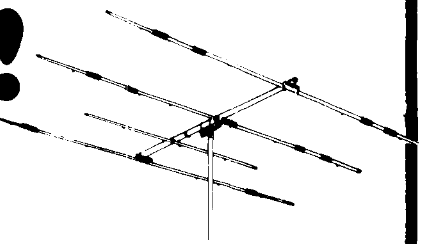

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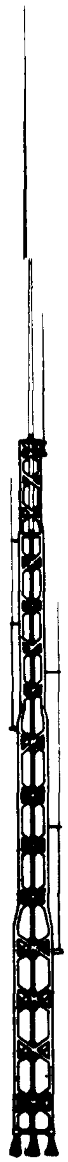

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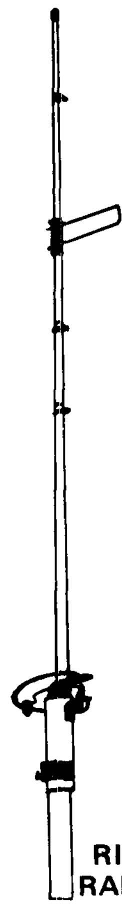

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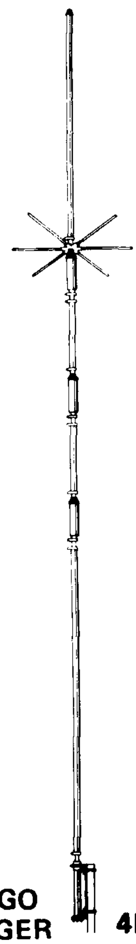

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RTTY — Bandpass active filter 2125/2295 Hz. Kit $11.95, W/T $16.95 ppd. SASE for info. Nat Stinnette Electronics, Tavares, FL 32778.

440-MHz — Regency HR-440 like new $220.00, SBE-450 very clean $140.00. trade/sell listing 70 items test equipment, FM, Ham misc, write K6KZT, 2255 Alexander, Los Osos, CA 93402.

MOTOROLA low band Mocom 70 29.6 MHz, no accessories $275. Motorola low band PT300 5W portable 52.525 MHz with charger $300, Motorola SSR-2 solid state 30W repeater 146.28/146.88 MHz $600. Homebrew "ACCU-MEMORY" keyer with paddle $125. Basket Case HT200 VHF $50. Eric Meth, VE2AS, 6716 Sherbrooke W., Apt. 201, Montreal, Que. H4B 1P2, (514) 482-4668.

TEKTRONIX 310A oscilloscope, mint condition, calibrated, $175.00 or trade for test equipment, commercial FM VHF, Ham gear. H. Beene, W5ZSL, P.O. Box 5702, Santa Fe, NM 87502, (505) 471-5458.

THE MEASUREMENT SHOP has used/reconditioned test equipment at sensible prices; catalog. 2 West 22nd St., Baltimore, MD 21218.

HAMS requesting our famous "SHOOT THE BULL" QSL Card, send yours & SASE K4NBN, Box 23413, Jacksonville, FL 32217.

CLUB CALL PINS 3 lines 1¼ × 3¼ $1.55 each. Call, first name and club. Colors — black, blue or red with white letters. (Catalog) Arnold Linzner, 2041 Linden Street, Ridgewood, N. Y. 11227.

SELL — Boonton 202D Signal Generator, Reconditioned, $50 plus transp. W6LGQ, 34 Laurel Ave., Petaluma, CA 94952.

AUTHORIZED DISTRIBUTOR F9FT Antennas, Microwave Modules, RIW Products' new tandem reflector, 19 element, 432 MHz Yagi — Radio Clinic — N2MB (formerly WA2BIT) 212-327-4952.

FOR SALE 75S-3B, 32-S3, 516F-2, Manuals & Cables. Excellent condition. $1375. Extra 75S-3B $550. S. J. Huber W7NOI, 318 Steven Ct., Benicia, CA 94510. (707) 745-8089.

TUNGSTEN CARBIDE CIRCUIT BOARD DRILLS. 12 assorted sizes for $3.95 ppd. L. R. Design, Box 41, McMinnville, OR 97128.

SWAN 250, TV-2, 14-117 power supply, bandswitching, manuals, mike, 250 Watts input on both 6 and 2 meters. $375.00. Fred Clinger, 640 Grove Avenue, Galion, Ohio 44833, WA8KJJ.

PORTA PAK — Make your FM mobile a self-contained portable. Models in stock for most popular makes. 4.5 amp hr model $67.50. 9 amp hr $88.00. Charger included, shipping extra. P.O. Box 67, Somers, WI 53171.

TEST EQUIPMENT CATALOG listing used Tektronix, HP and GR equipment at bargain prices. PTI, Box 8699, White Bear Lake, MN 55110. Price $1.00 refundable with first order.

WANTED: 150 MC HT RCA, Comco, Repco type with plug-in modules, 7735 TV camera tube, 2 meter cavities, K6KZT, 2255 Alexander, Los Osos, CA 93402.

WANTED — Radio transcription discs. Any size or speed. Larry, W7FIZ. Box 724, Redmond, Washington 98052.

DESK TOP CONSOLES, ultimate operating convenience. Free brochure. Thompson Electronics, P.O. Box 363, Westfield, IN 46074.

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.

TECH MANUALS for Govt. surplus gear — $6.50 each: SP-600JX, URM-25D, OS-8A/U, TS-173/UR. Thousands more available. Send 50¢ (coin) for 22-page list. W3IHD, 7218 Roanne Drive, Washington, DC 20021.

More Details? CHECK—OFF Page 118

DIODES/ZENERS

QTY.				
	1N914	100v	10mA	.05
	1N4005	600v	1A	.08
	1N4007	1000v	1A	.15
	1N4148	75v	10mA	.05
	1N4733	5.1v	1 W Zener	.25
	1N753A	6.2v	500 mW Zener	.25
	1N758A	10v	"	.25
	1N759A	12v	"	.25
	1N5243	13v	"	.25
	1N5244B	14v	"	.25
	1N5245B	15v	"	.25

SOCKETS/BRIDGES

QTY.					
	8-pin	pcb	.20	ww	.35
	14-pin	pcb	.20	ww	.40
	16-pin	pcb	.20	ww	.40
	18-pin	pcb	.25	ww	.95
	20-pin	pcb	.35	ww	.95
	22-pin	pcb	.35	ww	.95
	24-pin	pcb	.35	ww	.95
	28-pin	pcb	.45	ww	1.25
	40-pin	pcb	.50	ww	1.25
	Molex pins	.01	To-3 Sockets		.25
	2 Amp Bridge		100-prv		.95
	25 Amp Bridge		200-prv		1.50

TRANSISTORS, LEDS, etc.

QTY.			
	2N2222	(2N2222 Plastic .10)	.15
	2N2222A		.19
	2N2907A	PNP	.19
	2N3906	PNP (Plastic Unmarked)	.10
	2N3904	NPN (Plastic Unmarked)	.10
	2N3054	NPN	.45
	2N3055	NPN 15A 60v	.60
	T1P125	PNP Darlington	1.95
	LED Green,	Red, Clear, Yellow	.15
	D.L.747	7 seg 5/8" High com-anode	1.95
	MAN72	7 seg com-anode (Red)	1.25
	MAN3610	7 seg com-anode (Orange)	1.25
	MAN82A	7 seg com-anode (Yellow)	1.25
	MAN74	7 seg com-cathode (Red)	1.50
	FND359	7 seg com-cathode (Red)	1.25

9000 SERIES

QTY.			QTY.		
	9301	.85		9322	.65
	9309	.35		9601	.20
	9316	1.10		9602	.45

MICRO'S, RAMS, CPU'S, E-PROMS

QTY.			QTY.		
	8T13	1.50		2107B-4	4.95
	8T23	1.50		2114	9.50
	8T24	2.00		2513	6.25
	8T97	1.00		2708	10.50
	74S188	3.00		2716 D.S.	34.00
	1488	1.25		2716 (5v)	59.00
	1489	1.25		2758 (5v)	23.95
	1702A	4.50		3242	10.50
	AM 9050	4.00		4116	11.50
				6800	13.95
	MM 5314	3.00		6850	7.95
	MM 5316	3.50		8080	7.50
	MM 5387	3.50		8212	2.75
	MM 5369	2.95		8214	4.95
	TR 1602B	3.95		8216	3.50
	UPD 414	4.95		8224	3.25
	Z 80 A	22.50		8228	6.00
	Z 80	17.50		8251	7.50
	Z 80 PIO	10.50		8253	18.50
	2102	1.45		8255	8.50
	2102L	1.75		TMS 4044	9.95

C MOS

QTY.		
	4000	.15
	4001	.15
	4002	.20
	4004	3.95
	4006	.95
	4007	.20
	4008	.75
	4009	.35
	4010	.35
	4011	.20
	4012	.20
	4013	.40
	4014	.75
	4015	.75
	4016	.35
	4017	.75
	4018	.75
	4019	.35
	4020	.85
	4021	.75
	4022	.75
	4023	.20
	4024	.75
	4025	.20
	4026	1.95
	4027	.35
	4028	.75
	4029	1.15
	4030	.30
	4033	1.50
	4034	2.45
	4035	.75
	4037	1.80
	4040	.75
	4041	.69
	4042	.65
	4043	.50
	4044	.65
	4046	1.25
	4048	.95
	4049	.45
	4050	.45
	4052	.75
	4053	.75
	4066	.55
	4069/74C04	.35
	4071	.25
	4081	.30
	4082	.30
	4507	.95
	4511	.95
	4512	1.10
	4515	2.95
	4519	.85
	4522	1.10
	4526	.95
	4528	1.10
	4529	.95
	MC14409	14.50
	MC14419	4.85
	74C151	1.50

LINEARS, REGULATORS, etc.

QTY.			QTY.			QTY.		
	MCT2	.95		LM323K	5.95		LM380 (8-14 Pin)	1.19
	8038	3.95		LM324	1.25		LM709 (8-14 Pin)	.35
	LM201	.75		LM339	.75		LM711	.45
	LM301	.45		7805 (340T5)	.95		LM723	.40
	LM308	.65		LM340T12	.95		LM725	2.50
	LM309H	.65		LM340T15	.95		LM739	1.50
	LM309K (340K-5)	1.50		LM340T18	.95		LM741 (8-14)	.35
	LM310	.85		LM340T24	.95		LM747	1.10
	LM311D	.75		LM340K12	1.25		LM1307	1.25
	LM318	1.75		LM340K15	1.25		LM1458	.65
	LM320H6	.79		LM340K18	1.25		LM3900	.50
	LM320H15	.79		LM340K24	1.25		LM75451	.65
	LM320H24	.79		LM373	2.95		NE555	.45
	7905 (LM320K5)	1.65		LM377	3.95		NE556	.85
	LM320K12	1.65		78L05	.75		NE565	.95
	LM320K24	1.65		78L12	.75		NE566	1.25
	LM320T5	1.65		78L15	.75		NE567	.95
	LM320T12	1.65		78M05	.75			
	LM320T15	1.65						

– T T L –

QTY.			QTY.			QTY.			QTY.		
	7400	.10		7482	.75		74221	1.00		74LS02	.30
	7401	.15		7483	.75		74367	.95		74LS04	.30
	7402	.15		7485	.55		75108A	.35		74LS05	.35
	7403	.15		7486	.25		75491	.50		74LS08	.35
	7404	.10		7489	1.05		75492	.50		74LS09	.35
	7405	.25		7490	.45		74H00	.15		74LS10	.35
	7406	.25		7491	.70		74H01	.20		74LS11	.35
	7407	.55		7492	.45		74H04	.20		74LS20	.30
	7408	.15		7493	.35		74H05	.20		74LS21	.35
	7409	.15		7494	.75		74H08	.35		74LS22	.35
	7410	.15		7495	.60		74H10	.35		74LS32	.35
	7411	.25		7496	.80		74H11	.25		74LS37	.35
	7412	.25		74100	1.15		74H15	.45		74LS38	.45
	7413	.25		74107	.25		74H20	.25		74LS40	.40
	7414	.75		74121	.35		74H21	.25		74LS42	.75
	7416	.25		74122	.55		74H22	.40		74LS51	.45
	7417	.40		74123	.35		74H30	.20		74LS74	.45
	7420	.15		74125	.45		74H40	.25		74LS76	.50
	7426	.25		74126	.35		74H50	.25		74LS86	.45
	7427	.25		74132	.75		74H51	.25		74LS90	.65
	7430	.15		74141	.90		74H52	.15		74LS93	.65
	7432	.20		74150	.85		74H53	.25		74LS107	.50
	7437	.20		74151	.65		74H55	.20		74LS123	1.20
	7438	.20		74153	.75		74H72	.35		74LS151	.85
	7440	.20		74154	.95		74H74	.35		74LS153	.85
	7441	1.15		74156	.70		74H101	.75		74LS157	.85
	7442	.45		74157	.65		74H103	.55		74LS160	.95
	7443	.45		74161	.55		74H106	.95		74LS164	1.20
	7444	.45		74163	.85		74L00	.25		74LS193	1.05
	7445	.65		74164	.60		74L02	.20		74LS195	.95
	7446	.70		74165	1.10		74L03	.25		74LS244	1.70
	7447	.70		74166	1.25		74L04	.30		74LS367	.95
	7448	.50		74175	.80		74L10	.20		74LS368	.95
	7450	.25		74176	.85		74L20	.35		74S00	.35
	7451	.25		74180	.55		74L30	.45		74S02	.35
	7453	.20		74181	2.25		74L47	1.95		74S03	.25
	7454	.25		74182	.75		74L51	.45		74S04	.25
	7460	.40		74190	1.25		74L55	.65		74S05	.35
	7470	.45		74191	1.25		74L72	.45		74S08	.35
	7472	.40		74192	.75		74L73	.40		74S10	.35
	7473	.25		74193	.85		74L74	.45		74S11	.35
	7474	.30		74194	.95		74L75	.85		74S20	.25
	7475	.35		74195	.95		74L93	.55		74S40	.20
	7476	.40		74196	.95		74L123	.85		74S50	.20
	7480	.55		74197	.95		74LS00	.30		74S51	.25
	7481	.75		74198	1.45		74LS01	.30		74S64	.15
										74S74	.35
										74S112	.60
										74S114	.65
										74S133	.40
										74S140	.55
										74S151	.30
										74S153	.35
										74S157	.75
										74S158	.30
										74S194	1.05
										74S257 (8123)	1.05
										8131	2.75

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Coming Events

RADIO EXPO '79 September 15th and 16th, 1979, Lake County Fair Grounds, Routes 120 and 45, Grays Lake, Illinois. Manufacturers' displays, flea market, seminars, ladies programs. Advance tickets $2.00. Write EXPO, P.O. Box 305, Maywood, IL 60153. Exhibitors inquiries: EXPO Hotline (312) 345-2525.

MASSACHUSETTS: University of Lowell Wireless Society 5th annual ham radio auction, Friday, March 16. Doors open 5 pm, auction starts 6 pm, talk-in on 52, coffee, donuts. Directions: from Route 495 take exit 26 (Route 38) north two miles to route 110 west two miles right on University Avenue.

ROCHESTER Hamfest & NY State ARRL Convention, May 25-27. Add your name to mailing list. Send QSL to Rochester Hamfest, Box 1388, Rochester, NY 14603. Phone (716) 424-1100.

MINNESOTA: Rochester ARC and the Rochester Repeater Society's Hamfest, Saturday, April 7, St. John's School Gymnasium, 490 W. Center St., Rochester. Doors open 8:30 AM. Large indoor flea market, prize raffles, free parking. Talk in on 146.22/82. For info: RARC, c/o KØTS, 2514 N.W. 4th Ave., Rochester, MN 55901.

MICHIGAN: ARRL Great Lakes Division Convention and Hamfest, Muskegon Community College, Muskegon, March 30-31. Exhibits, technical forums, large swap/shop, dining facilities. Friday evening — "Ham Hospitality" at Muskegon Ramada Inn courtesy of MAARC; and a Wouf Hong initiation. For info: MAARC, P.O. Box 691, Muskegon, MI 49443 or WA8GVK (616) 722-1378/9.

OHIO: First Annual Lake County ARA Hamfest, April 1, 8:00 AM to 4:00 PM, Lake County Armory, N. E. corner Painesville Fairgrounds, Rt. 20, Painesville, (35 miles east of Cleveland). All indoors for exhibitors and flea market, 1:00 PM auction. Reserved tables — full $2.00, half $1.00. Admission: $2.00. Under 12 free. Talk in on 52/52 and 147.8121. For info: LCARA, P.O. Box 868, Painesville, OH 44077 or call (216) 257-4486.

WASHINGTON: Pacific Northwest Hamfest, July 14 & 15, HAM Inc., Box 78442, Seattle, WA 98178.

OHIO: Teays Amateur Radio Club Ham Fiesta, March 4, Pickaway County Fairgrounds colosseum, Circleville. All indoors. For info: Leonard Campbell, 8951 State Rt. 188, Circleville, OH 43113, phone (614) 474-6687.

OKLAHOMA: Lawton — Ft. Sill Amateur Radio Club's 33rd annual Hamfest. March 23, 24, 25, Montego Bay Motel, Lawton. Flea market, ARRL officials, technical meetings., QCWA breakfast. Activities for ladies. For info: Lawton-Ft. Sill ARC, P.O. Box 892, Lawton, OK 73502.

NORTH CAROLINA: Mecklenburg Amateur Radio Society's Metrolina Hamfest, March 24-25. NC State convention site, Charlotte. For info: Ken Winston, Jr., WA4OBO, Mecklenburg ARS, 2425 Park Rd., Rm. 023, Charlotte, NC 28203.

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RIW 432/19el	$59.95
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2M 10W In — 100W Out	$198.00
432 10W In — 50 W Out	$198.00
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Microwave Modules 432-28S, UPS Paid	$329.00
Telrex TB5EM, In Stock	$415.00
NEW Palomar Engr. Transceiver Preamp	$89.50
Bencher Paddles ... **$39.95**; Chrome	$49.95
ETO 76 Amplifiers	Stock
Lunar 6M-2M-220 In Line Preamps	$49.95
Lunar 2M Amp 10-80 with Preamp, UPS Paid	$198.00
Janel QSA-5	$41.95
CDE HAM-3 ... **$129.00**; HAM-X	$249.00
VHF Engrs. blue line amps	Stock
Cetron 572B	$29.50
Amperex 6146B	$7.95
Motorola HEP 170	$0.29 ea.
Mallory 2.5A/1000 PIV Epoxy Diode	$0.19 ea.
Aerovox 1000PF/500V Feed thru	$1.95
GE 6146B or 8950	$7.95
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8214, RG8 Foam	$0.25/ft.
8237, RG-8	$0.21/ft.
8267, RG-213	$0.25/ft.
Amphonol Silver Plate PL259	$0.59
TIMES ½" Foam Hardline **$0.65/ft** ... Connectors	$15.00 ea.
BERKTEK RG-8X, 52 ohm, KW	$0.16/ft.
Consolidated HD-18 Ga. Galv. Tower, 10' Sec.	$29.95
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MARYLAND: Greater Baltimore Hamboree, Sunday, April 1, 8:00 AM, Calvert Hall College, Goucher Blvd. and LaSalle Rd., Towson. (1 mile south of Exit 28, Beltway Interstate 695) Food, prizes, giant flea market. Admission: $3.00. 250 tables inside. For info and reservations: Bro. Gerald Malseed, W3WVC, Calvert Hall College, 8102 LaSalle Rd., Towson, MD 21204 or (301) 825-4266.

ILLINOIS: Libertyville & Mundelein Amateur Radio Society's annual Hamfest, March 25, J. M. Club, 708 Greenwood Avenue, Waukegan. Open 7 AM. Tickets: $2.00 gate, Advance: $1.50. Under 10 free. Tables $4.00 each. Large indoor flea market. Dozens of prizes including Wilson Mark IV Handie-Talkie. Hot Lunch, free parking. Talk in 146.94 simplex. For info: LAMARS, 1226 Deer Trail Lane, Libertyville, IL 60048. (312) 367-1599. (Include SASE).

NEBRASKA: Midway Spring Ham Convention, Saturday, Sunday, March 31, April 1. Holiday Inn — Holidome, Kearney. Over $3,000 in prizes, FCC testing, Ladies Day, QCWA meeting, Flying Hams breakfast. Code contest, flea market, auction, banquet. For free brochure: Midway Spring Ham Convention, 3606 Third Avenue, Kearney, NE 68847.

TEXAS: Midland Amateur Radio Club's annual Swapfest, March 18, Midland County Exhibit Building. Door prizes. Talk in on 146.16/146.76. Preregistration: $4.50 to Midland ARC, Box 4401, Midland, TX 79701 or $5.00 at door.

WISCONSIN: Tri County ARC Hamfest, March 18, Jefferson County Fairgrounds, Jefferson. (Formerly at Whitewater). Advance tickets $1.50. Reserve 6-ft tables $2.00 advance. 6-ft space $1.00. Send SASE to Glenn Eisenbrandt, WA9VYL, 711 East St., Fort Atkinson, WI 53538.

WISCONSIN: Madison Area Repeater Association's 7th annual Swapfest, Sunday, April 8, Dane County Exposition Center Forum Building, Madison. Open 7:00 AM for exhibitors and sellers, 8:00 AM public. Admission: $1.50 advance, $2.00 door. Twelve and under free. Tables $3.00 advance, $3.50 door. Flea market, plenty of parking, overnight camping and hotels within walking distance. Door prizes. All-you-can-eat pancake breakfast and Bar B-Q lunch. Free movies throughout the day. Talk in on WR9ABT — 146.16/.76. For reservations and info: MARA, P.O. Box 3403, Madison, WI 53704.

FLORIDA: Ninth Annual North Florida Swapfest, Ft. Walton Beach Fairgrounds, March 24 and 25. 8:00 AM to 4:00 PM. QCWA, MARS, ARES meetings. Talk in 52 and 19/79. For info: PARC, Box 873, Ft. Walton Beach, FL 32548.

QSO PARTY — NEW ZEALAND: ZL3 Canterbury Chapter of the International 10/10 net. From 0000 GMT Saturday, March 31, 1979 to 1200 GMT Sunday, April 1, 1979 (36 hours). Contact each station only once, on the ten meter band only; exchange call sign, name, QTH, 10X number, if any, Canterbury Chapter number (if held) and your own local Chapter name and number, if any. Awards include trophy to highest scorer overall, and a pennant to the highest scorer in each U.S., Canadian, Australian, Japanese and New Zealand call area; to each Central and South American country; to each European, Asian, and African country; and in three Pacific Ocean zones. Logs must be received no later than May 15, 1979. Please write clearly, show name, call, address and 10X number. Send logs to ZL3ME — C.J. Bramley, 198 Greers Road, Christchurch 5, New Zealand.

TEXAS: "Luckenbach DXpedition", 0800 CDT May 12, 1979 to 1200 CDT May 13, 1979, continuous. Call W5TEX. CW: 7.110 MHz and 21.110 MHz (+/− 5 kHz); FM: 52.525 MHz, 29.6 MHz, and 146.52 MHz; SSB: 3.9, 7.235, 14.285, 21.360, 28.625, 50.110 and 144.200 MHz; (+/− 5 kHz). Luckenbach sits nestled between two small rivers in the heart of the Texas hill country. Virtually untouched by modern civilization, this 1870's cowtown got its first pay telephone only last year. Luckenbach's general store/saloon/postoffice combination serves as a community center and gathering place for citizens to watch for the annual return of the mud dauber — a red hornet. Don't miss the fun of our "DXpedition". Send all logs and inquiries to Bob Schneider, AI5Q, 7206 Gumtree, San Antonio, Texas 78238.

Stolen Equipment

ICOM IC-701, serial number 8000-2786; ICOM matching power supply serial number E7802674; Yaesu FT-101, serial number 7K291710, plus matching accessories. Equipment packed in two bags and checked in at Braniff International, Inc., at Miami International Airport on January 6, 1979. It is believed that the equipment never reached the airplane, and probably will be sold locally. Any information, please advise Miami Police Department and/or Thomas Roesler, PY2DFR, Caixa Postal 6742, 01.000 Sao Paulo, SP, Brasil; telephone 288-7232.

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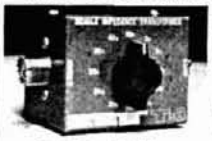

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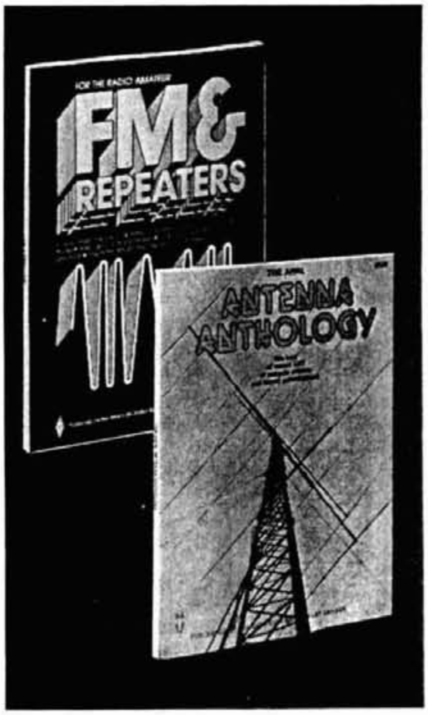

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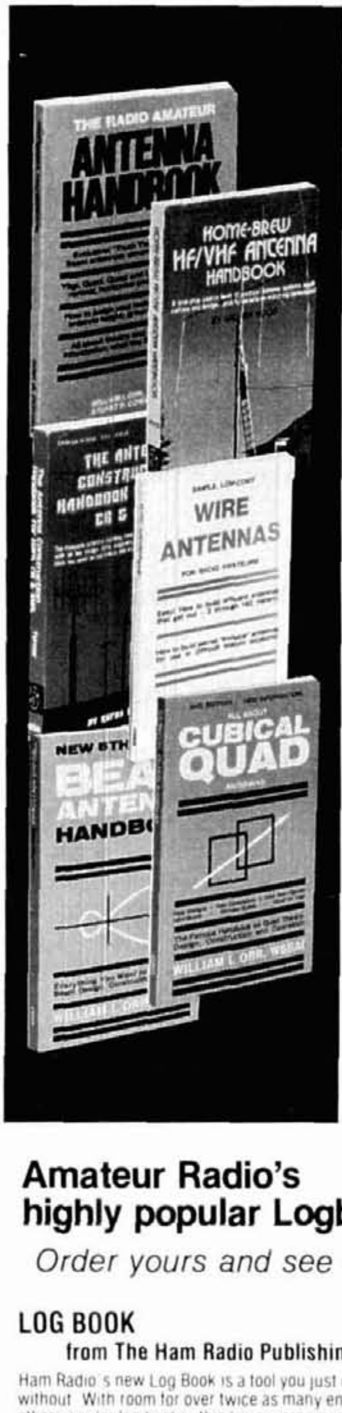

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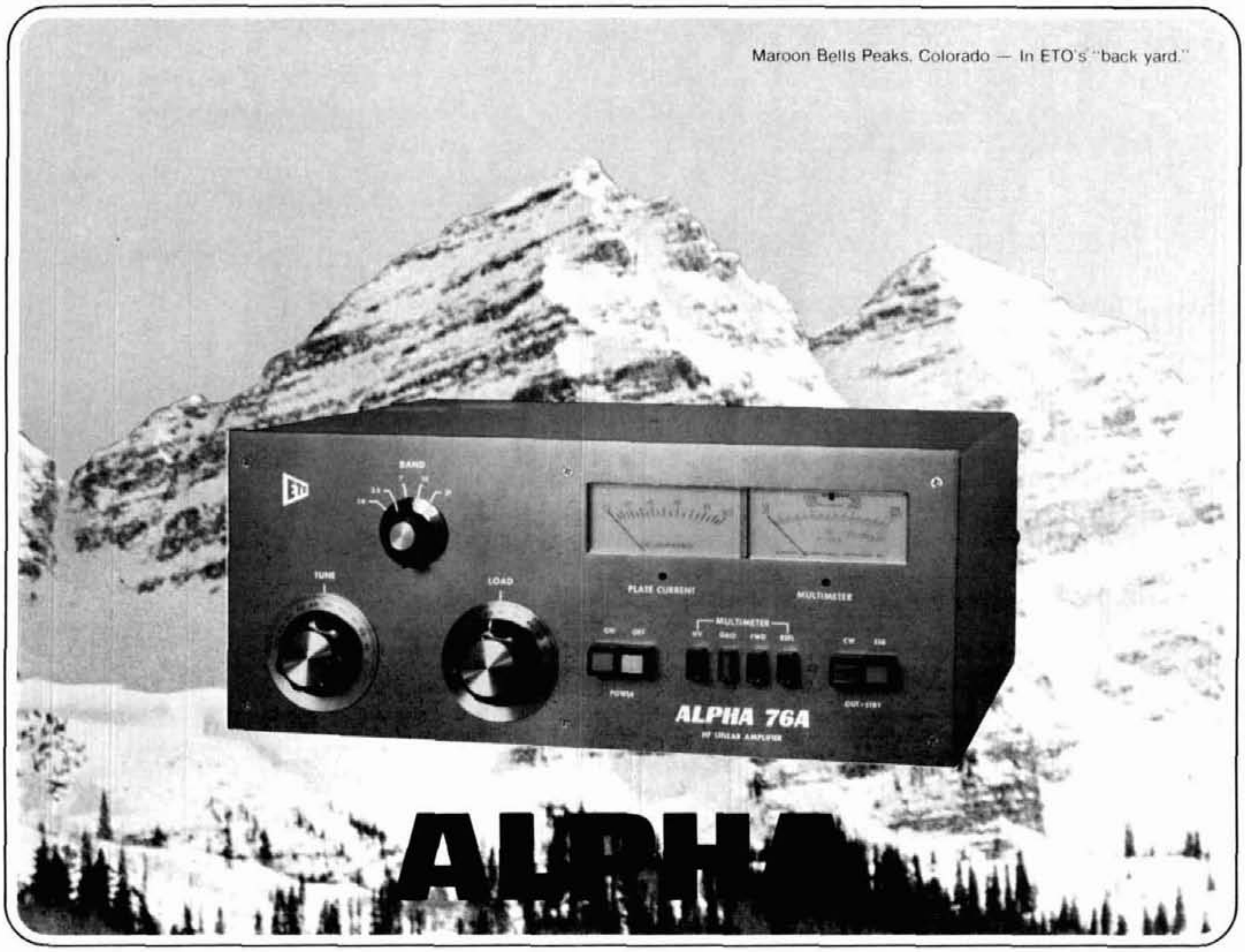

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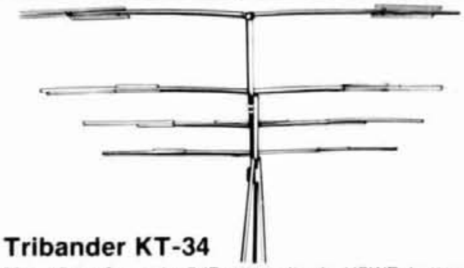

KLM Tribander KT-34

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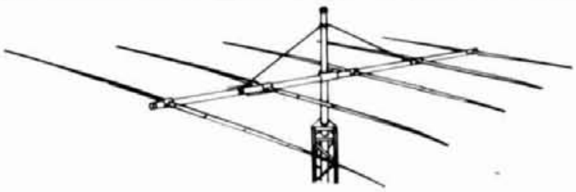

HY-GAIN 5-element monoband 20m beam antenna

5 elements up to 36½" long spaced on a 34' by 2" diameter boom, bandwidth: 400 KHz, average gain: 11.6 boom length: 34 ft., longest element: 36.5 turning radius: 25 ft., wind load: 230, surface area: 9 ft., F/B: 20 dB input impedance: 50 ohms.

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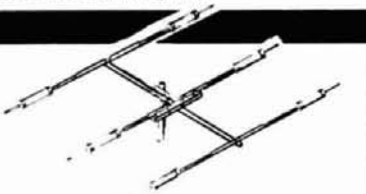

MOSELEY TA-33 Jr.

Covers 10, 15, 20 meters, 3 element beam features: Gain 10.1 dB (over isotropic source), F/B: 20 dB, 1KW PEP SSB input, VSWR at resonance 1.5/1 or better, longest element: 26 ft. 8 in., wind surface: 4.0 sq. ft.

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CUSHCRAFT A147-11 2m antenna

The 11-element antenna is rated at 1000 watts with direct 52 ohm feed and PL-259 connectors. Boom length 144 ins. Longest element 40 ins. Gain/F/B ratio dB: 13.2. Freq. 146-148 MHz. Wind area 1.21 sq. ft.

36.95 Call for yours today.

KLM 144-148 13LB 2 meter antenna

Has 13 elements, covers 144-148 MHz, gain: 15.5 dBd VSWR less than 1.2:1, feed impedance: 200 ohm balanced, boom length: 21.5 ft., center mounting, max mast size: 2 ins., 4:1 balun for 50 ohm coax feed supplied with the antenna.

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HY-GAIN TH6DXX The Ultimate tribander

Gain 8.7 dB • Front-to-back ratio 25 dB • SWR (at resonance) less than 1.5:1 • Number of elements 6 • Frequency 10, 15, and 20 meters • Longest element 31.1' • Boom length 24' • Wind load at 80 m.p.h., 207 lbs. • Surface area 8.09 sq. ft. Balun BN-86 recommended 15.95.

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CUSHCRAFT ARX-2 2m antenna

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More Details? CHECK—OFF Page 118

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SPECIFICATIONS

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PA Input Power:
180 watts DC
Carrier Suppression:
Better than 40 dB
Unwanted Sideband Suppression:
Better than 40 dB @ 1000 Hz, 14 MHz
Spurious Radiation:
Better than 40 dB below rated output
Third Order Distortion Products:
Better than −31 dB
Transmitter Frequency Response:
300-2700 Hz (−6 dB)
Stability:
Less than 300 Hz in first 30 minutes after 10 min. warmup; less than 100 Hz after 30 minutes over any 30 min. period
Negative Feedback: 6 dB @ 14 MHz
Antenna Output Impedance:
50-75 ohms, unbalanced

GENERAL

Frequency Coverage:
Amateur bands from 1.8-29.9 MHz, plus WWV/JJY (receive only)
Operating Modes:
LSB, USB, CW
Power Requirements:
100/110/117/200/220/234 volts AC, 50/60 Hz; 13.5 volts DC (with optional DC-DC converter)
Power Consumption:
AC 117V: 75 VA receive (65 VA HEATER OFF) 285 VA transmit; DC 13.5V: 5.5 amps receive (1.1 amps HEATER OFF), 21 amps transmit
Size:
345 (W) × 157 (H) × 326 (D) mm
Weight:
Approximately 15 kg.

COMPATIBLE WITH FT-901DM ACCESSORIES

RECEIVER

Sensitivity:
0.25 uV for S/N 10 dB
Selectivity:
2.4 KHz at 6 dB down, 4.0 KHz at 60 dB down (1.66 shape factor); Continuously variable between 300 and 2400 Hz (−6 dB); CW (with optional CW filter installed): 600 Hz at 6 dB down, 1.2 KHz at 60 dB down (2:1 shape factor)
Image Rejection:
Better than 60 dB (160-15 meters); Better than 50 dB (10 meters)
IF Rejection:
Better than 70 dB (160, 80, 20-10 m); Better than 60 dB (40 m)
Audio Output Impedance:
4-16 ohms
Audio Output Power:
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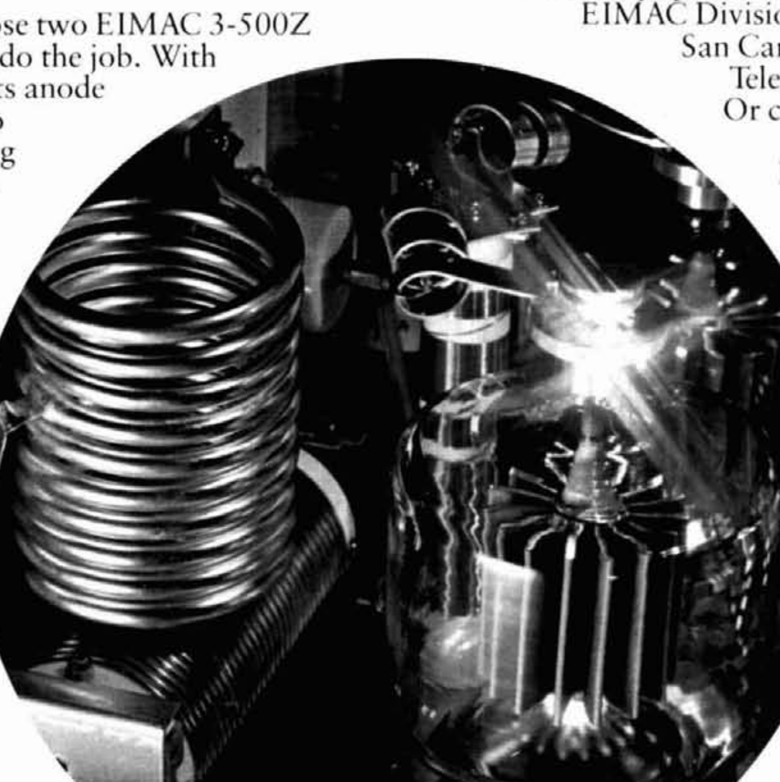
For more information

Send for the EIMAC Quick Reference catalog covering the complete line of EIMAC products and for the 3-500Z Data Sheet. Learn why the important manufacturers of communication equipment choose EIMAC. Varian, EIMAC Division, 301 Industrial Way, San Carlos, California 94070. Telephone (415) 592-1221. Or contact any of the more than 30 Varian Electron Device Group Sales Offices throughout the world.



What's your pleasure?

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