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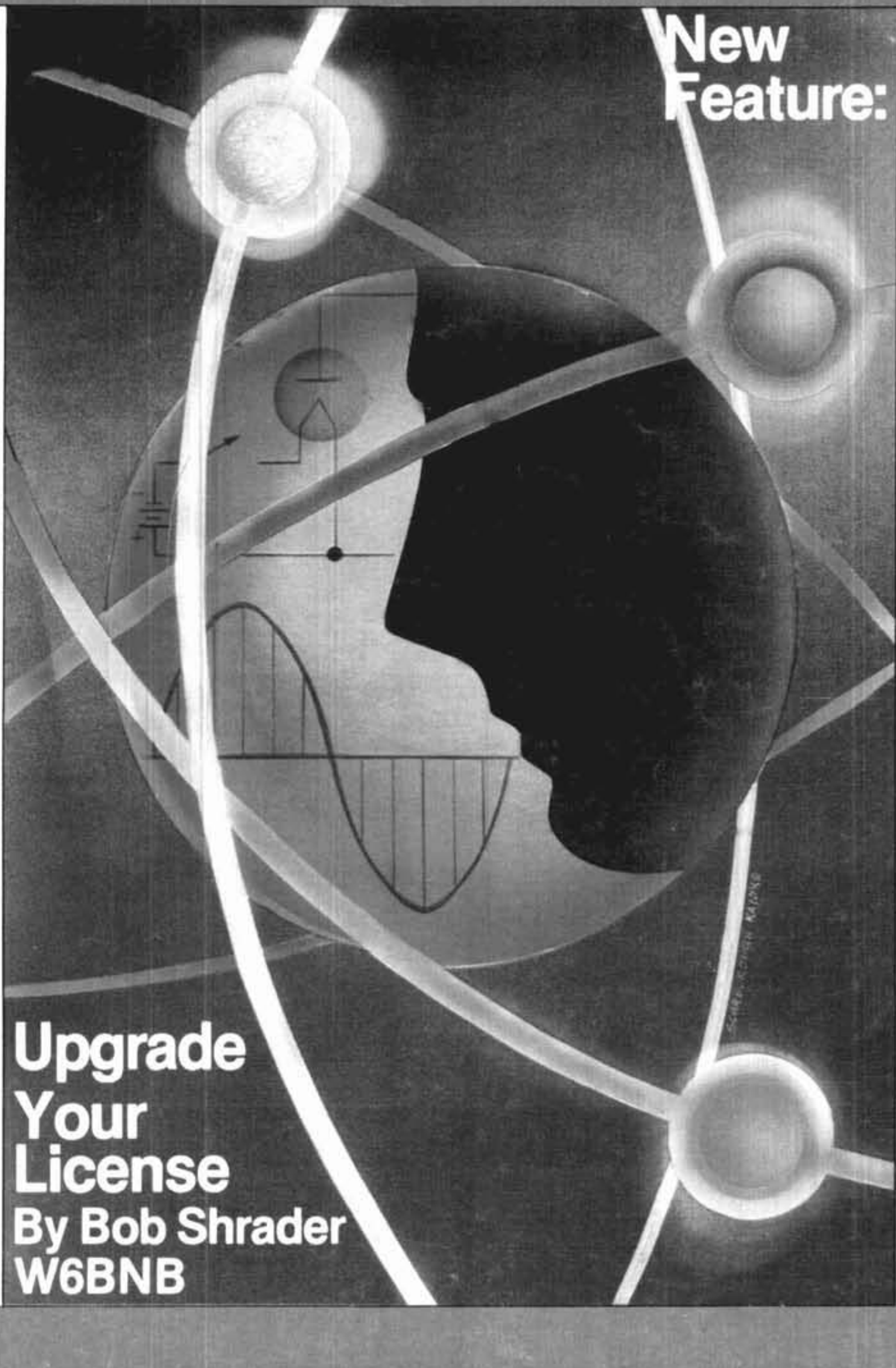

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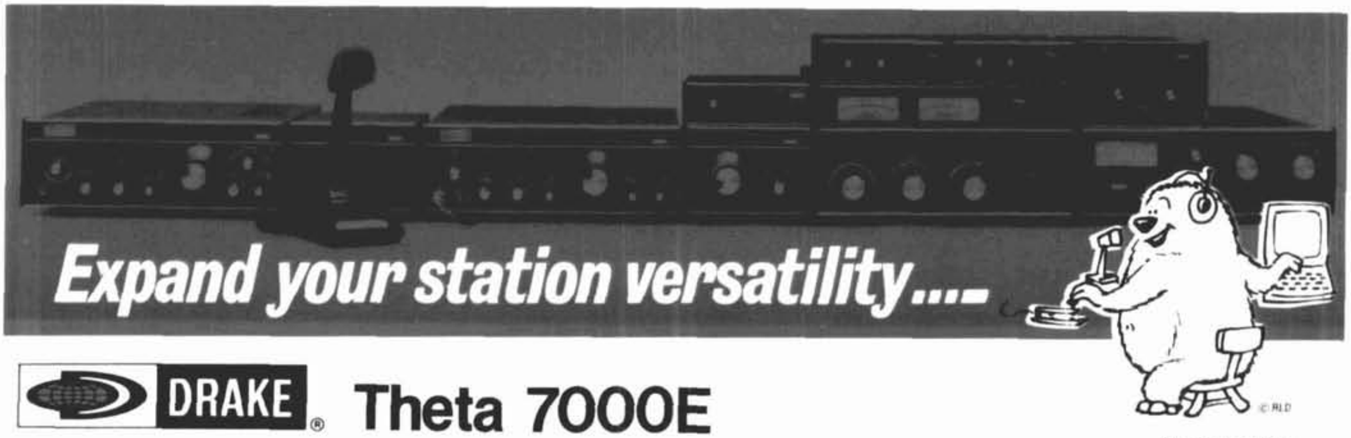

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More Details? CHECK—OFF Page 98

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HAM RADIO HORIZONS

SEPTEMBER 1981

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contents

publisher's log

by Skip Tenney

We asked for it and we sure got it. We've received a huge response to our survey in the May issue. It was designed to find out just who you our readers are, what your Amateur Radio interests are, what you think of the job we're doing, and what changes if any you would like to see in the magazine as we continue to work to fine tune the combined *ham radio*/HORIZONS that we put together earlier this year.

The number of returns and the amount of information we've collected are virtually overwhelming. Not only did we get a tremendous response to the questionnaire itself, but we also received a large number of thoughtful and very helpful letters from readers who felt that the necessarily limited questions we had asked did not give them enough of an opportunity to properly express themselves. We have already put many days of effort into trying to reduce this information into a useful and meaningful form. It isn't enough just to come up with the raw percentages of answers given to each question. We are putting a good deal of effort into cross-tabulating this data in order that we may learn just why those who like what we're doing feel that way, and why those who think we're going astray hold their opinion.

Many of the answers came out much as we had expected. Former HORIZONS readers missed their old magazine, but were increasingly satisfied with the changes we have been making, while some former *ham radio* readers lamented the changes to their favorite magazine. At the same time many offered constructive ideas as to what they would like to see in the magazine. Perhaps the most exasperating part has been the several features which seem to show up at both extremes of reader opinion. One group of readers will list a feature as most disliked while a similar sized group think the same item is the best part of the magazine.

It was very interesting to find out just who our typical readers are. For instance, we learned that engineers and technically employed people were the largest single active job category among former HORIZONS readers. We expected this from *ham radio* readers, but it came as quite a surprise to find out that 45 percent of *all* our readers are in that category.

By now you are probably wondering just how our report card came out. Have we been doing a good job or haven't we since combining our two magazines into one publication? Well 56 percent said that they like us as much or even better than before, while 44 percent preferred our previous approach, when we were publishing two separate magazines. And even among those who preferred our previous approach, very nearly half listed the new *ham radio* as their favorite Amateur Radio publication. These figures represent a great number of loyal readers.

Although not as high as we might like, these numbers do offer us very real encouragement. We're looking very carefully at the group who feel the new magazine is not as much to their liking as before and we'll be trying to offer a bit more to them while at the same time continuing to appeal to those who say we're doing just fine now.

Although we are far from having completely digested all of what you've told us, we are going to begin responding to your stated preferences by running a number of articles which will be a bit more in the traditional *ham radio* mold — although whenever possible we will try to edit them so that the reader who is technically less sophisticated can also learn a lot from them. Every reasonable effort shall be made to maintain *ham radio*'s pre-eminent technical reputation, while at the same time we maintain the greater balance we feel we've given to *ham radio* in recent months.

While we're on the subject of new features, it is with a great deal of pleasure that we direct your attention to a new series of license-upgrading articles by Robert L. Shrader, W6BNB, which starts in this issue. He is the author of the extremely popular license text *Electronic Communication*, which is by far the most thorough study guide in print for all FCC exams, both Commercial and Amateur. Bob's very complete yet easy to understand way of presenting material has led to many, many successful exam papers. His new series here in *ham radio* will add to that reputation I am sure. In fact, even many of you who are not in the process of upgrading will find this review of the technical basics valuable. Even our staff has been learning from Bob.

We've still got quite a way to go in evaluating and learning from the data you've given us (in fact we're still receiving over 25 replies each week), but when it's all over I think all of us, readers and editors, will find this time taken to reflect on where we stand and where we are going to have been very well spent. I'd personally like to thank all of you who have helped make this survey so successful. We have what we feel is the best magazine in Amateur Radio and we want to do everything we can to strengthen and further solidify that position.

Skip Tenney, W1NLB

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comments

on-air tune-up

Dear HR:

I enjoy Bob Locher's DX stories, but he certainly does not set a good example for the young aspiring DXer. Bob says, " 'OK Jerry, I hear him. Thanks a lot.' I move my VFO a couple of kHz above him and start tuning. The linear plate current, grid current, and rf output start climbing as I advance the exciter drive control."

Well, his rig blew — as should all who tune up in the band. No, I really don't mean that. But I guess Bob has never heard of a dummy load! Hey! The bands are full of creeps who tune their rigs on the bands. I for one am persistently plagued by tuner-uppers on stations I am working, and it seems invariably it's the really weak ones too!

When it comes right down to it, a dummy load is so darned easy to switch in for tune-up that it really is ridiculous not to use one. They are cheap too!

Fred Streib, W6NA
Palo Alto, California

Yes, I do tune up on the band, as does virtually everyone else. I have a dummy load, an excellent one, and I can switch it on line in a second or so. And, on the frequencies I operate on, it is virtually dead flat.

But my antennas are not! They display good SWR readings on the frequencies I normally operate on, but they are not perfect. Not only that, but they change a bit depending on the weather conditions. Wind or rain will change their characteristics slightly.

So, if I load up into my dummy load, I still have to retune once I am into a real antenna, or face poor harmonic rejection from a mistuned final, not to mention stress on the finals.

I do have preset tuning points marked on all my gear, and almost invariably I can complete a tune-up in less than five seconds of key-down time on the air. And I always *check the frequency before I do to insure that I cause no intereference.*

"No tune up" would be really nice, but in the real world using the equipment most Amateurs use it is impossible, even with solid-state finals which often require an antenna tuner with them. But, as Mr. Streib suggests, we have an obligation to avoid QRMing another QSO.

Bob Locher, W9KNI
Deerfield, Illinois

baluns

Dear HR:

I read with interest the fine article entitled "A Coreless Balun" by Roy N. Lehner, WA2SON, in the May, 1981, issue of *ham radio* magazine.

The first reference to this interesting device was in the Collins Radio Company's "Single Sideband Manual" (1965). Unfortunately, no construction data was given. I built several coaxial baluns and made measurements on them; in the February, 1966, issue of *CQ* magazine I gave several practical designs in an article entitled "A Broadband Balun for a Buck."

A replica of this design has appeared in each edition of the *Radio Handbook* for 14 years. Additional information on similar balun designs is included in the 21st edition of the handbook, which is published by Howard W. Sams Co., and available through Ham Radio's Bookstore.

Also discussed in the *Radio Handbook* are the small, air-core baluns wound of Formvar or enameled wire. Roy, WA2SON, claims the coaxial design is "much better" than the enameled wire balun, but this is like comparing apples and oranges. Each balun design has attributes that the other does not possess.

The enamel wire, air-wound balun is more compact than the coaxial design, weighs less and is not subject to coaxial cable "cold flow," wherein the center conductor migrates about and may short out to the shield — especially when the cable is wound into a small-diameter coil. And when properly designed, the enamel-wire balun has a somewhat greater frequency range of operation than the coaxial balun; that is, it is more "transparent" to the antenna system, as far as induced SWR goes, than is the coaxial design.

The coaxial cable balun, on the other hand, can probably withstand more brute power than the wire balun because of the higher breakdown voltage of the cable. Over the normal operating range, at normal ham power levels, there isn't much choice between the designs except on the basis of size or weight.

So you pays yer money and takes yer choice. But don't write off one particular balun design as being worse than another one. It isn't.

William I. Orr, W6SAI
San Carlos, California

nit-picker

Dear HR:

In the May, 1981, edition you have an article by John W. Frank, WB9TQG. This is a very interesting concept and will be of some help to the Amateur community. I wish I had thought of it.

But being the nit-picker that I am, I couldn't help but notice two errors. The first is the use of the symbol K **(eq. 2)**. This is usually used to designate a constant, not a reflection coefficient, which is designated by the symbol ρ. In the interest of clarity, the correct symbol should be used.

Second is the assertion that SWR will increase line losses. To examine this point let's look at a line of unit length with a 3 dB loss per unit length. With a generator and load matched to this line we find that when 100 watts is delivered into this line only 50 watts is delivered to the

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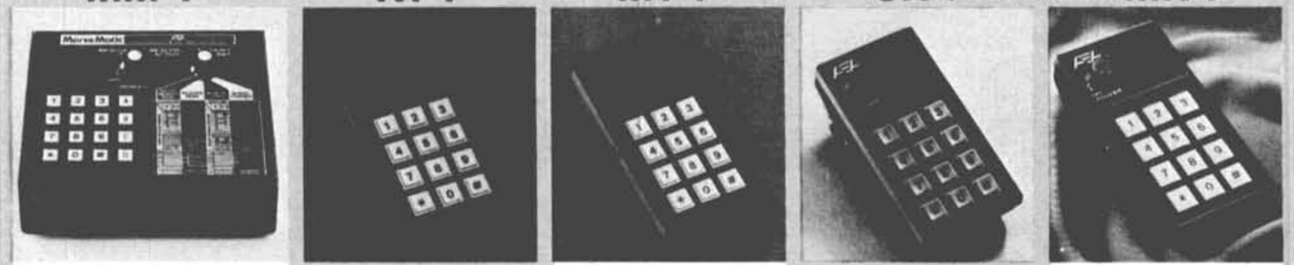

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load, the remaining 50 watts being "lost" in the line. This confirms the 3-dB loss factor. Now then, if we mismatch the load such that it is infinite (or as near as we can get to ∞) we can make another measurement and find that the SWR is very high and 25 watts now show up on our (directionally coupled) wattmeter at the generator end of the line. This tells us that at the far end we have lost an additional 25 watts (that is, 3 dB for the return trip).

This is the argument presented in the article, and you can see that the line loss factor has remained at 3 dB per unit length; it has not changed. We can infer from this that the line loss is constant and does not change with SWR. Any loss in addition to this in the load is the result of impedance mismatch (although it will be reflected to the generator as reactance, detuning the output network and probably aggravating the "loss" situation by further complication).

We may look at this as if the "reflected power" is absorbed by the PA plate circuit and dissipated there as heat, which is what the FCC says, and we won't be too far off base.

Michael D. Smith, WD4KMP

Just between us nit-pickers, I must admit that you are right. However, reference 2 used the letter K. The Radio Handbook, *21st edition, presents a different form of my* **eq. 2** *on page 25.8 and the reflection coefficient is again represented by the letter K.*

Regarding the increase in total line loss due to standing waves: According to the ARRL Electronics Data Book, *copyright 1976, page 82, "An increase in line loss occurs because of SWR." A graph showing additional loss caused by SWR is on page 83 of this data book. This same information is presented in nomograph form in* Reference Data for Radio Engineers, *6th edition, page 24-10.*

Proving the existence of the additional line loss takes about 26 pages of higher mathematics; I made the assumption that it is common knowledge.

John W. Frank, WB9TQG

at a loss

Dear HR:

I can't believe it, that what's given in **fig. 1** ("Measuring Coax Cable Loss," May, 1981, page 34) is really SWR. How about:

$$SWR = \frac{1+\frac{|R-Z|}{|R+Z|}}{1-\frac{|R-Z|}{|R+Z|}}$$

Since when is the reflection coefficient equal to the reflected power/forward power — which the meters don't read anyway?

If the line is (presumably) an open circuit it will be difficult to deliver 100 watts to it — unless it's *very* lossy.

I suggest you see the February, 1981, issue of *QST*, page 26. It can be done this way:

$$P_1(FWD) - P_1(REFL) - P_2(FWD) = loss$$

J.T. Kroenert, KA1PL
Barrington, Rhode Island

Yes, Mr. Kroenert, that is SWR. If you check reference 1 (listed at the end of my article) you will find that $SWR = R/Z$. *If you prefer the equation you refer to in your letter, let R equal infinity and Z equal 50 ohms, and the SWR will still be infinite.*

If you read my article carefully, you will note that I never said the reflection coefficient equals reflected power/forward power. What I said was, "...since SWR is a function of forward and reflected power...." I did not say it was a ratio; I said it was a function.

Your suggestion that loss can be measured by noting the difference between wattmeter readings at the source and at the load will work. However it isn't as convenient as my method. For example, if I chose to use your method, I would have to climb my tower and disconnect the coax from the antenna. Then, with my dummy load up 60 feet in the air, I would return to the shack to make power measurements. Next, I would have to invite another Amateur over to the shack. Why do I need another Amateur? I need someone to key the transmitter while I'm at the top of the tower making more power measurements. I said, your method will work but mine is more convenient.

John W. Frank, WB9TQG

blow your own horn

Dear HR:

After reading the Comments in *ham radio* (May, 1981), one might get the impression that experts don't want too much to do with anyone who might be coming up the ladder or maybe received his license without a complete knowledge of electronics.

Many permits and licenses are issued today with little or no knowledge — namely marriage, hunting, and driver's — at least with a ham license you won't kill anyone.

I am a professional driver and have driven tractor trailers, buses, motor homes, and cars the equivalent of eighty times around the world, but this does not mean that a novice driver with two hours of instruction and practice can't take a 400-horsepower car on the interstate and do battle with the experts.

So all you super pros in Amateur Radio (who I trust are in the minority) keep blowing your own horns and someday when we meet on the road, I'll blow mine.

Fish Gilpin, KA3DNT
Greentown, Pennsylvania

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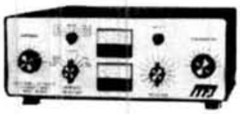

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More Details? CHECK—OFF Page 98

presstop

SATELLITE-RELAYED AMATEUR RADIO PACKET communications became a reality in Canada in July when packets were exchanged over the ANIK-B research satellite. The pioneering contact was made by VE3FOL in Ottawa and VE7APU in Vancouver, operating from the satellite ground stations at 1200 bits/second.

The Satellite Channels have been made available to Amateurs on a "space available" basis, under an authorization granted by the Department of Communications. Tie-ins with local "computer bulletin boards" and other computer hobbyist activities are also planned, so eventually not only Amateurs but non-Amateurs will be using the Amateur-built system.

STRONG ORGANIZED SUPPORT FOR AMATEUR RADIO is being proposed by a newly formed group in California, the Society for the Protection of Amateur Radio (SPAR). SPAR, the brainchild of K6QYO and W6POU (Santa Barbara County SCM), states as its purpose "to support when needed the interests of Amateur Radio as defined by the ARRL, with the strongest possible political action against harmful regulation and legislation, and to support that regulation and legislation which is beneficial." The SPAR articles of incorporation, which were signed June 14, are highly supportive of the ARRL but very critical of the FCC...in particular, the plain language rewrite.

SPAR Says It Will Support Amateur Radio through organized letter writing campaigns, introducing legislation and legal actions, and eventually by putting a "full-time legislative advocate" in Washington. The organization plans to work with and through the League, but feels it would be in a position to accomplish things that the ARRL cannot. Thus far it has received strong support from ARRL Southwestern Division Director W6EJJ, who plans to keep League officials aware of its progress. SPAR was discussed at the June executive committee meeting, but no position on it was taken.

SPAR's Support So Far is mostly from southern California, where it seems to be catching on rapidly. Interested Amateurs can write (SASE) SPAR, Box 41, Santa Barbara, California 93108 or call (805) 969-5304, 969-5623, or 642-7141.

SPREAD SPECTRUM HAS BEEN PROPOSED for the Amateur service in a Notice of Inquiry and Proposed Rulemaking announced by the FCC July 1. In this action the Commission proposes limiting use of the sophisticated broadband technique to the 6, 2, and 1¼ meter bands, by Advanced and Extra class licensees only. Though some technical details are proposed in the item, the principal limitation is that emissions be contained within the given band.

Further Details are not yet available. However, the document will pose a number of questions on such topics as how Amateur spread spectrum transmissions could be monitored and what potential interference would result from them. The complete text of FCC 81-290 should be in the Federal Register and available from the usual FCC sources.

Spread Spectrum Radiolocation in the 420-450 MHz band has also been proposed in a related action, FCC 81-291. Responding to a petition by Del Norte Technology, this FCC NPRM would let Del Norte use radiolocation equipment, previously limited to off-shore areas, within the United States. Such use would, however, be on a non-interference basis with government and Amateur use of the band.

Comment Dates On These Items have not yet been announced, but a long comment period, at least on the Amateur item, is expected.

Spread Spectrum Operation on the lower-frequency Amateur bands has already taken place under an FCC Special Temporary Authority. A detailed report on these first Amateur experiments, by AMRAD members W4RI, K2SZE, and WA3ZXW using commerical spread spectrum rigs on 75 meters, appears in the July AMRAD Newsletter. Amateurs interested in following the progress of this mode, as well as packet radio and application of computer technology to Amateur Radio, should join AMRAD. Membership is $12 a year, to treasurer N4GA.

ANTENNA PROBLEMS HAVE BROUGHT another Amateur to the Courtroom. N5SW of Kryder Electronics is suing Oklahoma City, after the city building inspector informed him his 78-foot tower was in violation of the city's 50-foot tower ordinance, and the city Variance Board denied him a variance for it.

The Suit, Which Was Filed June 11, has received much media attention in Oklahoma City and was picked up by UPI. In it, N5SW asserts the 50-foot restriction "limits my freedom of speech and violates my civil right to control my own property." In addition, he maintains the tower "is a necessary requirement in the exercise of my avocation" and the ordinance "limits the exercise of my federally granted Amateur Radio privileges."

N5SW Was Arrested in his home eight days after the suit was filed in Federal District Court and charged with violating the 50-foot ordinance. Contributions are being solicited to assist in the action by the Oklahoma City Antenna Defense Fund, c/o ADIS, Box 32735, Oklahoma City, Oklahoma 73123.

ARRL Is Watching N5SW's case closely, along with a half dozen others that were reviewed at the June 20 Executive Committee meeting. The League, under its tax exempt status, cannot assist an individual member financially in such a case unless its participation would benefit all its members. The League can assist only if the case is precedent setting, or would upset a previous precedent.

More Details? CHECK—OFF Page 98

upgrade your license: part 1

The first article in a continuing series designed to help you upgrade your ticket

If you are reading this magazine, you probably already hold an Amateur Radio Service license of some grade. Maybe you are a Novice. More likely you are a Technician, General, or better. A good theory review now and then is a good idea for all of us, Extras included.

frequencies and types of emission — right? Does it bother you that someone else can use them but you can't? Well, it was a challenge for all of those Extra-class hams who are using those frequencies, but they did something about it: they upgraded.

Bob's next article on license basics will explain items such as inductive and capacitive reactance, impedance, phase angles, solving simple ac circuits, reactive power, power factor, simple series and parallel circuits, impedance matching, series and parallel resonance, circuit Q, basic filters, wave traps, and a simple black-box circuit.

This means that not only did they learn more radio theory but they also improved their code sending and receiving abilities, which enables them to function better in an emergency where phone equipment is either not working or unavailable. Maybe they found out that code communications is a heck of a lot of fun when you get to the point where you can sit back and copy in your head, and not bother to write everything down on paper. Really, that transcribing the code is for the birds! We will talk about this later, but right now be sure that each day you have at least one good QSO on the air using CW, to raise yourself above that crawling along at 5 or 13 words per minute (WPM).

Probably the largest group of readers interested in upgrading are in the Technician/General category. For this reason, we will first concentrate on upgrading this group to the Advanced class license. Later we will take on the Extra class — so keep working on that 20 WPM code speed goal. If you are a Novice (or not yet a Novice), you will find that the fundamentals we are going to work on first should enable you to work up to the Technician/General level. At the beginning of each article we will point out what FCC topics are to be discussed in that article. In this month's article, the first in the series, you will find

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

basic electrical topics suitable for Novice, Technician/General, and Advanced license questions.

The first few articles will lay out the groundwork, so that we will all be speaking the same electronic language. If we say such things as current, resistance, reactance, or impedance, it should mean the same to all of us. Once we all understand the basic language we can better discuss the more advanced subjects.

The study of Amateur Radio theory requires some knowledge of electricity (volts, ohms, amperes, resistors, magnetism, coils, capacitors), electronics (diodes, transistors, vacuum tubes), basic circuits (oscillators, amplifiers), combinations of circuits which we will call systems (receivers, transmitters), antennas, FCC rules and regulations, radio telegraph code, and proper on-the-air operating procedures.

The FCC is basing its present license tests on nine areas of information:

a. Rules and Regulations

b. Operating Procedures

c. Radio Wave Propagation

d. Amateur Radio Practice

e. Electrical Principles

f. Circuit Components

g. Practical Circuits

h. Signals and Emissions

i. Antennas and Feedlines

FCC test topics

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

- *ampere*
- *voltage*
- *volt*
- *conductors and insulators*
- *watt*
- *energy and power*
- *fuses: appearance, applications, symbol*
- *open and short circuits*
- *direct current*
- *alternating current*
- *metric prefixes: mega, kilo, centi, milli, micro, pico*
- *hertz*
- *audio frequency*
- *radio frequency*

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

- *resistance*
- *resistors: appearance, types, characteristics, applications, symbols*
- *resistors in series*
- *ohm*
- *Ohm's law*
- *power calculations*
- *power measurement*
- *electrical power calculations*
- *root-mean-square value of a sine-wave alternating current*
- *inductance*
- *inductors: appearance, types, characteristics, applications and symbols*
- *henry, millihenry, microhenry*
- *capacitance*
- *capacitors: appearance, types, characteristics, applications, and symbols*

The following Advanced class test topics are discussed in this article:

- *sine, square, sawtooth waveforms*
- *root-mean-square value*
- *fields, energy storage, electrostatic, electromagnetic*

For additional information on these subjects you might refer to Electronic Communication, *by Robert L. Shrader, McGraw-Hill Book Co., both a commercial and Amateur license text, available through Ham Radio's Bookstore, Greenville, New Hampshire 03048 ($26.95 plus $1.00 shipping).*

Under these categories the FCC lists many specific topics. They do not indicate the questions they will ask, only what subjects the questions will cover.

All of the Amateur license tests contain one or more questions on all of the specified areas. For the Novice exam the level of knowledge required is rather rudimentary. For the Technician/General exam you'll need a good basic understanding of radio. For the Advanced class license the qualifications are definitely higher, and some of the questions seem to come from out in left field somewhere. As for the Extra-class license, well, you are supposed to know a lot about a lot of things. A word of warning is advisable here. Although they do not say so, the FCC tends to reach back down to lower level license topics for some of their test questions. You might find some Technician/General questions on Advanced license tests. But if you have passed the lower license you should not have too much trouble.

This series of articles will try to cover the whole field for you. We are sure that many hams who have had a license for several years have managed to forget most of the theory that they learned previously. So, to refresh their memories and to help those of you who do not have at least a Technician/General license, we will first go over the basic Electrical Principles and the Circuit Components, as taken from the FCC list above. Other categories of information will be covered in later articles.

There is no way that we can guess what the FCC is going to ask you on their present or on future tests. But if you have a good, basic understanding of the topics in the FCC list, you stand a good chance of choosing the correct answer in their multiple-choice test questions. Happily, you can miss a few and still get your license. After all, a 75 percent grade on a test gives you just as valid a license as a 100 percent score would. You might feel better if you made the 100 percent grade, but how many of us are perfect?

The idea of this series is to put radio theory into words you can understand, even if you have little or no training in this field. We are not out to produce electrical engineers, just knowledgeable Amateur Radio operators. If you want more information than you find here, there are textbooks that you can read once you understand the basic ideas.

One thing more. You must have a copy of Part 97, FCC Rules and Regulations, obtainable from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.* Space here is too limited to permit us to repeat all of the information on rules and regulations. Let's get started.

electrical current

Every electrical or radio device operates because a current of "things" moves through the copper wires and the device. The "things" that move are called electrons. We probably all know that everything that can be seen or felt is made up of atoms, usually in chemical combination with other atoms to form molecules. An atom consists of a central nucleus, which is made up of relatively heavy, zero-charged particles called neutrons and positively charged particles called protons. Essentially, the nucleus of an atom is never altered. Nothing we can do, short of nuclear fission or fusion, will alter it.

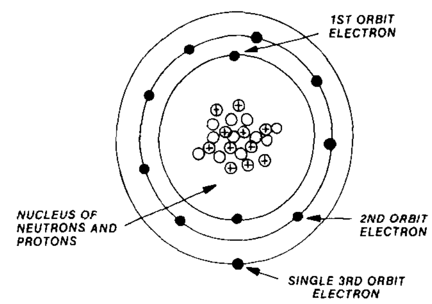

fig. 1. Representation of an atom that would make a good conductor.

Surrounding the nucleus, however, are orbiting electrons, **fig. 1**. The electrons have a negative charge and are attracted to the positive charges of the nuclear protons. These constantly moving electrons travel in orbits around the nucleus, somewhat similarly to the way in which the planets orbit the sun. The earth is attracted to the sun by gravitational forces; electrons are attracted to the nuclear protons by electrostatic (negative to positive) forces.

The outermost electrons of some atoms are susceptible to external effects. For example, if a single, outer-orbit electron is brought near a higher positive charge it may be stolen from its parent atom. This leaves the atom minus one electron, and therefore with one excessive positive charge in its nucleus. We say the atom has been ionized by losing the electron, and is now a positive ion. (We may think of this as being an electron hole in the ionized atom.)

In our real world we have dry cells (called batteries if two or more are used together) that have the ability to chemically separate electrons from atoms and pile

*Also published in *The Radio Amateur's License Manual*, available from Ham Radio's Bookstore, Greenville, NH 03048 ($4.00 plus $1.00 shipping).

the electrons on the negative terminal of the cell, leaving the opposite terminal electron-less, or positively charged. The chemicals can move only a given number of electrons across the cell before the electrical difference (electrostatic force) stops any further chemical action. In the common dry cell this occurs when an electrostatic force of 1.5 volts is across the cell. (Voltage is disussed in the next section.)

If we connect a flashlight lamp across the dry cell, using three pieces of copper wire and a switch, a simple electric circuit is formed, **fig. 2**. (Copper is used as connecting wire because it has one free, or easily moved, electron in its outermost orbit.) When the switch is closed, the excess electrons on the negative pole of the dry cell have a chance to move to the positive pole through the lamp and circuit. As a result, a current of electrons develops throughout the circuit. The copper wires allow the current to flow with almost no opposition, but the lamp's filament, made of tungsten or some other metallic wire, has fewer free electrons and tends to oppose the flow of the electron current. Because of this frictional opposition, energy is lost in the filament wire and it heats. Tungsten can be heated to a red, orange and even to a white-hot temperature without melting. Thus, while the copper connecting wires may heat slightly or not at all, the lamp filament heats white hot and light is radiated from it. When the switch is opened the current stops; the filament cools and it no longer radiates heat or light.

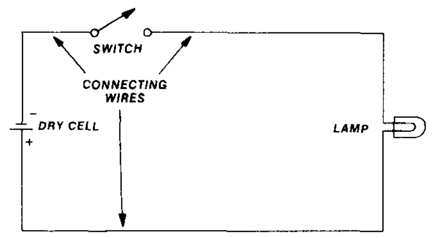

fig. 2. Simple lamp circuit.

In the dry cell, when electrons begin to enter the positive terminal, the electrical difference across the cell becomes less and the chemicals start working again, pumping more electrons to the negative pole from the positive. When the chemicals can no longer continue to move electrons across the cell, the cell is discharged, or dead. The cell converts chemical energy to electrical, and the lamp, or "load" on the circuit, converts the electrical energy to radiant (heat and light) energy.

An interesting sidelight to the subject of current is its direction of flow in a circuit. You can see that electrons must travel from the negative terminal of the source (the cell) through the outside circuit (the lamp or load), being attracted to the positive terminal. Back in the early days when electricity was first being investigated, cells were labeled positive and negative the same as today. It was only natural to assume that if something was traveling in the wires of electric circuits that it must travel from the terminal that had the most (positive) to the one that had the least (negative). So they said that current flowed from + to −, and they wrote all the textbooks that way.

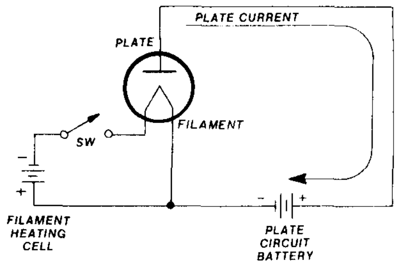

fig. 3. Adding a plate in a lamp produces a diode, or two-element control device.

In the early 1900s, when vacuum tubes were first being developed, it was found that hot filaments boiled free electrons off of their surfaces. A metal plate was put inside the vacuum area of a lamp; the plate could be made positive by connecting it to the positive terminal of a battery, provided the filament was connected to the negative terminal. A current could now flow through the plate circuit whenever the filament was hot, **fig. 3**. This proved that electric current actually flowed from the negative terminal of a source through the circuit to the positive terminal.

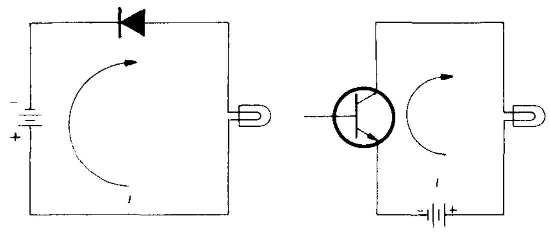

fig. 4. Electron current flows in the direction opposite to that indicated by the arrows on solid-state devices, which point in the direction of "conventional" current flow.

Well, that wasn't the way the textbooks said it was. Since nobody wanted to rock the boat, they just continued to teach that current flows from + to −, and the heck with the electrons! So, now we have two theories of current flow, one the original, "conventional" + to − theory, the other the electron theory. You will notice that all of the symbols on solid-state diodes, transistors, and so forth, **fig. 4**, have their arrows indicating current flowing in the conventional current direction. So, remember that symbols show conventional current direction, not the electron theory direction.

In **fig. 5** we have added a lamp as the load in the **fig. 2** circuit and substituted the correct symbol for a vacuum diode (two-element device). We have also added an ammeter in series with the lamp and the plate circuit B-battery. The ammeter measures the value of the current flowing through it, and therefore the current in the plate circuit. It is called an ammeter because current is measured in amperes, A. An ampere of current is considered to be 6.25×10^{18} electrons flowing past a point in a circuit in 1 second. Remember that 10^{18} means that you move the decimal place of the 6.25 over 18 places to the right (if the exponent were negative, 10^{-18}, you would move the decimal point 18 places to the left). That makes the number of electrons 6,250,000,000,000,000,000. From this you might deduce that an electron is a pretty small thing, and you would be right. A group of 6.25×10^{18} electrons is known as a coulomb (C), which is the basic unit of electric quantity (Q).

In modern radio we may more often measure current in thousandths of an ampere, called milliamperes, or mA. A microampere, or μA, is a millionth of an ampere. A billionth of an ampere is called a nanoampere, or nA.

The metric based prefixes used with electrical units of measurement are listed in **table 1**. You should know these.

table 1. Metric-based prefixes.

Pico (p, or μμ)	= trillionth of	= 10^{-12} times
Nano (n, or mμ)	= billionth of	= 10^{-9} times
Micro (μ)	= millionth of	= 10^{-6} times
Milli (m)	= thousandth of	= 10^{-3} times
Centi (c)	= hundredth of	= 10^{-2} times
Deci (d)	= tenth of	= 10^{-1} times
No prefix	= unity	= $10^0 = 1$
Deka (da)	= ten times	= 10 times
Hecto (h)	= hundred times	= 10^2 times
Kilo (k)	= thousand times	= 10^3 times
Mega (M)	= million times	= 10^6 times
Giga (G, or kM)	= billion times	= 10^9 times
Tera (T)	= trillion times	= 10^{12} times

voltage, resistance, and Ohm's law

The pressure exerted on electrons by chemical action in a dry cell has been explained as producing a moving force that makes electrons flow in a circuit. This pressure is known as electromotive force, or EMF, and is symbolized as E or e. Since it is measured in units called volts, it is also known as voltage, which is symbolized as V or v.

The opposition that the lamp filament had to the flow of electrons or current is properly known as resistance, symbolized as R. Resistance is measured in units called ohms, symbolized as Ω (the Greek letter omega).

One of the most important formulas for computing electrical circuit operation is Ohm's law, which simply states that if 1 volt of pressure is applied across 1 ohm of resistance, the resulting current value will be 1 ampere. Ohm's law is usually written as:

$$I = \frac{E}{R} \text{ and from this } E = IR \text{ and } R = \frac{E}{I}$$

where I = intensity of current in amperes (amps for short)
R = resistance in ohms
E = EMF in volts

Note that you cannot use milliamperes in this formula. The milliamperes must be converted to the basic unit of amperes before it will work in the formula.

Here is an example of the use of Ohm's law: If the dry cell in **fig. 2** has an EMF of 1.5 volts and the lamp's filament has 30 ohms resistance, then the current flowing must be:

$$I = \frac{E}{R} = \frac{1.5}{30} = 0.05 \text{ amps}$$

A value of 0.05 amps might also be expressed as 50 mA, or 50,000 μA, and even 50,000,000 nA. We will be using Ohm's law again and again. Be sure you know the formula.

The resistance of the tungsten filament in the lamp is not constant: the resistance varies directly with its temperature. The filament, when hot and glowing, will have a resistance many times its resistance when cold. Electronic components known as resistors, however, are made of substances that maintain their constant resistance whether operated cool or warm. Such substances are said to have a zero temperature coefficient of resistance. Tungsten has a positive

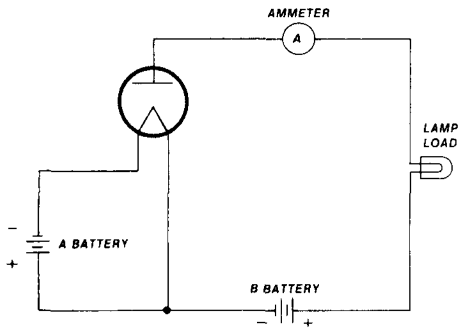

fig. 5. Vacuum diode with a filament or A-battery, a plate circuit or B-battery, ammeter in the plate circuit, and a lamp as the load.

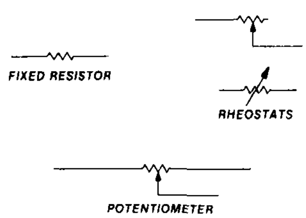

fig. 6. Symbols for fixed resistor, two ways of indicating rheostats, and a potentiometer.

temperature coefficient. In fact, most metals have positive temperature coefficients; carbon and other semiconductors have negative temperature coefficients. Thus, fixed-value resistors are usually made of both carbon and metals to produce the desired resistance as well as a nearly zero temperature coefficient.

Fixed-value resistors are usually constructed in tubular form with connecting wires out each end. They may range in length and diameter from perhaps 0.25 × 0.1 inch (7 × 2 mm) for the smaller sizes (0.1-watt, as discussed in the next section) to about 0.7 × 0.3 inch (17 × 8 mm) for medium sizes (2-watt types). Wire-wound types may be up to several inches long and an inch in diameter. There are all manner of intermediate sizes and wattages for fixed resistors. They are usually covered with an insulating (nonconducting) material.

There are variable resistors which consist of a contact arm that can be moved across an uninsulated resistance. If the variable resistor has a movable arm and only one end of the resistor is used, the device can be called a rheostat, **fig. 6**. If connections are made to both ends and the sliding arm, the device is known as a potentiometer. Potentiometers are used

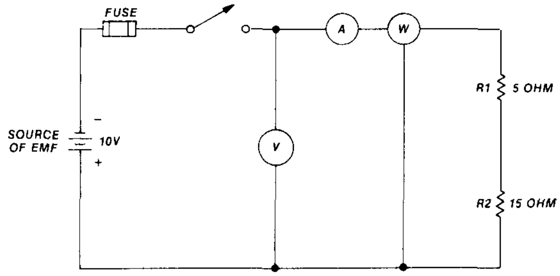

fig. 7. Circuit to be investigated for currents, voltages, and powers.

as voltage dividers in most applications, such as volume or gain controls on amplifiers or receivers.

power and energy

The term watt was used in conjunction with resistors. Watts of power indicate the energy that a resistor can safely dissipate without overheating. To determine power in watts we normally use the formula:

$$P = EI$$

where P = power in watts (W)
E = EMF in volts
I = intensity of current in amps

As an example, consider **fig. 2** again. If the voltage of the dry cell is 1.5 volts and the current through the lamp is 0.05 amps, the rate at which energy is being dissipated by the filament is $P = EI$, or 1.5 (0.05), or 0.075 watt. Note that we say the rate (which involves time, t) at which energy is being dissipated. This is because a watt is a volt times an ampere ($P = EI$), and an ampere is a coulomb-per-second (C/s, or Q/t).

If we remove the time (second) from a power computation we are left with pure energy. Thus, energy can be expressed as

$$energy = \frac{EI}{t}$$

which divides the time out of the right-hand part of the equation. If an ampere is a coulomb-per-second, and the second is cancelled, then energy must be equal to EQ (volt-coulombs). A volt-coulomb is commonly termed a joule, or a watt-second. (In the watt-second the second is added to cancel out the time in the watt.) Remember that energy is timeless and power is a rate.

Let's see how many things we can determine from the circuit shown in **fig. 7**. First, there are three new components shown, a fuse, a voltmeter (V) across the circuit, and a wattmeter (W) in "series" with the circuit and also across or in "parallel" with the circuit. The 1-amp fuse has a wire inside it which will melt if more than an ampere flows through it. The voltmeter is across the source of voltage as soon as the switch is closed. It indicates the EMF of the source in volts. The wattmeter must consider both voltage and current at the same time ($P = EI$). It must be connected in series with the circuit to obtain the current value, and across the circuit to determine the voltage value. It considers both of these factors and indicates the product of the two in watts. Also, we have two load resistors connected in series across the source. The total resistance the source sees is *5 ohms + 15 ohms = 20 ohms.*

When the switch is closed, the voltmeter reads 10 volts. The ammeter reads $I = E/R$, or 10/20, or 0.5 amp. The wattmeter reads $P = EI$ or 10(0.5), or 5 watts. Assuming the meters require almost no power to operate them, every second the source would be delivering 5 joules of energy to the two resistors. Between the two resistors, 5 watts are being dissipated. But, how much does each resistor dissipate? Let's apply what we have been discussing so far.

We know that the current through the two resistors is 0.5 amp, and since they are in series, R_1 must have 0.5 amp flowing through it, the same as R_2 has. Therefore the voltage drop across R_1 must be $E = IR$, or 0.5(5), or 2.5 volts. With 2.5 volts across R_1 and 0.5 amp flowing through it, the power being dissipated must be $P = EI$, or 2.5(0.5), or 1.25 watts. What would a voltmeter read if it were connected across R_1? If across R_2? How much power is being dissipated by R_2? You have all the information needed to compute this. Before reading on, try answering these three questions. (There are at least two ways of finding two of the answers.)

A voltmeter would read a 2.5-volt voltage drop across R_1. If there is a voltage drop of 2.5 volts across R_1 and the source is 10 volts, then there must be the difference, or 7.5 volts across R_2, right? You can also compute the R_2 voltage drop by $E = I_{R_2}R_2$, or 0.5(15), or 7.5 volts. If the total power being dissipated is 5 watts and R_1 is dissipating 1.25 watts, then R_2 must be dissipating the difference, or 3.75 watts. You could also compute the R_2 power by $P = EI$, or 7.5(0.5), or 3.75 watts.

Suppose R_2 were shorted out (copper wire connected across it). Why would all of the meters read zero after the switch is closed for a second? The answer is that the 1-amp fuse would blow out, but why? According to Ohm's law, the current flow in the circuit would be $I = E/R$, or 10/5, or 2 amps. Since the fuse is rated 1-amp it would melt when fed a 2-amp current. This would produce an open fuse, and an open circuit, even with the switch closed. The fuse is a protective device. Magnetic or other types of circuit breakers could be used in place of the fuse, and could be reset after the short-circuit is removed from the circuit. The usual radio fuse is to be a glass or other insulation material with metal caps at the ends and a fuse wire running down the center of the tube.

We might consider the power formula, $P = EI$, as being the fundamental way of determining power. However, by substituting the Ohm's law formulas into this power formula we come up with two other equally important power formulas. Consider using the IR portion of the Ohm's law formula $E = IR$ in place of the E in the $P = EI$ power formula:

$$P = EI \text{ becomes } (IR)I, \text{ or } P = I^2R$$

Similarly, by substituting the E/R part of the $I = E/R$ Ohm's law formula for the I in the power formula:

$$P = EI \text{ becomes } E(E/R), \text{ or } P = \frac{E^2}{R}$$

So, if you remember $E = IR$ and $P = EI$, by a little algebraic manipulation of the letters of the two formulas you can come up with six very useful formulas.

Refer back to **fig. 7** again. Try using the $P = I^2R$ and the $P = E^2/R$ formulas to determine the dissipation of R_1 and R_2. You should obtain the same answers as were computed above. Come on now, try at least a couple of formulas on R_1 or R_2!

alternating current

Up to this point the current that has been flowing in our circuits is known as direct current, or dc. When it flows it always moves in the same direction (− to + for electron current), and at the same strength or amplitude. If a variable resistor is added in series with a dc circuit the current varies as the resistance value changes. This produces varying dc, or VDC. In radio circuits all power supplies produce dc. When this dc is fed to amplifiers or oscillators these circuits usually change the dc to VDC, or if the current drops down to zero periodically, it becomes pulsating dc, or PDC. The graphs of **fig. 8** illustrate dc, VDC, and PDC, in which the amplitude of the current or voltage is plotted (vertically) against time (horizontally). In (a), once the current or voltage starts it continues at the same amplitude. We sometimes call this smooth dc. In (b) the current or voltage varies periodically higher and lower. In (c) the current or voltage actually stops periodically, making pulses of dc. The pulses may be smooth-curve shaped, square-wave shaped, or saw-tooth shaped, depending on what is producing the pulsations.

Most radio circuits deal with dc (either VDC or PDC) and alternating current, or ac. Alternating current is produced by sources which have their EMF alternating from one direction to the opposite for some reason. For example, a transistorized oscillator circuit produces an output with an ac component as a result of the dc fed to it from its power supply. Any load on the oscillator will have current flowing through it in one direction for a fraction of a second, and then the current alternates and flows through the circuit in the opposite before alternating again. The current continues to alternate as long as power is fed to the oscillator circuit. Ac can be graphed as in **fig. 9.** In (a) two cycles of sinusoidal, or sine-wave-shaped, ac are shown. In (b) two cycles of square-wave ac are graphed, and in (c) two cycles of saw-tooth ac are shown. The ac that we will be most interested in at this time is sine-wave ac. This is the form taken by ac generated from radio oscillators, transmitters, by utility companies, and by electromechanical ac generators which are properly termed alternators.

In ac work a full cycle is considered as having 360 degrees. Therefore a half cycle will consist of 180 degrees, and a quarter cycle will have only 90 degrees, **fig. 10.** If the ac cycle is a perfect sine-wave, at 30 degrees (also 150, 210, and 330 degrees) the amplitude of the voltage or current will be exactly 0.5 of the maximum value. At 60 degrees (also 120, 240, and 300 degrees) the amplitude of the wave will be exactly 0.866 of the maximum, or peak value. You will find these 0.5 and 0.866 values in a Table of Natural Trigonometric Functions, or on a slide rule, or they may be obtained from more advanced pocket calculators. You can find sine values given for every tenth of a degree for the first 90 degrees. The second, third, and fourth 90-degree quadrants will have the same values as the first 90 degrees.

If all of the sine values for each degree of the first 90 degrees are added and this total is divided by 90, the average value of the sine-wave would result. For sine-wave ac this will always be 0.636 of the peak value. Can you see that the average value of a square-wave ac would have to be 1.0 or equal to the peak value? The average value is usually considered only in power supplies and in meters.

A much more important value is the root-mean-square, RMS, or effective value. The RMS comes from taking the square root of the average (mean) of the squares of the sine values for each of the first 90 degrees of the sine curve. This results in a factor of 0.707 of the peak value for sine-wave ac. This 0.707 factor is very interesting because it represents the equivalent dc voltage that would be needed to produce the same amount of heating in a resistor as it

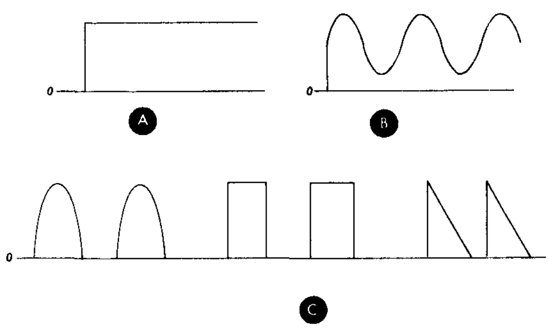

fig. 8. Various types of currents or voltages, (A) dc, (B) VDC, and (C) possible types of pulsating dc.

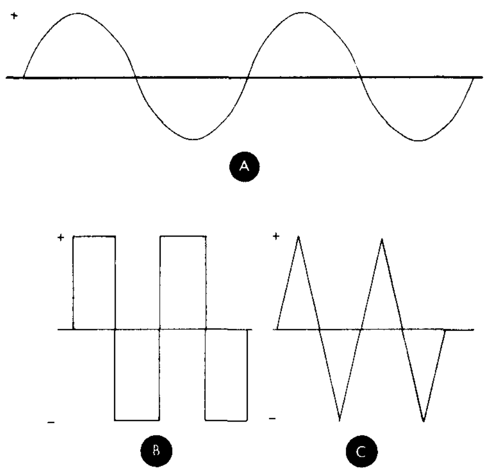

fig. 9. (A) Two cycles of sinusoidal ac. (B) Two cycles of square-wave ac. (C) Two cycles of sawtooth-wave ac.

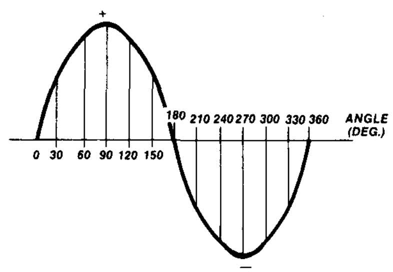

fig. 10. One cycle of sine-wave ac.

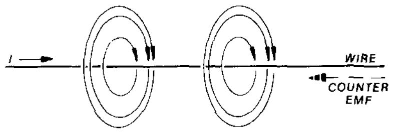

fig. 11. Magnetic field surrounds a current-carrying wire.

table 2. Frequency bands

audio frequencies	15 Hz to 20 kHz (kc)
power frequencies	50, 60, and 400 Hz (cps)
electromagnetic radiation (EMR)	
extremely low frequencies (ELF)	30 to 300 Hz
super-low frequencies (SLF)	300 to 3000 Hz
very-low frequencies (VLF)	3 to 30 kHz
low frequencies (LF)	30 to 300 kHz
medium frequencies (MF)	300 to 3000 kHz
high frequencies (HF)	3 to 30 MHz (mc)
very-high frequencies (VHF)	30 to 300 MHz
ultra-high frequencies (UHF)	300 to 3000 MHz
super-high frequencies (SHF)	3 to 30 GHz
extremely-high frequencies (EHF)	30 to 300 GHz

produced by the sine-wave ac voltage. For example, a sinusoidal 20-volt-peak ac voltage will produce the same heating effect as will *20 (0.707) = 14.14 volts dc*. The RMS, or effective value, puts dc and ac on an equal basis for many things. You will find that the 120-volt ac sold to you by your utility company is actually (1/0.707)(120), or 1.414 times 120 volts. It has a peak value of about 170 volts. So, if you want to insulate something to prevent your 120-volt RMS from sparking, it will be necessary that the insulation stand at least 170 volts, and preferably two or three times 170 volts.

Can you see that the RMS, or effective value, of a square-wave ac would be equal to the peak value, since the current or voltage is always at either the positive or the negative maximum value? Incidentally, the +100 volt peak of an ac cycle will give you just as bad a shock as a −100 volt peak will. The currents might be driven through you in opposite directions, but at the same effective or "ouch" value.

If an ac alternates 100 times a second it is said that the ac has a frequency of 100 cycles per second (cps), or 100 hertz (100 Hz). The human ear can hear sound waves developed by a loudspeaker being fed all frequencies from about 15 Hz up to about 20,000 Hz (20 kHz). Older persons, however, may have difficulty hearing above 12 or 15 kHz. The audible frequencies are called audio frequencies. Ac currents of between 15 Hz and 20,000 Hz are needed to produce air-wave vibrations of these frequencies, which the ear can recognize as sound. Dogs and other animals may hear sounds up into the 25 to 30 kHz range, sounds which are inaudible to humans.

Some of the common bands of frequencies are listed in **table 2**. Previously used abbreviations of kilocycles (kc) and megacycles (mc) are indicated.

Amateur Radio bands fill in the medium through extremely high frequencies bands. When we speak of "radio frequency" we mean rf frequencies from 10 kHz through 300 GHz (VLF through EHF). Microwaves are usually 1 GHz through 300 GHz.

inductance and transformers

Radio circuits involve dc sources, resistances, coils, capacitors, and transistors or vacuum tubes. A coil is just what its name implies, a piece of wire usually coiled around a tubular form made of an insulating material. It will be found that if a smooth dc current is flowing through a straight piece of wire, **fig. 11**, a stationary field of force will be developed around the wire. We can represent this magnetic field by drawing a few circular field lines around the wire. With the current flowing from left to right we indicate the field direction as coming out below the wire, passing upward on this side of the wire, passing over the top, and going down behind the wire. Arrowheads may be drawn on the field lines to indicate relative field direction, as shown.

If the current decreases, the field collapses back into the wire. As the current increases, the field expands further outward. The interesting thing about these expanding and contracting lines of magnetic force is that they induce a voltage in the wire as they expand and collapse. If the current is flowing from left to right and is increasing in amplitude, the magnetic field expands and induces a voltage of its own in the wire itself, but in a direction opposite to the source voltage and the circuit current direction. This reverse-direction induced voltage is called a counter-EMF. The counter-EMF acts to prevent a rapid current increase in the wire.

When the magnetic field collapses as current decreases, the counter-EMF is now developed in the direction of the current flow, tending to increase the circuit current. Whatever the current wants to do, the counter-EMF developed in a wire tries to counteract that effect.

If the wire is coiled, **fig. 12**, the field lines of each turn add together to form a concentrated field in the core of the coil. The end of the coil where lines of force emerge from the core is called the north pole (*N*) of the coil. Where the lines enter the core is the south pole (*S*) of the coil. The coil in this case can be called an electromagnet. An air-core coil's magnetic strength can be increased by a factor of thousands by winding the coil on an iron core or ferrite core (a powdered iron-oxide compound bound together with an insulating substance). The more turns and the more current, the more ampere-turns — and the *more magnetism developed in the core.*

A relay utilizes an electromagnet, **fig. 13**. A few volts and relatively little current applied to the coil creates a magnetic field that pulls down an iron armature, against the tension of its return-spring. This closes a circuit between points A and C. When the relay switch is opened the magnetic lines collapse back into the coil and the armature is pulled back upwards by the spring, breaking the contact between points A and B. Relays are used to open or close

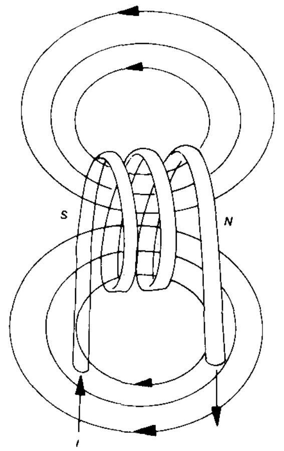

fig. 12. A coil becomes an electromagnet when current flows through it, developing north and south poles.

remote circuits, particularly when high currents or high voltages are involved.

The single armature and two-contact relay shown is called a single-pole-double-throw (SPDT) type. With only one contact, the relay would be a single-pole-single-throw type (SPST). With two armatures and four contacts, the relay would be a double-pole-*double-throw* (DPDT) type. *Both relays and switches* are made in SPST, SPDT, DPDT, as well as more complicated forms. A relay coil must be fed dc, VDC, or PDC for it to hold its armature down. If ac is used across the coil, the core will be alternately magnetized in one polarity and then in the other, which

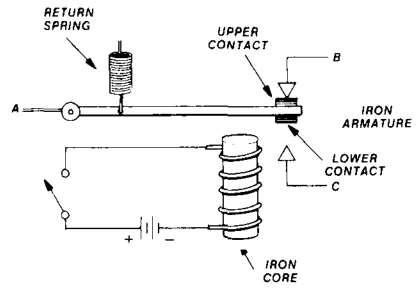

fig. 13. Essentials of a SPDT relay.

causes the armature to vibrate. However, if half of the top of the iron core piece is encircled with a copper ring, there will be an induced current in the ring that produces its own field which tends to hold the armature while the magnetic fields are alternating. This makes an ac relay.

Any wire or coil of wire is said to have self-inductance because it induces counter-EMF into itself. A coil is often referred to as an inductor. If an inductor has a 1-amp-per-second increasing current fed to it, and this results in 1 volt of counter-EMF, the inductor is said to have an inductance of one henry. The symbol for inductance is L, and the symbol for its unit of measurement, the henry, is H. Inductances used in radio may range from several henrys in choke coils to milli-, micro-, nano-, and picohenrys. They all store energy in their magnetic fields when current is flowing through them. When the current stops, the energy in the fields is returned to the inductor wires.

The straight-core, or solenoid, type of coils shown so far have a tendency to allow their fields to expand a considerable distance from them, causing interference with nearby circuit operations. This can be reduced by shielding the coils by placing them in aluminum cans. If the core is made in a toroidal (doughnut) shape, **fig. 14**, all of the field lines are essentially contained in the core material and there are no external lines leaking out into the surroundings. Many modern tuned circuits in radio equipment now use toroid coils, since they require no shielding.

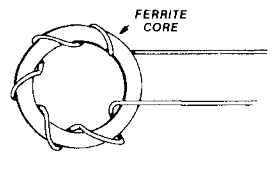

fig. 14. Toroidal inductor has minimal external field.

One of the important components in radio is the transformer. A simple transformer consists of two wires laid side by side, **fig. 15**. When the switch is closed, current flows in the "primary" wire, developing a counter-EMF in it. However, the expanding magnetic lines of force also induce an EMF into the "secondary" wire as they cross it. This produces a pulse of current through the load resistor across the secondary. When the switch is opened, the field around the primary collapses and in so doing induces an opposite-direction EMF in the secondary wire, and another pulse of current flows through the load resistor. Thus, one pulse of primary current produces one cycle of ac in the secondary circuit.

A much more efficient transformer has its primary and secondary wires wound on either a straight core or on a toroidal core, **fig. 16**. If the primary winding has 200 turns and the secondary has 400 turns, the transformer will step up the ac component of any voltage fed to the primary by a factor of two. We say the transformer has a voltage step-up ratio that is directly related to the number of turns on the primary and the secondary. If there are fewer turns on the secondary than on the primary the transformer has a step-down ratio.

The current ratio of a transformer is just the opposite of its voltage ratio. If there are more turns on the primary and fewer on the secondary, the secondary current will be greater than the primary. This is because the product of the primary E and I (remember, $P = EI$) will always be slightly more than the product of the secondary E and I, the difference being due to core losses and other inefficiencies. Since the power output can never exceed the power input, the power ratio is usually considered to be about 1:1 for all iron-core transformers.

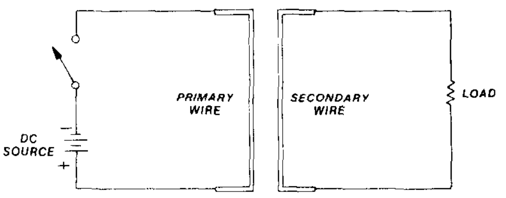

fig. 15. Simplest form of transformer.

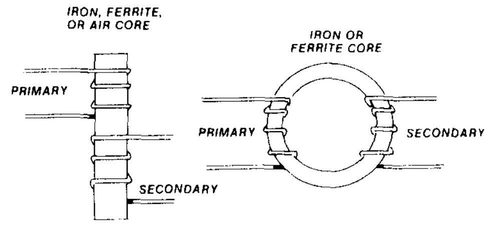

fig. 16. A more efficient transformer and toroidal transformer.

Power frequency and audio frequency transformers use laminated iron cores (made of multiple, insulated thin sheets) to reduce eddy current losses in the core. Their secondaries are usually wound right over the primary windings. Radio frequency transformers use air or, in many cases, ferrite cores to reduce hysteresis loss, which is an energy loss that results from the flipping over of magnetic iron molecules when the primary current alternates and remagnetizes the core in the opposite direction. Primaries and secondaries are usually separated slightly.

Iron-core inductors are used as choke coils in power supplies, making use of their ability to oppose any current changes. They produce a smoother dc from varying or pulsating dc. Air and ferrite inductors are used in radio frequency choke (RFC) coils, tuned circuits, and when coupled together, in rf transformers. Symbols for the various inductor applications are shown in **fig. 17**.

capacitance and capacitors

Capacitance exists whenever two conductors of any kind are separated from each other by some form of insulator. Two wires laying next to each other have a small capacitance between them. A component made to have capacitance is called a capacitor (originally called a condenser). A basic capacitor is shown in **fig. 18**. It consists of two metal plates separated, in this case, by air. When the DPST switch is closed, the top plate is connected to the negative terminal of the battery and the bottom plate to the positive terminal. Electrons rush through the lamp into the top plate, and electrons on the bottom plate are repelled and made to flow into the positive terminal of the battery. This charges the capacitor plates, and an electrostatic field develops between them.

If the capacitor is large and battery voltage is high enough, the charging current may pulse the lamp on for an instant. When the switch is opened, electrons will be trapped on the plate of the capacitor and it remains charged. If the left terminal of the lamp is now connected to the positive plate of the charged capacitor, a discharge current will flow through the lamp, possibly pulsing it on again for an instant. The greater the resistance of the lamp the slower the capacitor will charge and discharge.

The insulation between the plates, in this case air, is called the dielectric. It would be possible to draw lines across the dielectric to represent the electrostatic field, just as lines were used to represent magnetic fields. Magnetic and electrostatic fields are not the same, however, although both will be developed in all working radio circuits. Inductors store energy in their magnetic fields. Capacitors store energy in their electrostatic fields.

If a capacitor can store one coulomb of charge in itself when across 1 volt of EMF, it is said to have one farad (F) of capacitance. The farad is a very large value of capacitance. We usually use capacitors with microfarad (μF), or picofarad (pF) ratings in radio circuits.

Variable capacitors are usually made by using intermeshing plates. When the plates are completely intermeshed the capacitance is at its maximum. When the plates are completely unmeshed the capacitance is at its minimum. Usually, one set of plates is fixed in position; these are called the stator plates. The movable plates are called the rotors. Adjustable — as opposed to variable — capacitors depend on their plates being compressed together by screwdriver action.

If the air-dielectric capacitor shown in **fig. 18** has a sheet of mica, paper, ceramic, or plastic slipped in between the plates, the capacitor will store more electrons than it would otherwise, given the same source voltage. The capacitor will have greater capacitance because these new dielectric materials can accept more lines of electrostatic force than air can. Such dielectric materials are said to have a higher dielectric constant. Air has a dielectric constant of 1. Mica, waxed paper, and plastics have constants that are between 5 and 10. Ceramic dielectrics may range in the thousands. All of these capacitors will be nonpolarized. That is, they may be connected into a circuit without regard as to which leads are used where. They may be used in ac, dc, VDC, or PDC circuits, although paper capacitors are not used in circuits where the frequency is expected to exceed about 2 MHz.

Two high-capacitance types of polarized capacitors are electrolytic and tantalum capacitors. They are made of sheet aluminum plates held apart by some material and dampened in a chemical solution. When manufactured they are connected across a dc voltage or potential and the plates "form," developing an oxide on one of the plates. This oxide layer is very thin and has a very high dielectric constant. Such capacitors always carry a polarity marking (+) on one lead and must be connected in the circuit according to this polarity. If not, they will deform, heat, and burn out. These capacitors can not be used in ac circuits: only in dc, VDC or PDC circuits.

Fixed capacitors may be made in flat oblong or flat round shapes, or they may be in tubular form. They may have their leads emerging from the far ends. If made to be soldered into printed circuit (PC) boards, the leads will both come out the same side of the device. Capacitors range from tiny BB-shot size to the size of a small book.

Capacitors are used in conjunction with inductors in tuned circuits, both audio frequency and rf. Their ability to oppose any change in voltage allows them to be used to smooth (filter) varying or pulsating dc. They are also used to pass ac-effects without any direct connections, and are used to "bypass" ac energy to ground. Symbols of various types of capacitors are shown in **fig. 19.**

ham radio

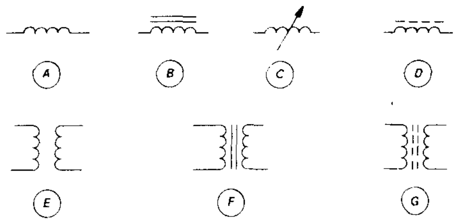

fig. 17. (A) Air-core coil. (B) Iron-core coil. (C) Variable air-core inductor. (D) Ferrite core inductor. (E) Air-core transformer. (F) Iron-core transformer. (G) Ferrite-core transformer.

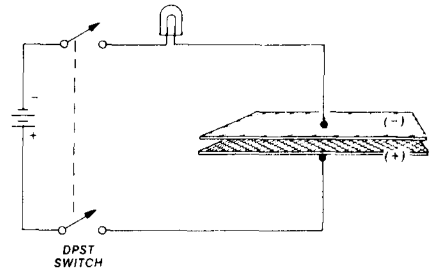

fig. 18. Basic air-dielectric, two-plate capacitor in charging circuit.

fig. 19. Symbols of (A) fixed capacitor, (B) polarized capacitor, (C) variable capacitor, (D) screwdriver variable capacitor.

More Details? CHECK—OFF Page 98

simplifying the multipurpose UHF oscillator

Some modifications making use of inexpensive and easy-to-find components

An earlier article[1] in *ham radio* described a low-power, voltage-tuned oscillator operating above 1000 MHz. It was designed primarily for use as a local oscillator in microwave television converters.

Two means of frequency control were described: 1) a free-running mode involving continuous tuning by means of a potentiometer, and 2) a phase-lock mode for click-stop tuning. These circuits are incapable of producing the degree of waveform coherence in a UHF oscillator for narrowband systems involving CW and SSB. In the free-running mode the circuit *Q*s are too low, and in the phase-locked-loop mode switching noise and oscillator subharmonics generated by the prescaler produce too much phase noise. In either case, however, the spectrum is clean enough for microwave TV applications.

By using more sophisticated circuitry it's possible to provide almost any degree of spectral purity. These advanced circuits are based on the oscillator described here and will be the subject of a future article. They will allow Amateurs to use CW and SSB modes in the microwave region as we do today on the high frequency-bands.

In developing the original UHF oscillator, I paid very little attention to component parts cost. I used parts on hand. Typical of this extravagance are the Plessey prescalers, which together cost about $40.00. Other examples are the tuning diode and the HP35821 transistor, which cost about $25.00 and $15.00 respectively in small quantities. Few can afford the luxury of such expensive components; those who can may find them difficult or impossible to procure in small lots.

The development work that followed my original effort was dedicated to *simplification and cost reduction.* These goals were to be met without sacrificing performance. Also all components were to be readily available in small quantities.

modifying the UHF oscillator

Much effort went into developing the circuit changes and making the modifications to meet the design goals. While the original electrical circuit configuration was retained, I made major changes to the PC board to accommodate new components. Those that were changed include the oscillator transistor, tuning diode, prescaler, and voltage regulator. Also, the PC board was scaled down in size to fit inside an inexpensive and readily available enclosure.

component changes

I used a Motorola MRF-901 high-frequency plastic

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transistor to replace the more expensive HP-35821 to help meet the design goals. While the MRF-901 is specified primarily for use as a low-noise amplifier and switch, it also performs very well as an oscillator. This transistor has become very popular with Amateur experimenters because of its favorable performance characteristics and modest cost in small quantities. It has a typical f_T of 4.5 GHz with 15 mA collector current. Although the pinout is intended for common-emitter circuits, I designed the UHF oscillator PC board to accept this configuration without difficulty.

A Motorola MV2201 plastic 6.8-pF tuning diode (70 cents in small lots) has replaced the expensive and hard-to-find GC type 1607 diode. The capacitance tolerance of this diode is 5.5-8.0 pF at 4.0 volts bias. The MV2101, which sells for about $1.25 and has a lower tolerance of 6.1-7.5 pF, can also be used.

The Q of the MV2201/2101 is low compared with that of the more expensive devices. Theoretically, a small amount of oscillator power that would otherwise be available at the rf output jack replaces the tuning-diode loss. Despite this drawback, this modified UHF oscillator described here easily provides 10 mW of rf output power. Thus, modest tuning diode Q is an acceptable compromise.

An RCA CA3179G 1.25-GHz prescaler replaces the more expensive Plessey types. The 3179G costs less than $10.00 each in small quantities. The RCA CA3163G, which has an identical pinout, is a suitable substitute. These prescalers divide by 256 when connected in the UHF mode.

The modified prescaler circuit is less comlex than the original one. It uses fewer components, and expensive 0.1-watt resistors have been eliminated.

The Plessey prescalers used in the original UHF oscillator[1] provided division by 40. It was recommended that an external divide-by-25 circuit be added to allow a counter to display, in kHz, the oscillator frequency in MHz. In retrospect, while the divide-by-40 circuit was a novel idea, it offered nothing in terms of oscillator performance that would justify the high cost of the prescalers. For experimental purposes, the CA3179G, which divides by 256, together with a simple conversion chart or hand-held calculator, will do just as well. Therefore, in keeping with the goal of availability and reduced cost, I decided to use the CA3179G prescaler.

You can get along without the prescaler if you have access to a digital counter that operates to about 1400 MHz. In most applications it's not necessary to display the oscillator frequency continuously, but it's useful to have the prescaler available for tune up and frequency adjustment. In my design I included a switch to disable the prescaler when not in use.

There are several reasons why I added this switch. First, I found that careful shielding was necessary to prevent small but measurable amounts of subharmonic signal power, generated by the prescaler, from appearing at the rf output jack.

Another reason for the switch is to reduce drift of the oscillator. The prescaler dissipates 325 mW of power, and 455 mW more is dissipated in the 5.0-volt series-pass regulator. The oscillator's frequency stability is considerably improved when the prescaler is inoperative; otherwise, over a period of time, the additional 780 mW of heat increases the temperature of the oscillator module and causes some frequency drift. The component most affected by temperature changes is the tuning diode.

Two voltage regulators, an MC78L12 and an MC78L05, are connected in series to provide regulated +12 and +5 volts. These regulators have become very popular with Amateur experimenters because they are inexpensive and available in small quantities. Originally the +12 volts was supplied by a 723 IC, and a separate negative supply was needed for the prescalers. The modified UHF oscillator unit requires only a single positive supply voltage of between +15 and +19 volts at a current of about 100 mA.

The enclosure for the modified UHF oscillator consists of a RACO 11.5-cubic-inch (188.4-cm^3) extension box (92 cents) at hardware stores. The RACO box is made of welded steel and is normally intended for electrical house wiring purposes. Experience has shown that the PC board containing the UHF oscillator should be mounted inside of a rigid electrostatic enclosure. At UHF, fm microphonics may occur if the box is not rigid; furthermore, a good rule is to make the box rf tight to avoid the unpleasant consequences of rf leakage.

The RACO box meets these requirements. It measures 1-1/2 inches (38 mm) high, 2 inches (50 mm) wide, and 4 inches (102 mm) long. It is open both at the top and bottom. A flat 0.074-inch-thick (1.9-mm) aluminum plate 2-1/8 × 5-5/8 inches (54 × 143 mm) is attached with four screws to the bottom of the box. Matching holes, drilled into the bottom of the box, are tapped for 4-40 (M3) screws for that purpose. The plate extends out 5/16 inch (8 mm) from the box on each side where 1/8-inch (3-mm) holes are drilled to provide means for mounting. The top of the RACO box is fitted with a 0.020-inch-thick (0.5-mm) aluminum cover with 1/4-inch (6.4-mm) flaps turned down on all four sides. Except for the oscillator line and grounding shims to be described, the top and bottom covers are the only two sheet metal parts that need to be fabricated. These relatively simple parts are illustrated in **fig. 1**.

the oscillator line

The mechanical details of the oscillator line L1 are shown in the original article and therefore will not be duplicated here. However, the line should be shortened from 2-1/16 inches (52.4 mm) to 1-3/4 inches (44.5 mm). This is necessary to compensate for the parasitic (lead) inductances of the inexpensive MV2201 tuning diode.

assembly procedure

You can make the PC board yourself from the full-scale patterns shown in **fig. 2** or obtain them from Rock Engineering Supply Company, Inc., 1769 Armitage Ct., Addison, Illinois 60101. Another option is to procure a kit of parts including the PC board from RadioKit, Box 411, Greenville, New Hampshire 03048.

In simplifying the UHF oscillator, the expensive feed-through capacitors have been eliminated. All bypass capacitors are ceramic disc types except for C6, which is a 24-pF dipped mica. The schematic diagram is shown in **fig. 3**. C6 is soldered directly on the foil side of the board with extremely short leads. The original article describes how to prepare this capacitor before installation.

It is recommended that parts be assembled on the component side of the board first, including the voltage regulators, prescaler, the 2N5179 transistor and associated parts. Next, oscillator line L1 should be mounted on the foil side of the board. The pointed end of this inductance fits into the insulated hole near the MRF-901 transistor. The other end of L1 is supported by a 3/32-inch-thick (2.4-mm) epoxy fiberglass shim. Apply two-part, five-minute epoxy glue sparingly to the shim and each end of the line to secure them in position.

mounting the varactor tuning diodes

Because the MV2201 is equipped with wire leads, solder should be applied as close to the plastic body as possible to minimize lead inductance. The anode is soldered to the large pad under the oscillator line, while the cathode lead is bent at a right angle and soldered to the top of the line. **Fig. 4** shows the installation of the diode. For operation at approximately 1100 MHz, the tuning diode should be soldered to the oscillator line at 1-1/4 inches (31.8 mm) from the collector end of the line.

mounting the PC board in the enclosure

The PC board is mounted in a RACO box about 1/2 inch (12.7 mm) from the top. It is held in place by

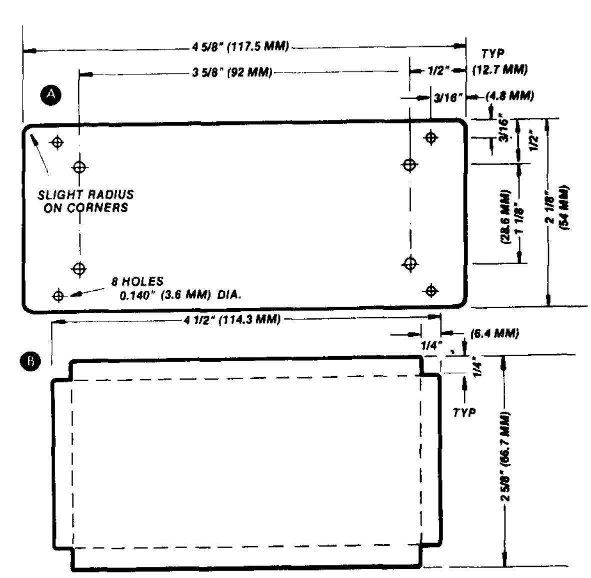


fig. 1. Construction details of the bottom plate and cover, (A) and (B) respectively, used with the UHF oscillator enclosure. Material is aluminum stock, 0.074 inch (1.9 mm) thick for the bottom plate and 0.020 inch (0.5 mm) thick for the cover. Flaps should be bent around a RACO box to form a tight fit.

means of L-shaped spring-brass shims soldered to the top and bottom of the rf output edge of the board. These shims also serve as rf grounds. I used scissors to cut my shims from a discarded piece of weather stripping; then I bent them at an angle of about 120 degrees using a bench vise as a makeshift brake. The dimensions of the L are 1/8 × 1/2 inch (3.2 × 12.7 mm); the small dimension is soldered to the board. The board is secured in position by means of 4-40 (M3) screws through both the wall of the box and the shims.

There are two holes located at the rear edge of the board, which are intended for through-grounds. Insert a short piece of tinned copper busbar in these holes, fold over and solder on each side.

operating frequency range

I built the modified UHF oscillator primarily to operate at its fundamental frequency in the range between about 1100 and 1200 MHz. However, by adjusting the position of the tuning diode on the line, the range can be moved up or down as in the original design. It's also possible to use frequency multipliers for higher-frequency operation, as described in the original article.[1]

output coupling

The output-coupling circuit is similar to the original one; however, a 3/16 inch-diameter (4.8 mm) powdered iron slug inserted in the output coupling loop and screwed to the board has been added to increase the coupling. The slug acts as a magnetic dipole, which aids the output current in the loop. Although it may seem surprising, carbonyl C iron made by Cambion (Cambridge Thermionic Corporation), which is normally intended for use at much lower frequencies, gave very good results. Power output was measured to be in excess of 10 dBm with the slug.

The rf coupling loop is formed from 3/16-inch (4.8 mm) wide 12-mil (0.3 mm) shim stock. The rf output jack should be mounted in a 3/8-inch-diameter (9.5 mm) hole centered on the middle knockout. The rf coupling loop terminates on the large pad under the BNC connector. The pad acts as an rf bypass capacitor and also allows dc power to be brought into the box by way of the coaxial center conductor.

To ensure a good rf output termination, a 3/16-inch-wide (4.8 mm) piece of copper foil is soldered to the flat on the threaded portion of the BNC connector. The other end of the copper foil is soldered to the ground foil on the edge of the PC board under the BNC connector. It is important that this ground foil be made as short as possible.

test and adjustment

Provisions have been included on the PC board to monitor the MRF-901 collector current for tune-up purposes. Temporary leads should be tack soldered to the doughnuts on each side of the gap in the PC conductor leading to the + 12V oscillator pad. When the adjustment is complete, a jumper will be soldered across this gap, as illustrated in **fig. 4**.

The feedback capacitor, not shown, is made of 1/8-inch-wide (3.2 mm) copper foil. One end is soldered to the emitter, while the other end extends out over the top of a 1/32-inch-thick (0.8 mm) epoxy fiberglass insulator cemented with epoxy to the top of the oscillator line. See **fig. 4** for details.

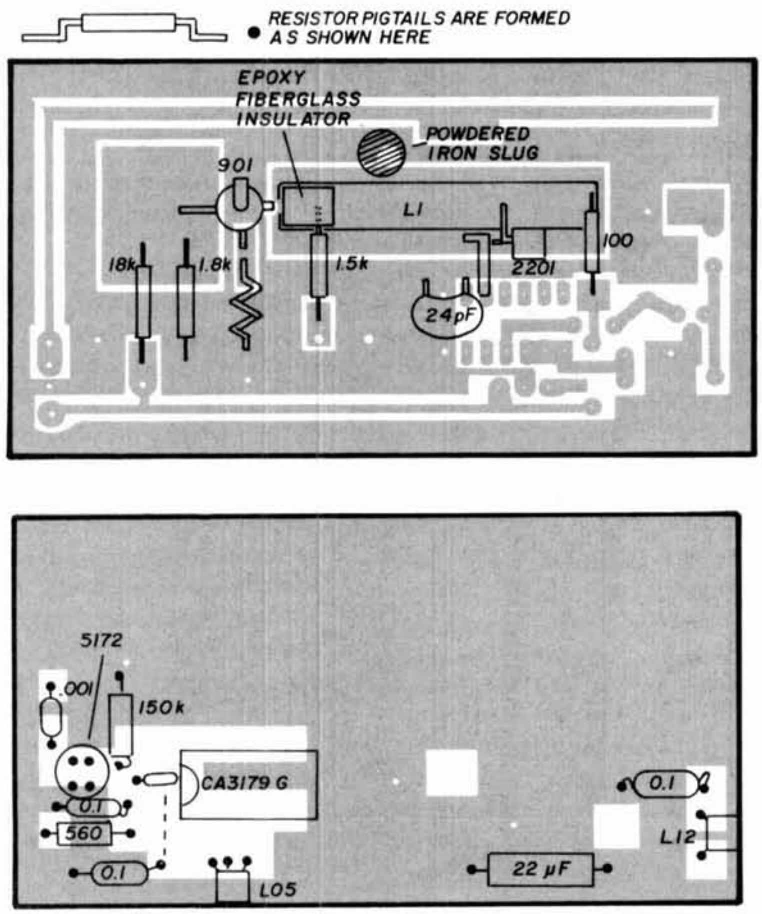


fig. 2. Printed-circuit board layout. The foil side is shown in (A); component side in (B).

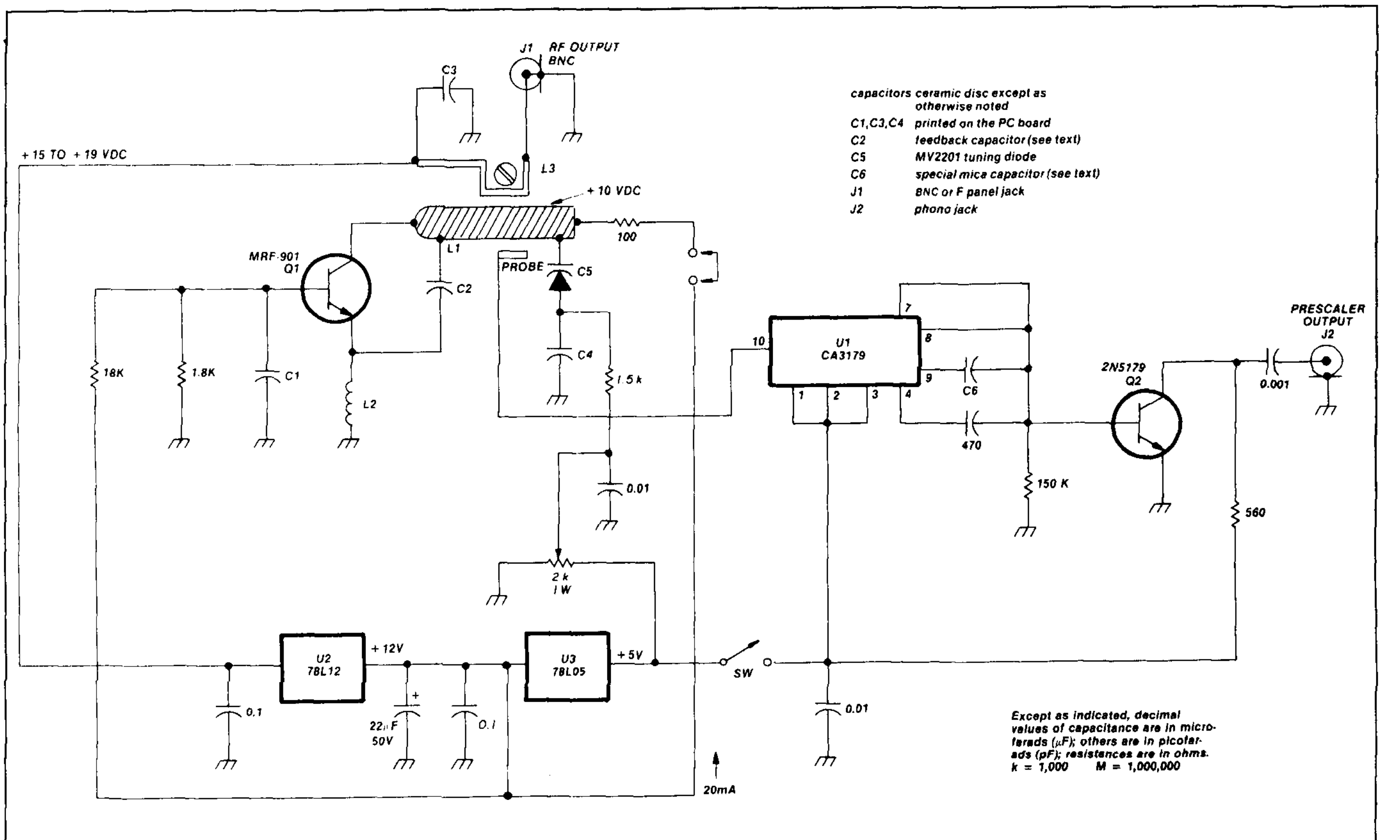


fig. 3. Schematic diagram of the improved UHF oscillator. The more expensive oscillator transistor, tuning diode, and prescaler used in the original circuit have been replaced with the components shown. Oscillator line L1 in the original design has been shortened from 2-1/16 inches (52.4 mm) to 1-3/4 inches (44.5 mm).

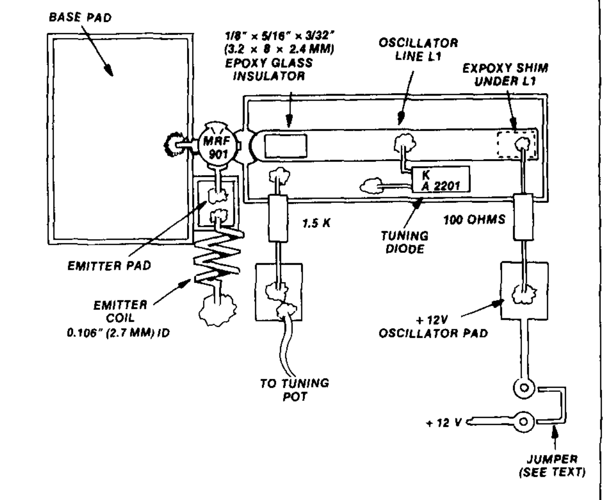
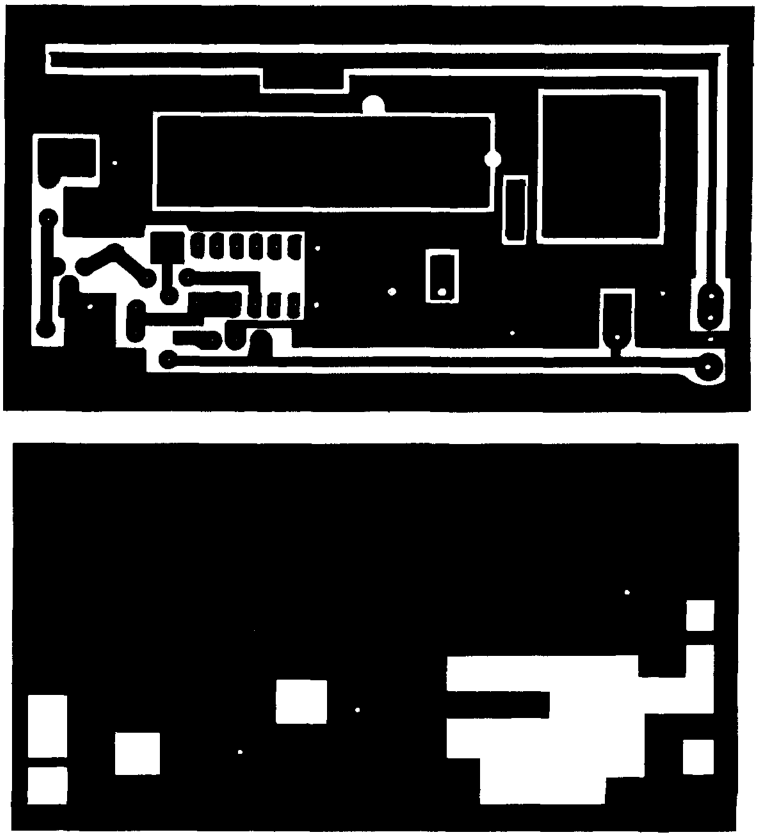


fig. 4. Details of oscillator assembly. Feedback capacitor C2 in fig. 1 is made by bending the unused emitter lead of the MRF-901 up and over the top of the transistor. A 1/4 × 1/8 inch (6.4 × 3.2 mm) piece of copper foil is then slid under the emitter and over the epoxy insulator and soldered to the emitter. (This capacitor is not shown in the drawing. See text for adjustment.)

tune-up procedure

The procedure for tuning up the MRF-901 is somewhat different than for the HP35821B transistor used in the original model. First of all, a 100-ohm current-limiting resistor (which also acts as an rf choke) tends to maintain a relatively constant collector current. The 1.8k and 18k biasing network should set the collector current between 15 and 20 mA for most MRF-901s. *Do not* permit the collector current to exceed 30 mA. To reduce the collector current, increase the value of the 18k resistor to 20 or 22k as required.

The oscillator frequency is highly dependent on the capacitance between the emitter and collector. To adjust frequency, set the tuning pot output voltage to zero (12 volts tuning-diode bias). Connect a counter to the prescaler output jack; adjust the value of the feedback capacitor until the oscillator frequency is equal to the desired high-end frequency. Either clip the foil or bend it back on itself to increase frequency. Note that the counter readout corresponding to a frequency of 1100 MHz should be 4.2969 MHz. After making this adjustment, apply a very small amount of epoxy cement to the feedback capacitor to secure it to the epoxy insulator.



Etching pattern for the printed-circuit board.

The tuning range of the modified oscillator is smaller than with the original model — about 3 percent of the center frequency instead of ten percent. This is due primarily to the relatively high capacitance of the tuning diode. This range may be increased by using two tuning diodes in series.

The tuning range of the new oscillator has deliberately been reduced to permit use of a single-turn instead of ten-turn tuning pot. This is in keeping with the goal of cost reduction.

You may want to provide means to tune the UHF oscillator from a remote location. If so, remove the tuning pot and insert a phono jack in its place. Connect a 470-ohm, 1/4-watt resistor from +5 volts to the junction of the 1.5k resistor and the 0.01 μF bypass capacitor. Then connect the junction to the center conductor of the phono jack. The 2k pot can then be located at the far end of a shielded cable. Solder a phono plug on the near end.

conclusion

The UHF oscillator as described in reference 1 leaves something to be desired in terms of component cost and availability, which explains the reason for further development. Although its performance is outstanding in most respects, the original model was complex and difficult to construct. Also there was measurable rf leakage because some of the components were not totally shielded. Nevertheless, it proved to be a good starting place.

The modified UHF oscillator overcomes the problems of the original unit while retaining its good points. Because the RACO box is rugged and provides full shielding, stability and drift are negligible by comparison. For example, the warm-up drift of my modified oscillator operating in the free-running mode measured 650 kHz. After stabilizing in four minutes from a cold start, the frequency drifted only 0.06 percent at 1100 MHz. When buffered with a 3-dB pad, the effect of changing the load from a short to an open circuit through all possible angles caused a frequency change of less than 1.5 percent. Finally, despite the fact that the MRF-901 has less power-handing capability than its predecessor, it delivers a full ten milliwatts into a 50-ohm load.

Without compromising the important performance characteristics, the UHF oscillator can now be constructed easily with components that are readily available at a fraction of the cost of the original unit. The design goals specified at the beginning of this article have been met.

reference

1. Norman J. Foot, WA9HUV, "A Multipurpose UHF Oscillator," *ham radio*, December, 1980.

ham radio

ham radio TECHNIQUES

Bill Orr, W6SAI

Making a crystal from a pair of eyeglasses! From time-to-time I receive interesting letters based on material in this column, and I'd like to share some of them with you.

G.W. Thomas, G5YK, of Suffolk, England, writes, "I was very interested to read your April issue...on 10 meters.

"I was also on 10 meters in those days and the first India-Europe contact was made on February 10, 1929: I established contact with VT2KT on that day using about 50 watts.

fig. 1. Charlie Atwater, nu2JN, and his pioneer 10-meter transmitter. Charlie's 1928-1929 experiments helped open this new Amateur band. Using a UX-210 driving a UX-852, Charlie's transmitter delivered about 80 watts into a Zeppelin antenna. Unfortunately, the sunspot cycle was on the downward trend. After a few exciting months 10 meters went dead, and interest lapsed for nearly eight years.

"I was also fascinated in the making of a crystal from a quartz slab. The price of a crystal in those days was more than my weekly wage, so I found a way of making one cheaply and with less effort. From an optician's shop I bought old quartz spectacle lenses and slowly and painstakingly ground them down to 80 meters. They were marvelous, and a friend (then G5YX) and I had a little business going as a sideline for a short while. Oh, those were the days!"

Charles Atwater, W2JN

A real old timer passed away a short time ago: Charlie Atwater, W2JN. Located in Upper Montclair, New Jersey, Charlie established the first-ever, 10-meter transatlantic QSO, with ef8CT in France. Ten meters had until then been considered a worthless band. W2JN exploded this idea around 1928 with a *two-hour, 100-percent contact*. Using an experimental license, Charlie made this record before the 10-meter band was opened for general Amateur use. The nu2JN transmitter (**fig. 1**) is an eye opener today! Doesn't look much like a Kenwood, does it?

W1BVL was there!

A note from Dick Briggs, W1BVL, says, "Your article in the April, 1981, *ham radio* was of great interest to me, particularly your description of W1XM's 10-meter crystal-controlled transmitter of 1928. The four-tube driver unit using 201A tubes was built and used for my thesis at MIT in May, 1927. In 1928, a year after my graduation, the unit was used as described by Howard Chinn in November, 1981, *QST* magazine.

"At that time little was known about frequency doubling with vacuum tubes. My thesis made an analysis of the operating parameters. Also it was found that frequency changers could be made somewhat regenerative to enhance the gain per stage.

"My first DX QSO on 10 meters was with Bill Eitel, W6UF, on October 21, 1928, at 3:40 pm, EST. My transmitter was a tuned-plate, tuned-grid (TPTG) oscillator with a UV-203A with about 80 watts input from a chemical rectifier. The antenna was 70 feet long slanting up from 30 feet to 55 feet and a counterpoise wire slanting down from 30 feet to 8 feet.*

"All the above brings back memories of those old times. I am now a retired vacuum-tube engineer and do consulting on microwave magnetrons."

the final word on 10 meters

George Elliott, W6ENC, sends the final word on 10 meters — a beautiful copy of the *Ten-Ten International Net* bulletin celebrating 50 years of 10-meter activity. The complete story of the famous nu2JN contact is in the bulletin, plus many other articles of interest to the 10-meter operator. The *Ten-Ten International Net* monitors 28,800 kHz daily except Sundays and publishes an interesting quarterly bulletin, chock-full of articles of interest to 10-meter ops. Full information on the net and the bulletin can be ob-

*Also known as the "up and out" antenna — a version of the sloper. A popular antenna of the 1930s was "40 up and 40 out." Sometimes the counterpoise was run close to the ground and was called a "worm warmer." It also warmed people who came in contact with it. **Editor.**

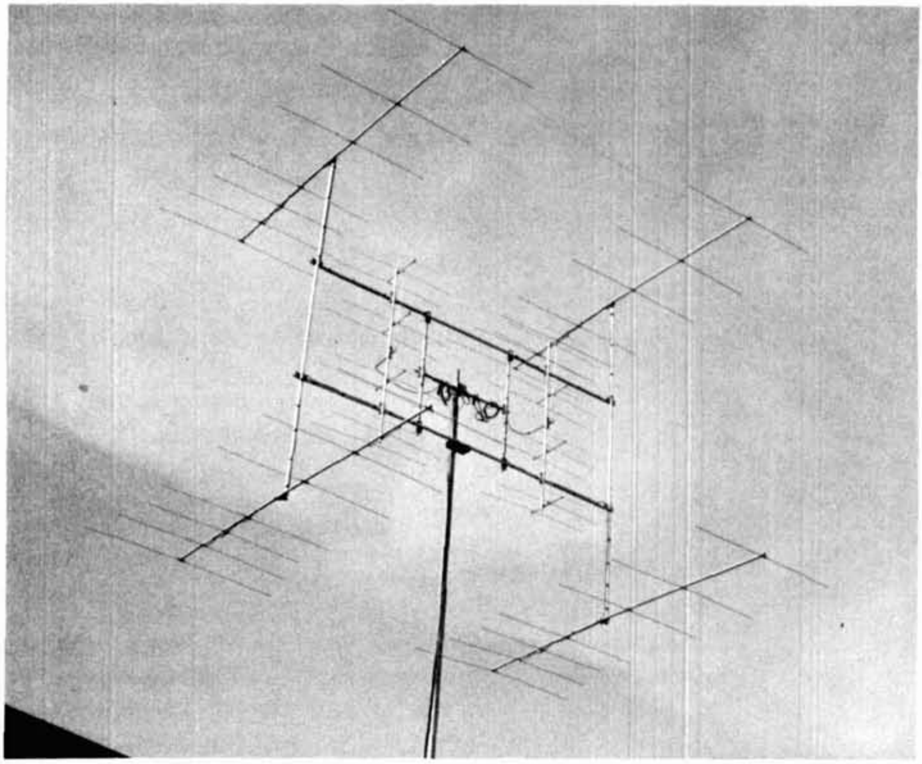


fig. 2. This photo explains why K6QXY has such a robust signal on 6 and 2 meters. The 6-meter array is composed of four seven-element KLM LPY Yagi antennas. Inside the array is the 2-meter beam, which consists of two twenty-element expanded collinear arrays.

tained from W6ENC, George Elliott, whose QTH is 942 Victoria Drive, Arcadia, California 91006. I would imagine that two postage stamps included in your letter to George would help.

To become a member of *Ten-Ten* you have to work some of the present members on 10 meters. I'm sure George can bring you up to speed on that, too.

how to be LOUD on 6 and 2 meters

Have you ever heard the ear-splitting signal of Bob Magnani, K6QXY, on 6 or 2 meters? No? Then you must be off the air. Bob has an outstanding signal, and the pictures he sent me tell why. **Fig. 2** shows the present installation, which consists of four seven-element KLM LPY Yagi antennas spaced one wavelength apart for 50 MHz. Estimated gain over a dipole — about 17 dB. Inside the 6-meter array is the 144-MHz array, which consists of two twenty-element expanded collinear arrays providing about 16 dB gain over a dipole.

Fig. 3 shows Bob's new antenna project, which seems to me to be comparable to building the pyramids of Egypt. This shows the base assembly for his new moonbounce antenna. It consists of three *Rohn* 25 towers in a triangle, 10 feet (3 meters) on a leg. In the center of the triangle is a stressed steel and concrete sub-base that has 6 cubic yards (4.6 cubic meters) of concrete in it, going down 10 feet (3 meters). The top pour, which will cover the excavation, will have 17 cubic yards (13 cubic meters) of concrete in it, for a total of 23 cubic yards (17.6 cubic meters). Two towers will go up about 80 feet (24 meters), tied together every 10 feet (3 meters). An antenna, steerable in azimuth and elevation, will go at the top. It is planned to have eight seven-element KLM LPY antennas providing a power gain of about 21 dB, with six-

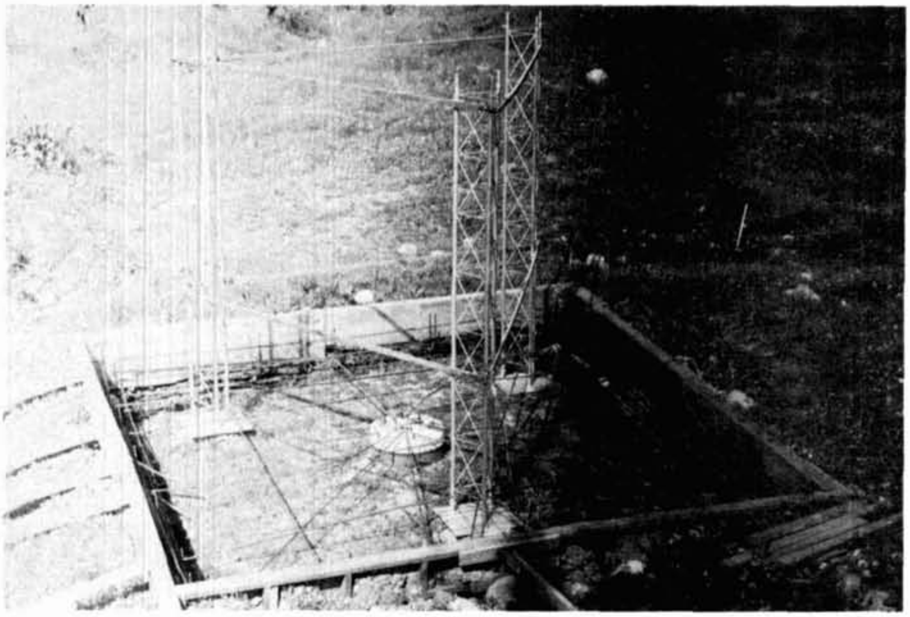


fig. 3. The base for K6QXY's new moonbounce antenna consists of three lattice towers arranged in a triangle. The first sections are up in the photo. The towers will go up to about 80 feet (24.4. meters), tied together every 10 feet (3 meters). Twenty-three cubic yards (17.6 cubic meters) of concrete will be poured into the base.

teen fourteen-element "Junior Boomers" for 144 MHz nestled inside the bigger antenna. This will provide about 25 dB gain on 2 meters.

So if you haven't heard K6QXY yet, you soon will!

a long wire antenna for field day

"Wait until next year!" That's the cry of the *Field Day* enthusiast. And sure enough, the antennas for 1982 will be bigger and better than those used in 1981 for portable work.

Bob Walton, W6CYL, has the perfect scheme for getting a longwire antenna up in the air with a minimum of fuss and bother. He uses an arm-brace slingshot. This is a device that has a lightweight aluminum frame mounted at the bottom of the vertical handle, which rests back on the forearm and reduces the force on the handle when you draw back on the rubber tubing bands for a long shot into a tall tree.

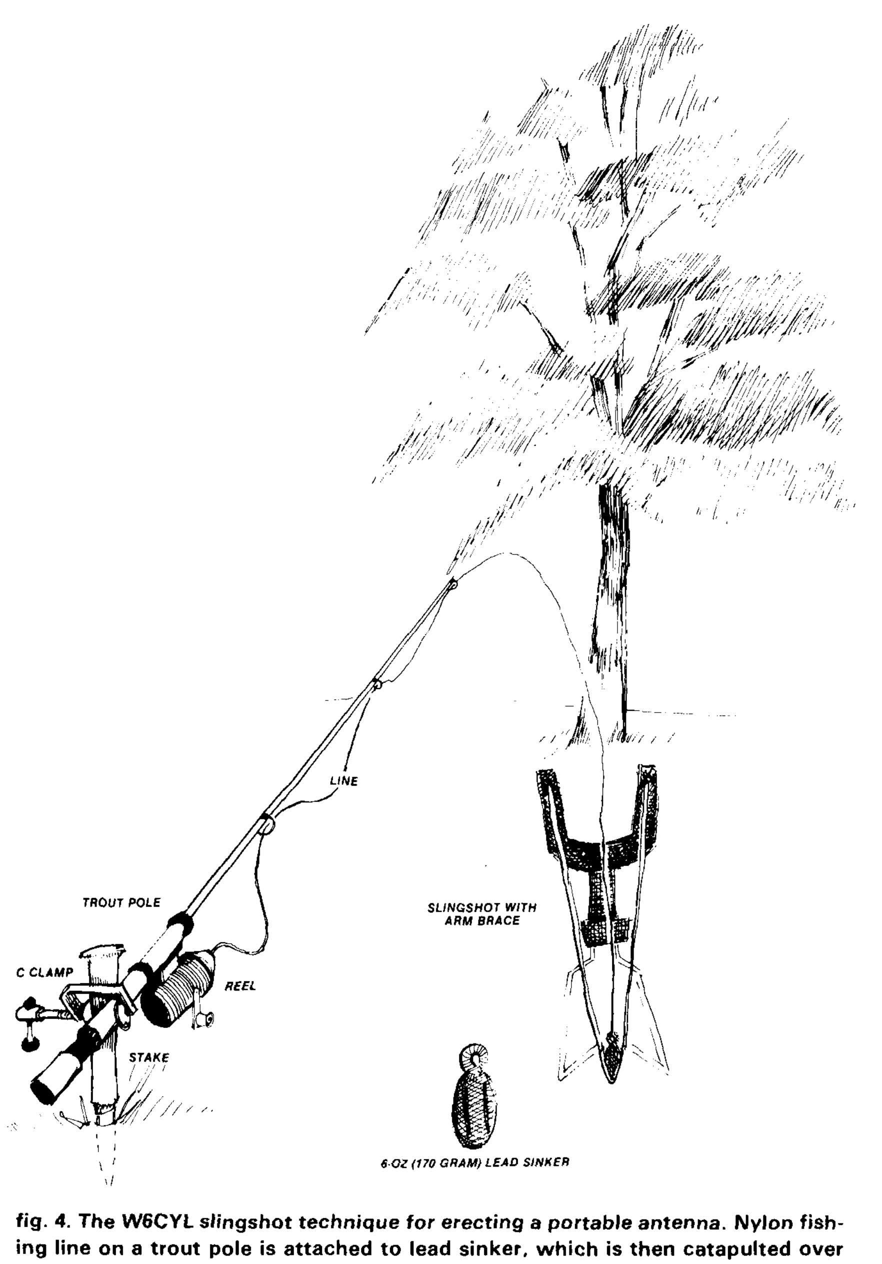


fig. 4. The W6CYL slingshot technique for erecting a portable antenna. Nylon fishing line on a trout pole is attached to lead sinker, which is then catapulted over nearby trees using an arm-brace slingshot. Bob prefers this to the bow-and-arrow technique. Try it out next Field Day.

Bob places a 6-ounce (170-gram) fishing line sinker on a heavy monofilament nylon line wound on the reel of a take-apart Japanese-imported trout rod. This setup will take about 200 feet (60 meters) of line. Bob mounts the pole and reel on a ground stake and releases the drag on the reel. Then, with the sling shot, he shoots the sinker up and over a tree using the fishing line as a messenger cable to pull up a longwire antenna. He puts an egg insulator on the end of the antenna wire so that he can see when the end is getting near the tree leaves and branches.

Bob has also tried the bow-and-arrow technique of shooting an antenna into a tree. He says that works, too, but it requires more expertise to spot the antenna wire where you want it. Bob says that you can buy a reel of braided copper antenna wire (part number AS-207/CRT-3) at Fair Radio Sales, Box 1105, Lima, Ohio 45802.

After he gets the monofilament line safely up into a tree, with the sinker down at ground level, he attaches the braided copper wire to the line, unreels the wire and pulls in the sinker and line. Up she goes! When he's finished operating, he releases the fishing line from the tie-down at ground level, and reels in the braided copper wire. In the event of a snag, he pulls on the wire and the nylon line breaks, freeing the balance of the wire.

Bob says, "Operating from a trailer, as I often do, requires searching for a parking spot that will permit a longwire antenna. Here, trees are ham's best friends. And when you put up the antenna, stand by for a rash of CBers who descend upon you with all kinds of questions. Some even report inventing radio and the thrill of working skip, etc.!" Bob shows how it's done in **fig. 4**.

the 2-meter quad at K3AC

K3AC, Malcolm Williams, lives in a high-rise apartment, as do many other Amateurs. The building frame is steel, and the use of an indoor antenna is out of the question. But K3AC puts out a powerful 2-meter signal with the aid of his portable four-element quad antenna. In a matter of minutes the quad can be assembled and placed onto the porch. And in bad weather, the quad can be used indoors, shooting out through the sliding glass doors (**fig. 5**). Dimensions for a quad of this type, cut to 146 MHz are: reflector loop, 21-1/2 inches (54.6 cm) on a side; driven element loop, 20-1/4 inches (51.4 cm) on a side; two director loops, each 19-1/4 inches (49 cm) on a side. Reflector-to-driven-element spacing is 16 inches (40.6 cm); driven-element-to-director spacing is 13 inches (33 cm). Spacing between directors is 13 inches (33 cm).

For vertical polarization the driven loop is broken in the middle of one vertical side and fed with a random length of RG-58/U coaxial line. The line is brought back to the boom and then run down the supporting mast. For horizontal polarization, the driven loop is broken in the middle of the bottom for the coaxial line. The reflector and director elements are the same in either case; they "don't know" the polarization of the driven element!

A duplicate of this quad beam is easy to build. The boom can be a 4-foot (1.2-meter) length of 1-inch (2.54-cm) diameter wood dowel rod, varnished to protect it from the weather. The loops are built from lengths of 1/4-inch (0.6-cm) diameter wood dowel rods, fitted into holes drilled in wood blocks. The blocks, in turn, are drilled to press-fit over the boom. The loops are made of No. 20 (0.8 mm) enameled wire.

To space the loops properly on the X-frame, the wire can be temporarily positioned with the aid of short pins pushed into the dowel rods. Once the position of the wires has been determined, the dowel tips are drilled to pass the wire element. The loop is made taut by pulling the dowels out of the holes in the center block a bit before epoxy cement locks the dowels to the block.

The array is collapsed by sliding the loops off the dowel boom. For a more portable affair, the loops themselves can be made to collapse.

There's no reason the vertical mast can't be lashed to the balcony and rotated by hand. K3AC mounts his quad on a small case, which provides a base and container for the quad when it is not used.

fig. 5. The compact 2-meter quad at K3AC is ideal for the apartment dweller. Sometimes Mal uses it indoors, shooting the signal through the sliding-glass doors. See text for dimensions and construction details.

what about your antenna?

Do you have an interesting antenna? Send me a description of it and if it appears in this column, *ham radio* will send you a free, one-year subscription to this magazine (or extend your subscription for a year if you already have one). Send your material to me, care of the magazine (address on the contents page 3 of every issue).

ham radio

the half-wave vertical

A 40-meter DX antenna without a radial-wire ground system

A current-fed vertical antenna, such as a quarter- or five-eighths-wavelength monopole, must have a radial-wire ground system for maximum efficiency.[1-3] This is known as a groundplane.

the groundplane

What is the purpose of this groundplane? Will it provide the low-angle radiation necessary for working distant stations? The radial-wire ground system under the antenna must provide a low resistance to reduce ohmic losses in the system. The ground-loss resistance, referred to the base of the antenna can, by a groundplane, be made low with respect to the system radiation resistance. For a quarter-wave vertical the radiation resistance is approximately 36 ohms. The radiation efficiency is therefore high. The radial-wire groundplane system is therefore important, since the length and number of radials, as well as the conductivity of the ground, determine this terminal loss resistance.

The parameters of the antenna, however, to launch sky waves at low angles above the horizon extend to distances well beyond the antenna and its ground system. *In fact,* the conductivity of the ground, fifty or more wavelengths from the antenna, is important in that it influences the vertical radiation pattern of the antenna. And this effect is significant, especially for launch angles of less than 10 degrees above the horizon.

Fig. 1A shows the theoretical vertical radiation pattern for a 6-MHz quarter-wave antenna over poor, good, and very good ground (sea water). The pattern for an antenna over very poor ground, but with an extensive ground system,[4] is shown in **fig. 1B**. It is clear that, while the radiation efficiency of the antenna is improved by using a ground screen, the power gains for elevation angles less than 10 degrees becomes vanishing small.

the half-wave antenna

An alternative approach is to use a half-wave radi-

By John S. Belrose, VE2CV, 3 Tadhoussac Drive, Aylmer (Lucerne), Quebec, J9J 1G1, Canada

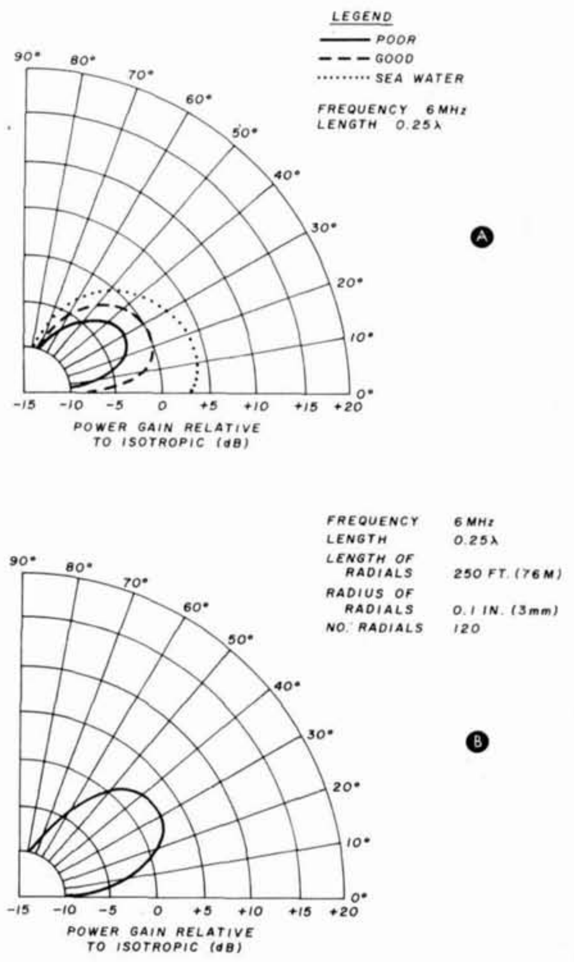
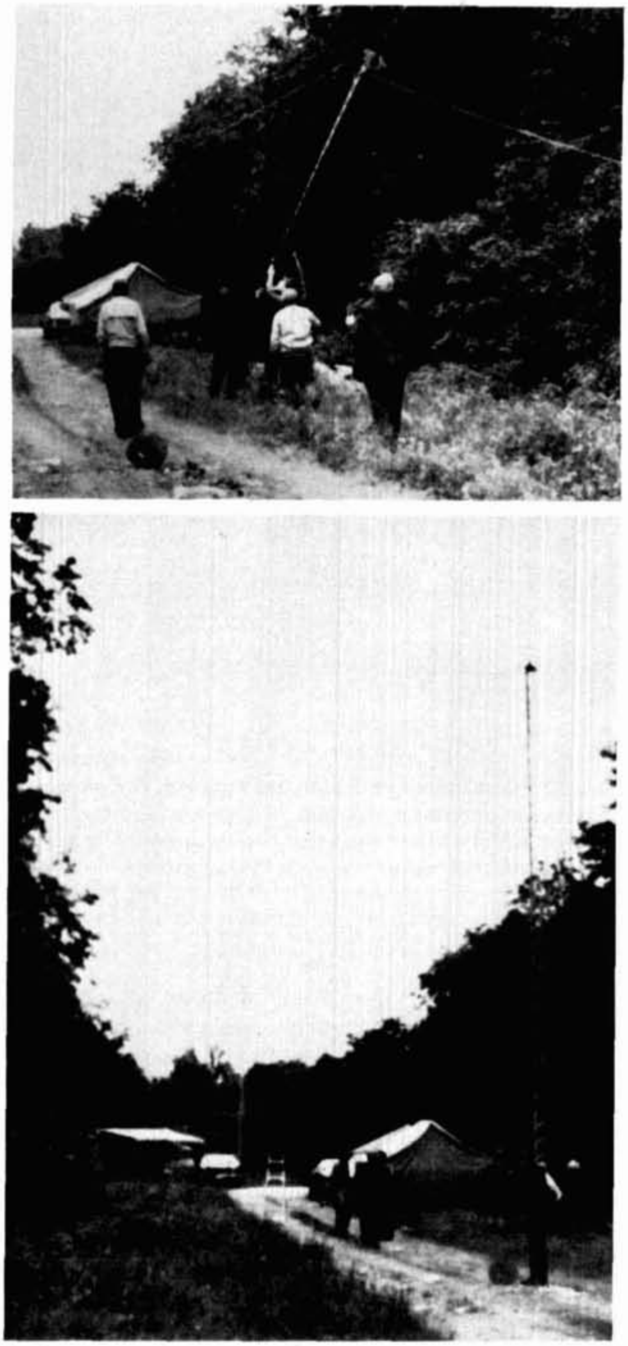


fig. 1. Theoretical radiation pattern for a quarter-wave antenna over poor, good, and very good ground (A) and over very poor ground but with an extensive ground system (B).

ator. Since its radiation resistance is high compared with the ground-loss resistance, the radiation efficiency can be high, even without wire ground radials. The base resistance of a half-wave antenna depends on its height-to-diameter ratio. For a tower antenna, the base radiation resistance is about 500 ohms; for thin wire antennas this resistance is several thousand ohms. Furthermore, if the antenna feedpoint is elevated from the ground, the influence of the finite conductivity of the ground on the input impedance of the antenna is even further reduced. The antenna will therefore radiate with good efficiency, even with no ground screen at all. Of course, the far-field vertical radiation pattern, especially at low elevation angles, is affected by the conductivity of the ground as discussed above; but we have little control over this except to erect the antenna over a salt marsh or over alkaline flats in the prairies.



Erecting the home-built coaxial sleeve antenna at a field-day site (top). Lower photo shows the antenna in operating position.

The coaxial vertical, or sleeve antenna, (**fig. 2**), is a half-wave radiator. This antenna is used extensively at VHF. It can also be used effectively at high frequency, at least for frequencies greater than 7 MHz. The coaxial sleeve is composed of a cage of four wires connected to the top of a tower, insulated from ground and the tower but connected by a skirt wire at the lower ends. The antenna is fed by a coaxial

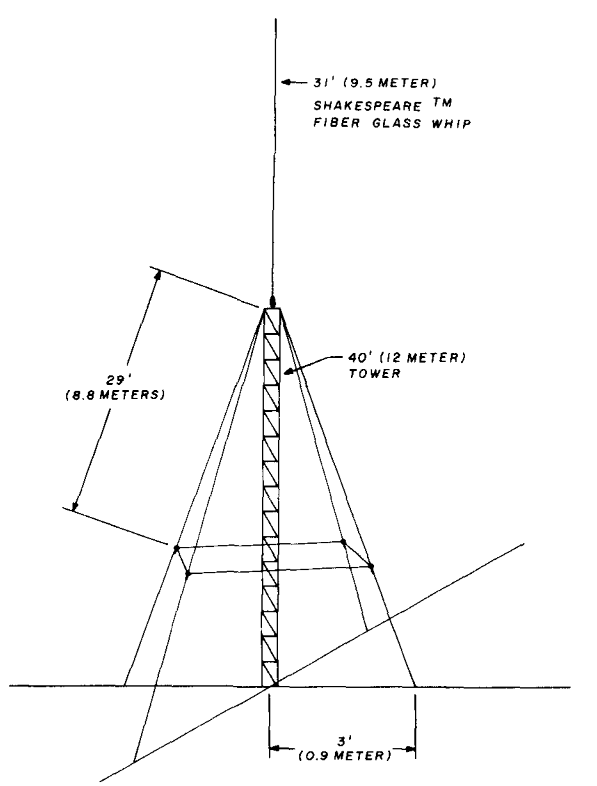


fig. 2. The 40-meter coaxial-sleeve antenna. The coaxial sleeve is composed of a cage of four wires connected to the top of a tower, insulated from ground and tower, but connected by a skirt wire at the lower ends.

cable that runs up the center of the mast. The outside conductor of the coax is connected to the top of the tower; the center conductor is connected to the base of a free-standing, base-insulated whip at the top of the tower. (For base-station use, the tower should be grounded for lightning protection.)

The optimum height, measured from the center of the antenna above the ground, is one-half wavelength, since the antenna and its image are then separated by one wavelength. This is the height for maximum gain, which for a perfectly conducting ground, would be 6.27 dB over a dipole in free space. However, this height can be decreased to about 0.35 wavelength before ground losses appreciably affect the input impedance.[5]

antenna fundamentals

A vertical antenna of physical length or height, H, is related to its electrical length, G, by a factor k:

$$H = kG \tag{1}$$

where H is height
k is a factor (less than 1)
G is electrical length (degrees)

That is, the physical height, H, is *less* than the electrical height, G, due to a) end effects and b) the velocity of propagation of the wave along the radiator, which is less than its velocity in free space. Usually G will be one-quarter, one-half, or five-eighths wavelength (90, 180, or 225 electrical degrees). If G is measured in meters rather than in degrees, (as for example, we express wavelength in meters), then the physical height, H, or in this case, h, will also be in meters.

The factor k depends on the length-to-diameter ratio (H/D) of the radiator and on its electrical length. **Fig. 3** shows the experimentally determined relationship between these parameters. In **fig. 3** the percent increase of G over H is plotted versus the electrical diameter, D, (degrees), for a very wide range of values of D. Thus for thin antennas, this factor is approximately 5 percent, and for fat antennas, the percent increase is considerable. The experimental values were obtained from various sources. I measured those labeled 2 in **fig. 3** for first and second resonance. Previous investigators, for example Brown and Woodward,[6] got into difficulty for the larger values of D because of the capacitance of the base plate since the disk they used, which closed the bottom of the cylindrical radiator, formed a shunt capacitance across the terminals of the radiator. In my measurements I used rods rather than tubes, and the radiators were tapered to a point at their bottom end (but the taper was over a distance small with respect to the length of the radiator) to minimize this effect. I have used the curves in **fig. 3** for antenna design. The curve for $G = 225$ *degrees* probably lies midway between those for $G = 90$ *degrees* and 180 *degrees*.

Towers are not usually of circular cross section. For triangular towers $d = 0.48b$ **(2)**

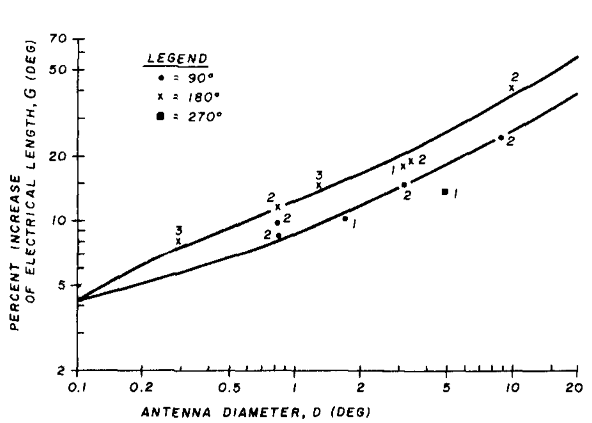


fig. 3. Percent increase of electrical length, G, over the physical length of a monopole antenna at height H. Points labeled 2 were measured by the author for one-quarter and one-half wavelength resonance. Other points were taken from various sources.

and for square towers

$$d = 1.18b \qquad (3)$$

where b = face width of tower
d = effective diameter of the tower

design of the coaxial-sleeve antenna

Suppose we design a coaxial-sleeve antenna for a frequency of 7.15 MHz ($\lambda = 984/fMHz = 137.6$ *feet or 42 meters*, and *a quarter wavelength* $= 34.4$ *feet*, or *10.5 meters*). The antenna arrangement is sketched in **fig. 2**.

The Shakespeare™ whip had a diameter of 1-1/4 inches (31.8 mm) at its base, and 1/4 inch (6.4 mm) at the top of the radiator. The effective diameter is therefore $\frac{1.25 + 0.25}{2} = 0.75$ *inch, or 19 mm (0.0625 foot, or 0.02 meter)*.

Thus $D = \frac{0.0625\,(360)}{137.6} = 0.16$ *degrees*. In metric terms, $D = \frac{0.02\,(360)}{42}$.

The percent lengthening is therefore approximately 5 degrees, or $k = \frac{1}{1.05} = 0.95$. However, for fiberglass whips, the conducting wires are embedded in fiberglass. The velocity of propagation is therefore further reduced by the velocity of propagation in fiberglass, which is about 0.95 times the velocity in free space. Hence

$$k_{eff} = 0.95k$$
$$= 0.95\,(0.95) = 0.9$$

The length of the whip is therefore: $0.9\,(34.4) = 31$ *feet (9.5 meters)*.

The effective diameter of the coaxial sleeve is estimated as follows. The top of the sleeve is the diameter of the supporting tower, which for a triangular tower 8 inches on side is $0.84\left(\frac{8}{12}\right) = 0.56$ *foot (0.17 meter)*.

The four wires of the cage that form the sleeve are tied to stakes forming a 3-foot (0.9-meter) radius about the base of the tower (see **fig. 2**).

Visualize these tie points to form the corners of a square, which at ground level has a side length of $2\sqrt{2} = 4.24$ *feet (1.3 meters)*. Thus the effective diameter is $1.18\,(4.24) = 5$ *feet (1.52 meters)*. The effective diameter at the end of the sleeve is approximately $\frac{30}{40}\,(5) = 3.75$ *feet (1.14 meters)*. The average effective diameter of the sleeve is therefore $\frac{3.75 + 0.56}{2} = 2.15$ *feet or 6.57 meters*. (that is, 5.6 degrees). Hence (see **fig. 3**), the percent lengthening for $D = 5.6$ *degrees*, $G = 90$ *degrees is 19 percent*. The antenna factor $k = \frac{1}{1.19} = 0.84$. The length of the sleeve is therefore 0.84 times the length of a free-space quarter wavelength, or $0.84\,(34.4) = 29$ *feet (8.8 meters)*.

The antenna* was built according to these dimensions, and indeed it was resonant in the middle of the 40-meter band. Since the input impedance of the antenna (which was not measured) is expected to be closer to 72 ohms than to 50 ohms, the feed cable should be RG-11/U. If 50-ohm cable is preferred (RG-8/U), the feeder cable should be cut so that it is an integral multiple of one-half wavelength (a cable one wavelength long would be 90.83 feet, or 27.7 meters). This is because such a transmission line, regardless of its impedance, transfers to the feedpoint the terminal impedance without introducing reactance.

a practical antenna

The antenna that we constructed for use at a field-day site is shown in the photos. A full-wave delta loop (apex down, apex fed) was also used. This antenna has quite a different vertical radiation pattern (dominantly high angle). Switching from one antenna to the other provided reception from quite a different zone — a very desirable feature for field day.

acknowledgments

I would like to thank Harry, VE2RO, and Arn, VE2SD, for help in constructing the antenna. Thanks are also due to the field-day crew who raised the antenna, and to Geof, VE3KID, who took the photographs.

---

*The 40-foot (12.2-meter) tower employed is just marginally high enough, since the height of the antenna measured from its center is approximately 0.3 wavelength. Ideally, a 70-foot (21.4-meter) tower should be employed.

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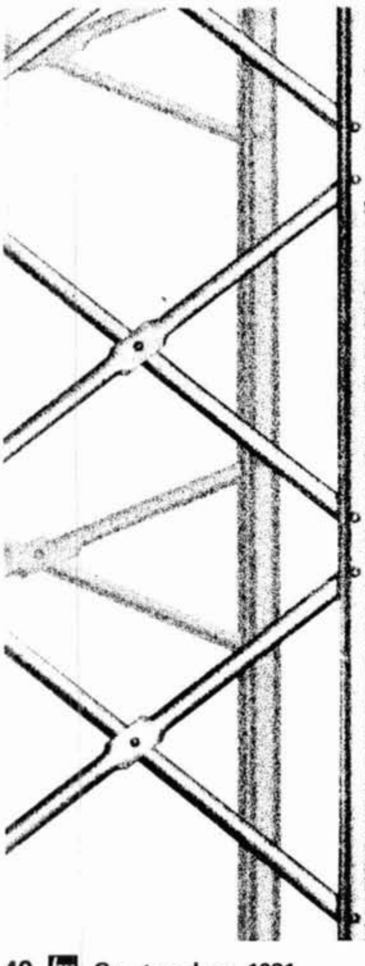

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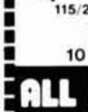

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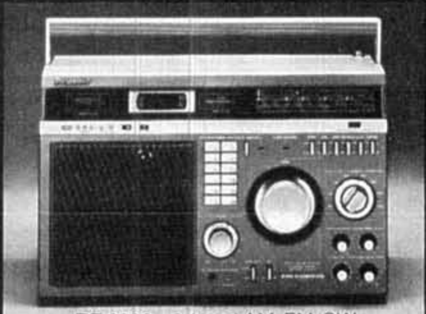

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DIGITAL TECHNIQUES

avoiding built-in digital-circuit problems, part one

Many problems common to analog circuits pose no problems at all for well-designed digital circuitry, but digital circuits may be subject to built-in errors caused by inattention to logic timing, improper power-supply filtering, or radio-frequency interference (RFI). Examples of some problems and cures are presented, including oscilloscope waveforms for several divider circuits. Output pulse stretching modifications are shown for dividers with low repetition rates. Attention to logic-state timing is stressed, and the "logic race" condition is explained.

Methods of improving power-supply distribution are presented, concentrating on decreasing supply-source impedance. Off-board wiring can act as an antenna for RFI, and improvements shown here demonstrate filtering methods for RFI. Adding gating with dc control lines restricts data selection. Mechanical-switch-contact bounce is shown, and a debounce circuit given. The author suggests studying past mistakes to avoid future problems. **Editor**

A nice feature of digital circuitry is that it's not sensitive to drift, noise, or realignment problems, which are common to analog designs. A good digital circuit performs the same function each time. But a few digital designs are not well executed by the designer, usually the result of lack of experience.

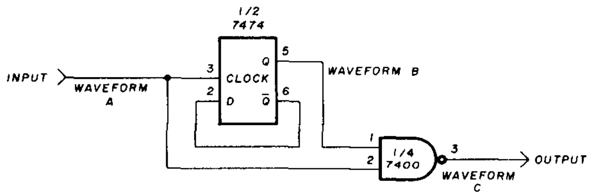

fig. 1. Simple flip-flop circuit with extended output.

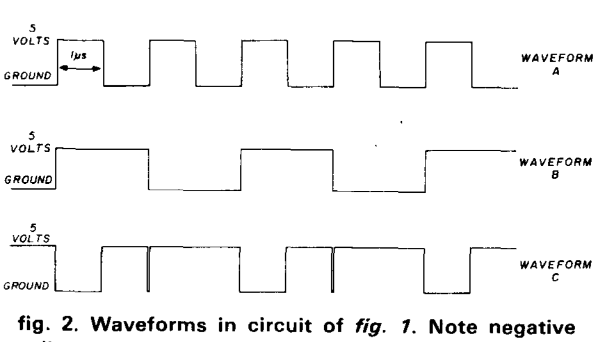

fig. 2. Waveforms in circuit of *fig. 1*. Note negative spike in waveform *C*.

One can thus "build-in" problems; and the purpose of this article is to help you learn how to "build them out".

There are several ways to spot a poor digital design: a project may work only over a limited supply-voltage range. Interchanging identical devices may not be possible, or certain portions of the circuit may be critical. Strange things may happen when switches are thrown. Worst of all, the circuit may be sensitive to rf pick-up.

Tracking down and fixing these problems can be difficult. The underlying cause may show itself only *during a transition, and not be obvious from an* examination of resting states. Useful troubleshooting tools are a fast multi-channel oscilloscope, good data books, and lots of experience.

Professionals have access to good scopes and also have the design experience. Good data books are available, and pitfalls are easy to avoid once understood. But the mass of data on each device may be overwhelming to the eyes of the inexperienced. So let's expose the critical factors.

The greatest design problem is poor timing. Modern logic operates with nanosecond transition and delay times. These times are so fast that they may appear instantaneous when compared with a 50-WPM keyer, for example. Nanoseconds are important, though, and the proper sequencing of logic signals is crucial to the success of a circuit design.

Many logic designs work because the designer was lucky: the arrangement of propagation delays just *barely* allowed proper sequencing. Copying such designs, using long leads, will add time delay and may make the circuit marginal. Inadequate power-supply bypassing may fail to remove glitches (unwanted, short spikes), which can make the circuit inoperative.

the logic race

A constant problem is the *race* condition. This phenomenon occurs when two or more sequence paths are mixed with improper time delays among each path. The circuit may work, but it's not clear how much margin exists and glitches may appear that affect circuitry further downstream.

A glitch-generating condition is shown in the simple flip-flop circuit of **fig. 1** and the waveforms of **fig. 2**. The flip-flop circuit could be used to generate a string of dashes in a keyer (input clock speed in this example was increased to make the negative glitch clearly visible).

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

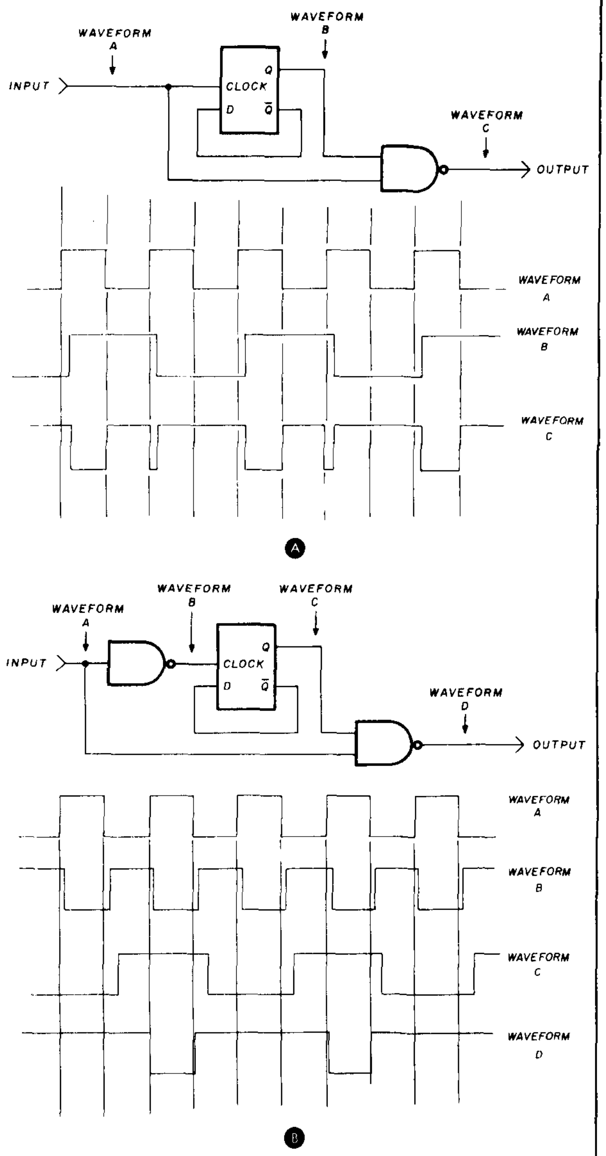

fig. 3. Using ruled paper to analyze timing. Note how propagation delays have been exaggerated to show glitch formation. Circuit of *A* is the same as in *fig. 1*; *B* adds a gate to eliminate the output spike.

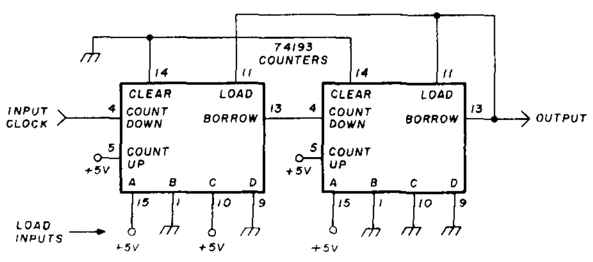

fig. 4. Divide-by-20 circuit using 74193 up-down counters.

The negative spike is the result of a race condition: the input clock signal reaches both the flip-flop and gate at the same time. Since the flip-flop has some delay in changing state, a brief time occurs when both gate inputs are high, to produce a low gate output.

Each race condition must be judged for a particular application. Some don't matter. If the circuit of **fig. 1** were used as a keyer, the CW transmitter would ignore a 50-nanosecond spike since carrier envelope response is usually several milliseconds. On the other hand, if the output were used to clock or gate some other logic, the spike would not go unnoticed! A problem spike should be modified so that the race is always won by the designer.

a simple race analysis tool

This tool is simply a piece of lined paper turned sideways. Paper lines provide time markers for the input waveform. This technique is used in **fig. 3.** It shows the original **fig. 1** circuit and timing in **A**, one solution in **B**.*

The solution toggles the flip-flop on the opposite edge and adds a gate delay to the flip-flop clock input. Output-gate inputs will "line up" without glitches. Use of this fix will depend on remaining circuitry; note that the opposite clock edge does the flip-flop toggling.

judging a race

An important point to remember is that races can result from many causes: device delays, board layout, temperature, and operating voltage, which can vary a spike width. Such races may be hard to spot because of time differences. Even a fast scope can't display a short spike at a low repetition rate. Troubleshooting may require a fast rate for test or simply the paper analysis tool. More than one device has been discarded because it was properly responding to "invisible" spikes!

the brief but necessary spike

Some medium-scale integrated (MSI) devices generate very short output pulses by design. This forces close attention to board layout because long lines can distort short pulses and cause trouble.

The divider circuit of **fig. 4** is an example. The 74193 counters are connected in a down-count mode with preset of 20. When the second stage borrow goes low, the preset condition is loaded into the counters. The input clock then counts down until both counters reach all-zero, causing the borrow out-

*Propagation delays should be taken from data books, but the paper sketch can exaggerate the delays for clarity.

put to go low, and the process repeats.

Fig. 5 shows the input and output waveforms with a 1-kHz input rate. The output *appears* to have nothing, but it *is* working.

A 74193 device has a direct asynchronous preset load feature. Borrow out is determined by all-zeros, but this is also the preset load. Width of the output pulse is determined by the propagation delays of borrow output and load: about 30 nanoseconds in this case.

Fig. 6 is an expanded time-scale version of **fig. 5**. It shows the negative edge of the 20th clock pulse in relation with the output pulse. A delaying-sweep oscilloscope is required for this brief-but-necessary spike, but other problems exist.

Distributed capacitance and series-lead inductance of long lines may distort the output and prevent proper loading. (Long lines tend to form lowpass filters.) Both counters should have borrow and load propagation delays within specification; out-of-specification device problems are covered later.* It doesn't make sense to choose a circuit requiring fast-pulse layout with a 1-kHz clock. Three added NAND gates will improve things.

improved divider with visible output

The circuit of **fig. 7** adds a set-reset latch (U1, U2) between borrow and load. U2-6 is held high by clock inverter U3. The low borrow from the second counter will flip the latch and make U2-6 low, enabling the preset load. The load will remain low for one-half clock cycle through the inverter.

Once the latch has been set and preset load enabled, the latch is reset only when the input clock goes high. The positive edge of the clock would normally toggle the counter, but the 74193 is designed to inhibit counting until the load pin returns high. This means the circuit of **fig. 7** will skip one input clock.

The input-output waveforms of **fig. 8** show a visible output pulse, one for every 21 inputs. The same preset connections as in **fig. 4** were used. A proper division by 20 requires a preset connection one *less* than the desired count.

Layout problems are reduced, and the output is visible, but two gates and an inverter are required. (If these are not available, another device may be chosen.)

a different device but same function

Another way out of the fast-spike problem is to

*Sometimes these problems are caused by off-brand ICs.

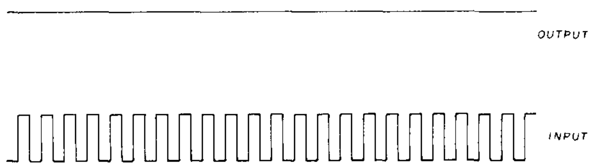

fig. 5. Input-output waveforms for the circuit of *fig. 4*. The output is too short to be visible on the oscilloscope.

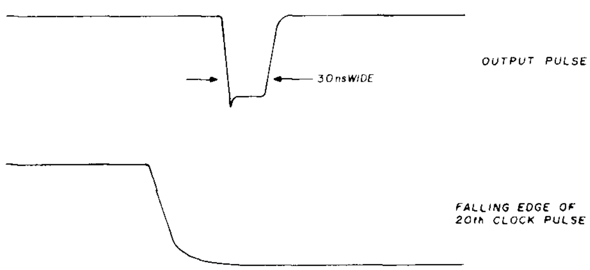

fig. 6. Expanded time trace for the circuit of *fig. 4*. Bottom trace is the negative edge of 20th clock pulse. Top trace is output pulse — too short to observe in *fig. 5*.

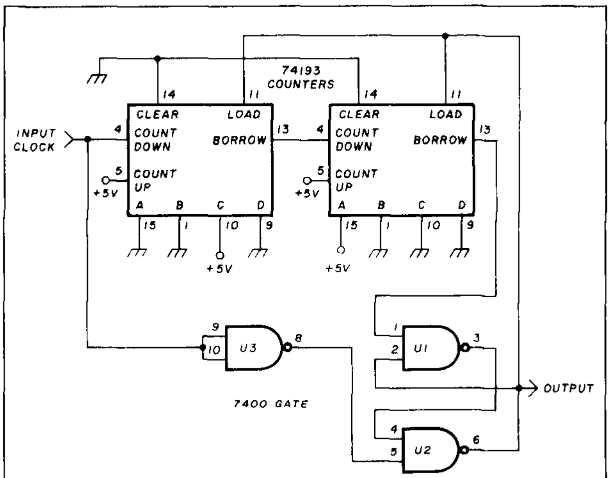

fig. 7. Divide-by-20 circuit of *fig. 4* modified to lengthen output pulse.

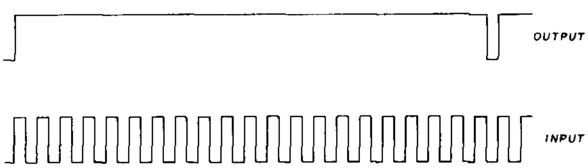

fig. 8. Waveforms of circuit of *fig. 7*. Top trace is output with width equal to negative input clock time. Bottom trace is input clock with preset connections (same as in *fig. 4*). Added gating adds 1 to the division ratio.

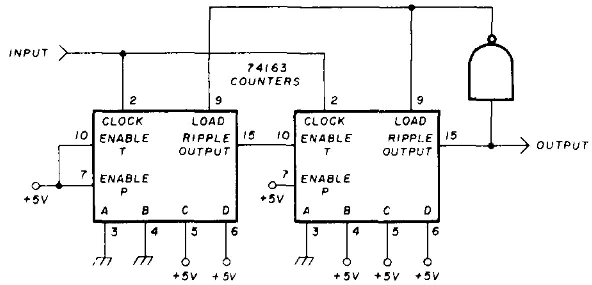

fig. 9. Divide-by-20 circuit using 74163 up counters.

design with a device such as the 74163. It features synchronous loading; the preset loading occurs only when the required clock edge is received. A divide-by-20 circuit is shown in **fig. 9**, with waveforms in **fig. 10**.

Operation is similar to that in **fig. 7** except that the 74163 is an up-counter. Preset is maximum count, minus desired count, minus one. It is the binary *complement* of **fig. 7**.

Ripple carry output goes high on full count, then it's inverted for the preset load input. The 74163 is designed to inhibit counting when the load pin is low. The clock enables preset loading instead, and the counters have an entire clock cycle to settle before the first up-count.

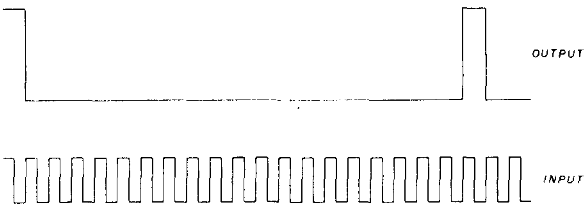

fig. 10. Waveforms of *fig. 9* circuit. Top trace is output at 2-volts per division; bottom trace is input at 5 volts per division.

reliability

The important thing to remember about these examples is that a reliable design must allow sequences in a nice, orderly fashion, with plenty of time for setup and settling. The designer must hold device speed limits and observe propagation delays. Layout and wiring problems then have easier, low-frequency solutions.

The next part of this article will show some other problems and solutions, plus methods of reducing radio-frequency interference (RFI).

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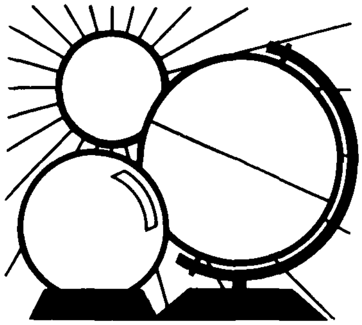

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Garth Stonehocker, KØRYW

fall equinox propagation outlook

September, like March, is a special time of year for propagation, and therefore DX. Equinox is the reason: equal-length nights and days; the sun is directly overhead at noon on the geographic equator. At this time, with the radiation from the sun hitting the earth broadside, and because the equatorial plane of the earth and the plane of the sun's equator nearly coincide, particles from the sun's eruptions (flares) and coronal holes (thin places in the sun's gases) have a bull's-eye path to the earth. These charged particles, called the solar wind, enter the earth's atmosphere in the polar regions. They also build up in the Van Allen belts around the earth above the equatorial region. When full, the belts dump into the polar auroral zone, on the Canadian-U.S. side after about 2200 local time. This is a geomagnetic storm.

Coincident with the geomagnetic storm are three ionospheric processes that affect propagation and DX. First, the particles coming into the auroral zone ionospheric D and E regions absorb the energy from the signal, lowering the S-meter reading. Weak signals on east-west paths and few signals across the poles are the result. Second, the particles form a reflective curtain along the equator side of the auroral zone for VHF auroral scatter propagation openings. Third, the F region of the ionosphere toward the equator from the auroral zone is depleted to form a trough where the maximum usable frequency (MUF) for a particular path through this area decreases by 30 to 50 percent. Paths through the trough require the lower frequency bands. However, north of the geomagnetic equator a similar-size enhancement of the F region MUF takes place to give the evening trans-equatorial openings during the equinox and winter seasons. These three effects are not steady but quite variable on any time scale (hours, minutes, or seconds); therefore fading is an almost normal occurrence. The effects continue to occur each night for 2 to 3 days before ionospheric equilibrium is obtained again. The bigger the geomagnetic storm (higher K or A value) the closer to the equator these effects occur.

You'll remember during the last spring equinoctial period, March, April, and into May, seven periods were experienced with these phenomena going on for days at a time. This was the most disturbed period so far this solar cycle. We may not have a fall equinox like the spring disturbances, but if so, you can be on the lookout for those effects. When the ionosphere is this variable, DX openings come at very odd times and locations with weak and fading signals. Be on the lookout for that needed country or just have a lot of fun.

gray-line DX

Another equinox propagation phenomena for interesting DX is known as gray-line DX. This propagation enhances DX on north-south paths over the polar regions during quiet geomagnetic conditions. The best times for openings are just as dawn or sunset comes upon your location with your antenna pointed north or south. Signals will be unbelievably strong and clear, reminiscent of sporadic E (Es) one hop. By the way, there may be a few short-skip openings from Es left for this summer's Es season, if you're lucky enough to catch them. Let's look at the September forecast.

The 27-day solar minimum is expected about the 13th of September, building to a maximum about the 27th. Geomagnetic disturbances from solar flares are expected as short periods during ascending activity around September 23 and even more likely on the descent about the 30th. A longer disturbance may be experienced about the 10th if a solar coronal hole develops near the minimum solar activity. Solar flux should be building somewhat into the winter months for better DX.

Full moon is on the 14th and perigee on the 17th this month. The time the equinox occurs is on September 23rd at 0305UT.

band-by-band summary

Six meters will provide some excellent openings to South Africa from the eastern U.S. and from the western and central U.S. to Australia and New Zealand around local noontime. The openings are more probable during high solar flux values.

Ten, fifteen, and twenty meters will be full of signals from morning into early evening almost every day and to most areas of the world. The openings will be shorter on the higher bands and concentrated more near noon for the path of interest. High solar flux values and geomagnetic disturbance will favor these bands for trans-equatorial contacts.

Forty, eighty, and one-sixty meters are the night DXer's bands. The bands are open beginning just before sunset and lasting until just as the sun comes up on the path of interest. Except for daytime short-skip signal strengths, high solar flux values don't affect these bands much. Geomagnetic disturbances may cause much signal attenuation and fading on polar paths.

ham radio

SEPTEMBER

WESTERN USA

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

MID USA

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

EASTERN USA

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

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

Power up.

40 W, 15 memories/offset recall, scan, priority, DTMF touch-pad

TR-7850

Kenwood's remarkable TR-7850 2-meter FM mobile transceiver provides all the features you could desire, including a powerful 40 watts RF output. Frequency selection is easier than ever, and the rig incorporates new memory developments for repeater shift, priority, and scan, and includes a built-in autopatch touch-pad (DTMF) encoder. A 25-watt output version, the TR-7800, is also available.

TR-7850 FEATURES:

- **Powerful 40 watts power output**
  Selectable high or low power operation. High 40-watt output provides reliable signal for wide area coverage.
- **15 multifunction memory channels, easily selectable with a rotary control**
  M1-M13 ... memorize frequency and offset (±600 kHz or simplex). M14 ... memorize transmit and receive frequencies independently for nonstandard offset. M0 ... priority channel, with simplex, ±600 kHz, or nonstandard offset operation.
- **Internal battery backup for all memories**
  All memory channels (including transmit offset) are retained when four AA NiCd batteries (not Kenwood supplied) are installed in battery holder inside TR-7850. Batteries are automatically charged while transceiver is connected to 12-VDC source.
- **Extended frequency coverage**
  143.900-148.995 MHz, in switchable 5-kHz or 10-kHz steps.
- **Priority alert**
  M0 memory is priority channel. "Beep" alerts operator when signal appears on priority channel. Operation can be switched immediately to priority channel with the push of a switch.
- **Built-in autopatch touch-pad (DTMF) encoder**
  Front-panel touch pad generates all 12 telephone-compatible dual tones in transmit mode, plus four additional DTMF signaling tones (with simultaneous push of REV switch).
- **Front-panel keyboard**
  For frequency selection, transmit offset selection, memory programming, scan control, and selection of autopatch encoder tones.
- **Autoscan**
  Entire band (5-kHz or 10-kHz steps) and memories. Automatically locks on busy channel; scan resumes automatically after several seconds, unless CLEAR or mic PTT button is pressed to cancel scan.
- **Up/down manual scan**
  Entire band (5-kHz or 10-kHz steps) and memories, with UP/DOWN microphone (standard).
- **Repeater reverse switch**
  Handy for checking signals on the input of a repeater or for determining if a repeater is "upside down."
- **Separate digital readouts**
  To display frequency (both receive and transmit) and memory channel.
- **LED bar meter**
  For monitoring received signal level and RF output.
- **LED indicators**
  To show: +600 kHz, simplex, or -600 kHz transmitter offset; BUSY channel; ON AIR.
- **TONE switch**
  To actuate subaudible tone module (not Kenwood-supplied).
- **Compact size**
  Depth is reduced substantially.
- **Mobile mounting bracket**
  With quick-release levers.

More information on the TR-7850 is available from all authorized dealers of Trio-Kenwood Communications, Inc., 1111 West Walnut Street, Compton, California 90220.

KENWOOD
...pacesetter in amateur radio

Matching accessory for fixed-station operation:
- KPS-12 fixed-station power supply for TR-7850

Other accessories not shown:
- KPS-7 fixed-station power supply for TR-7800
- SP-40 compact mobile speaker

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

Small wonder.

Processor, N/W switch, IF shift, DFC option

TS-130S/V

An incredibly compact, full-featured, all solid-state HF SSB/CW transceiver for both mobile and fixed operation. It covers 3.5 to 29.7 MHz (including the three new Amateur bands!) and is loaded with optimum operating features such as digital display, IF shift, speech processor, narrow/wide filter selection (on both SSB and CW), and optional DFC-230 digital frequency controller. The TS-130S runs high power and the TS-130V is a low-power version for QRP.

TS-130 SERIES FEATURES:

- **80-10 meters, including three new bands**
  Covers all Amateur bands from 3.5 to 29.7 MHz, including the new 10, 18, and 24-MHz bands. Receives WWV on 10 MHz. VFO covers more than 50 kHz above and below each 500-kHz band.
- **Two power versions... easy operation**
  TS-130S runs 200 W PEP/160 W DC input on 180-15 meters and 160 W PEP/140 W DC on 12 and 10 meters. TS-130V runs 25 W PEP/20 W DC input on all bands. Solid-state, wideband final amplifier eliminates transmitter tuning, and receiver wideband RF amplifiers eliminate preselector peaking.
- **CW narrow/wide selection**
  "N-W" switch allows selection of wide and narrow bandwidths. Wide CW and SSB bandwidths are the same. Optional YK-88C (500 Hz) or YK-88CN (270 Hz) filter may be installed for narrow CW.
- **Built-in speech processor**
  Increases audio punch and average SSB output power, while suppressing side-band splatter.
- **SSB narrow selection**
  "N-W" switch allows selection of narrow SSB bandwidth to eliminate QRM, when optional YK-88SN (1.8 kHz) filter is installed. (CW filter may still be selected in CW mode.)
- **Sideband mode selected automatically**
  LSB is selected on 40 meters and below, and USB on 30 meters and above. SSB REVERSE position on MODE switch.
- **Built-in digital display**
  Six-digit green fluorescent tube display indicates actual operating frequency to 100 Hz. Also indicates external VFO or fixed-channel frequency, RIT shift, and CW transmit/receive shifts. Backed up by an analog subdial.
- **IF shift**
  Allows IF passband to be moved away from interfering signals and sideband splatter.
- **Built-in RF attenuator**
  For optimum rejection of intermodulation distortion.
- **Single-conversion PLL system**
  Improves stability as well as transmit and receive spurious characteristics.
- **Built-in VOX**
  For convenient SSB operation, as well as semibreak-in CW with sidetone.
- **Effective noise blanker**
  Eliminates pulse-type interference such as ignition noise.
- **Compact and lightweight**
  Measures only 3-3/4 inches high, 9-1/2 inches wide, and 11-9/16 inches deep, and weighs only 12.3 pounds.

Optional DFC-230 Digital Frequency Controller
Allows frequency control in 20-Hz steps with UP/DOWN microphone (supplied with DFC-230). Includes four memories (handy for split-frequency operation) and digital display. Covers 100 kHz above and below each 500-kHz band. Very compact.

More information on the TS-130 Series is available from all authorized dealers of
Trio-Kenwood
Communications, Inc.,
1111 West Walnut Street,
Compton, California 90220.

KENWOOD
...pacesetter in amateur radio

Matching accessories for fixed-station operation:
- PS-30 base-station power supply (remotely switchable on and off with TS-130S power switch).
- SP-120 external speaker
- VFO-120 remote VFO
- MC-50 50kΩ/500Ω desk microphone

Other accessories not shown:
- YK-88C (500 Hz) and YK-88CN (270 Hz) CW filters
- YK-88SN (1.8 kHz) narrow SSB filter
- AT-130 compact antenna tuner (80-10 m, including 3 new bands)
- MB-100 mobile mounting bracket
- MC-30S and MC-35S noise cancelling hand microphones
- PC-1 phone patch
- TL-922A linear amplifier
- HS-5 and HS-4 headphones
- HC-10 world digital clock
- PS-20 base station power supply for TS-130V
- SP-40 compact mobile speaker
- VFO-230 digital VFO with five memories

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

RFI cures:

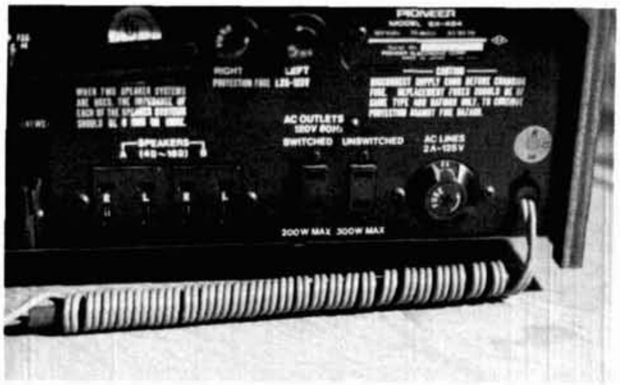
avoiding side effects

Advice on preventing additional problems when making RFI fixes to home-entertainment equipment

Many Amateurs have had it happen: You're on the air and the phone rings, or there's a loud knock on your door. It's a neighbor who says, "Your signals are getting into my stereo and clock radio." Whatever the device, you are expected to do something about it. The problem still exists today, despite advances in engineering. If you want to stay on the air and keep peace in the neighborhood, you might offer to add a few components to the affected equipment to make it less susceptible to RFI.

Much has been published in the Amateur literature on cures for Amateur-caused radio-frequency interference (RFI) to these devices. If you handle the problem diplomatically and apply the appropriate cure to your neighbor's equipment, the interference from your Amateur transmitter may disappear, but you may be faced with more problems. What happens when your neighbor's precious stereo set doesn't have the original audio response it had before you made the fix? Suppose your friendly neighbor's phono preamp develops a 60-Hz hum after you've added components to cure RFI?

By **John W. Frank, WB9TQG**, P.O. Box 5113, Madison, Wisconsin 53705

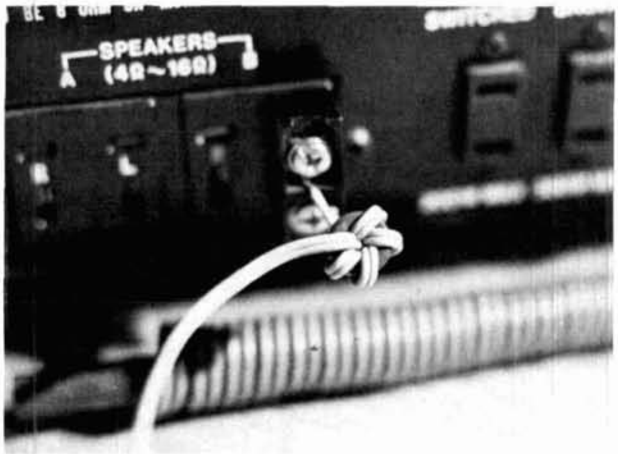


If the interference is entering the stereo through the ac line, the cord can be wrapped around a ferrite rod to form a bifilar choke.

This article is based on my experience with RFI problems in commercial home-entertainment devices. It offers some advice on dealing with the side effects that can occur when trying to tame such devices. Such side effects include parasitic oscillations and high-frequency attenuation in audio amplifiers, hum in phonograph preamps, and the so-called "hot-chassis" syndrome.

a personal experience

Not long ago, a neighbor and I were victims of RFI. After determining that the offending CB transceiver was being operated legally, we added the standard filtering and shielding to our stereos only to encounter the side effects of these commonly accepted RFI cures. The side effects included parasitic oscillations, high-frequency attenuation, the hot-chassis syndrome, and a 60-Hz hum. Since each of these side effects is the result of a different cure, each must be considered separately.



Parasitic oscillations and high-frequency attenuation (described in the text) can be avoided by installing a toroid on each speaker lead.

parasitic oscillations

Bypass capacitors on speaker leads are sometimes unnecessary and often their effect can be disastrous. Fortunately I didn't destroy the audio output transistors in my receiver. Another RFI victim in my neighborhood wasn't so lucky: capacitors on the speaker leads of his stereo set caused feedback, and the resulting high-frequency oscillations destroyed the audio power amplifier.

Some solid-state amplifiers will oscillate when bypass capacitors are placed across their output. Quite often, these oscillations occur at frequencies too high to be audible. These parasitic oscillations can cause overheating of the output transistors and put an extra burden on the power supply. The sad part is that often bypass capacitors aren't needed on the speaker leads. Many articles on RFI suppression recommend bypassing speaker leads for rf. But unless the leads are acting as an antenna, there's no need for this cure.

How can you tell if the speaker leads are acting as an antenna? If you're using a receiver with a headphone jack, disconnect all speakers at the receiver output, plug in a set of headphones, and listen. If the receiver doesn't have a headphone jack, disconnect all speakers at the receiver and connect headphones to the receiver output with short jumper wires. If the interference disappears when the speakers are disconnected, it's safe to assume that the speaker wires are acting as an antenna. If the interference remains, you'll need to keep looking and listening to find out how the offending signal is getting into the stereo set.

high-frequency attenuation

Another approach to keeping rf on the speaker leads from getting into the receiver is to use an rf choke in series with the speaker leads at the receiver (**fig. 1**). In theory this works fine; in reality it creates a new set of problems. The inductive reactance of the rf choke will prevent rf from reaching the receiver, but the choke will have enough reactance to attenuate higher audio frequencies as well.

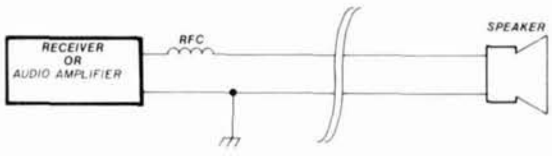


fig. 1. An rf choke in series with a speaker lead can cause high-frequency attentuation as described in the text. An alternative is to use a ferrite bead on each speaker lead or thread each lead through a toroid core.

For example: 2.5 mH at 15 kHz will have a reactance of approximately 235 ohms. At 500 Hz that same 2.5 mH will have a reactance of less than 8 ohms. The load on the receiver will be changing because the reactance of the choke will constantly be changing with frequency. A substantial amount of power will be lost in the choke. Most small, pi-wound chokes are designed for small amounts of current, generally 1 ampere or less. At higher audio frequencies, the reactance of the choke will limit current through the series combination of choke and speaker. But, at lower frequencies and higher power levels, the current through the choke could reach several amperes, until the choke overheats and acts like a fuse. Now the audio output stage is looking into an open circuit.

Some receivers and amplifiers can tolerate loads of varying impedance; others can't. An alternative to the rf choke is to slip a ferrite bead over the speaker lead at the receiver or, in more stubborn cases, thread the lead through a toroid core (see photo).

Another cause of high-frequency attenuation is excessive capacitance in the signal path. In my stereo, the CB signal was getting into the phono preamp through the magnetic phono cartridge. This problem was confirmed by removing the cartridge from the tone arm without hearing any interference.

The simplest approach to this problem was to add rf bypass capacitors to the phono preamp inputs. When 100-pF capacitors were installed, as shown in **fig. 2**, a noticeable deterioration occurred in the high-frequency response. The reason for the attenuation of high frequencies is that the total capacitance in the signal path exceeded the maximum load capacitance the cartridge could tolerate. **Fig. 3** illustrates the factors that contribute to the total capacitance in the circuit.

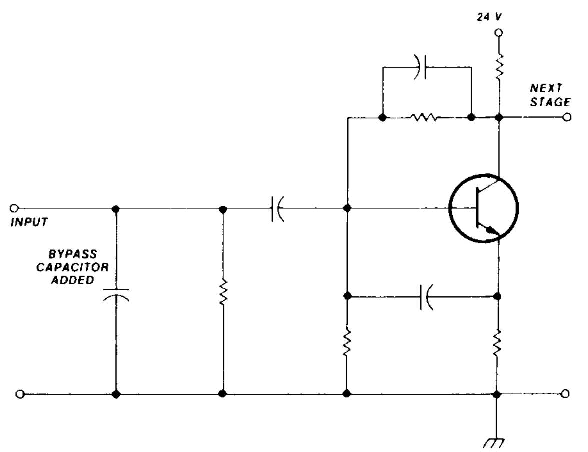


fig. 2. Unless the value of the bypass capacitor is chosen very carefully, high-frequency attenuation of the stereo's audio can result.

How much capacitance is too much? Specification sheets for good-quality phono cartridges include data for the optimum load resistance and maximum load capacitance. High-frequency attenuation can be avoided by keeping the total capacitance well below the maximum tolerable capacitance.

hum

Phono preamps are high-gain, high-impedance circuits. Adding any unshielded components to their inputs can result in an annoying hum. The side effect is the result of installing rf chokes in the preamp input circuits, as shown in **fig. 4**. Although rf chokes will solve the interference problem without causing high-frequency attenuation, any nearby magnetic fields will induce enough voltage in the choke to cause a 60-Hz hum. Depending on the intensity of the magnetic field and the type choke used, the hum could range from barely audible to loud and objectionable.

the hot chassis syndrome

Occasionally, rf will find its way into a stereo by way of the ac line cord. The commonly accepted cure for this type of RFI consists of placing bypass capacitors across the primary of the power transformer (**fig. 5**). While this will prevent rf from getting into the stereo through the ac line, it might create a shock hazard. This problem arises from the fact that almost all consumer audio equipment uses a two-wire line cord. The chassis is almost never at ground

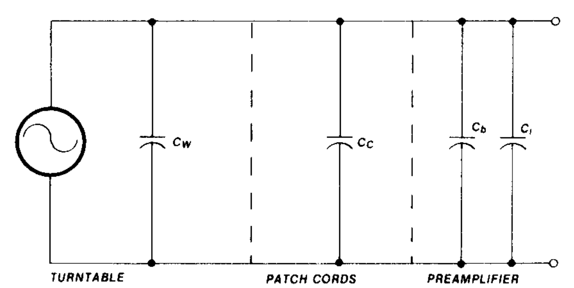


fig. 3. Total capacitance in the signal path will be the sum of the following: C_w, wiring in the tone arm; C_c, patch cords; C_b, the bypass capacitor; and C_i, the input capacitance of the preamplifier itself.

potential and, with the addition of the bypass capacitors, the potential between chassis and ground terminal of a three-wire outlet can be as much as 20 volts. (This number is based on my own measurements and may vary, depending on the type of equipment and the value of the bypass capacitors as well as other factors).

avoiding side effects

There's nothing mysterious about avoiding side effects of RFI cures. All it takes is a basic understanding of electronic theory and some common sense in application.

Parasitic oscillations can be avoided by not putting bypass capacitors on speaker leads unless it's absolutely necessary, and then only when recommended by the manufacturer of the equipment affected.

Since high-frequency attenuation can be caused by either of two cures, there are two ways to avoid such attenuation. If it's necessary to use rf chokes on the speaker leads, use the smallest amount of inductance that will do the job. If one or two ferrite beads placed on each speaker lead at the amplifier don't provide enough inductance, try a toroid, as shown in the photo.

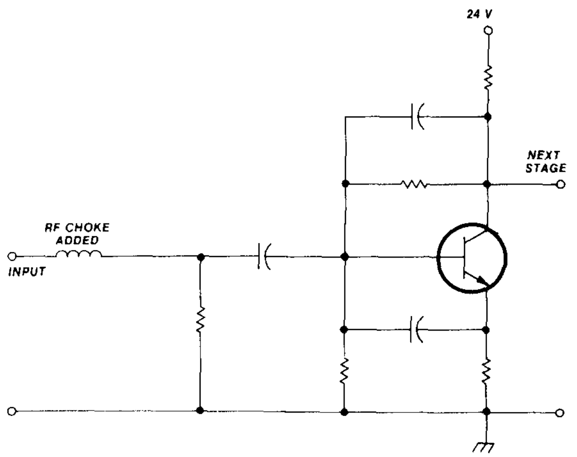


fig. 4. Adding an rf choke to the input of an amplifier may cure RFI but can cause hum in high-gain circuits.

When high-frequency attenuation is caused by too much capacitance in the signal path, the solution is to reduce the capacitance wherever possible. If a bypass capacitor is needed on each preamp input, use the smallest value that will cure the RFI problem. An old rule of thumb states that *the reactance of the bypass capacitor should be one tenth the impedance of the circuit being bypassed at the lowest frequency encountered*. If poorly shielded patch cords contribute to an RFI problem, replace them with RG-59 coax cable. Why use RG-59 when RG-58 is less expensive and more flexible? Answer: RG-59 cable has less capacitance per unit length.

Hum can be avoided by not adding unshielded components to high gain circuits. If an rf choke is needed on a preamp input to block out the offending signal, very carefully remove the first amplifying transistor from the circuit and slip a ferrite bead over the input lead.

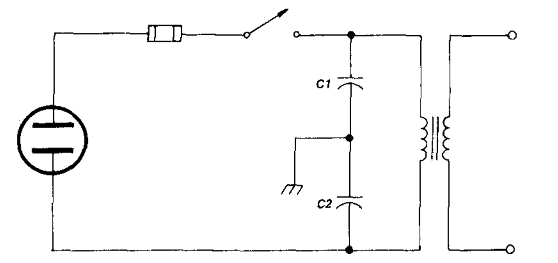


fig. 5. Capacitors *C1* and *C2* form a voltage divider, which places the chassis above ground for ac. A three-wire line cord might help.

If the rf is entering the receiver or amplifier on the ac line, the hot-chassis syndrome can be prevented by using a bifilar choke, as shown in the photo.

If wrapping the ac-line cord around a ferrite rod to form a bifilar choke is too bulky or inconvenient, the hot-chassis syndrome can still be avoided. When installing capacitors across the power-transformer primary winding, make sure the caps have a high-enough voltage rating to withstand the peak ac voltage plus any surges, spikes or transients that may occur. A 600-volt rating is usually adequate. Also make sure the capacitors have a very high leakage resistance. One final step you can take is to add a three-wire line cord. When the chassis is grounded through the line cord, a shorted capacitor will blow the fuse.

some final thoughts

Because of the variety of tuners, turntables, tape decks, preamps, power amplifiers, graphic equalizers, and speakers on the market, no two cases of RFI are exactly alike. Add to this the variety of antennas and transmitters available to the Amateur-Radio operator and very few sources of RFI are exactly alike.

The point is that one audiophile might suffer from interference and his neighbor might not. One audio amplifier might have an adverse reaction to a commonly accepted RFI cure, and another might not.

The intent of this article has been to make you aware of some of the common side effects of RFI cures and how they can be avoided. However, when in doubt consult the manufacturer! For example, if an audio amplifier uses inverse feedback to reduce distortion, the manufacturer can tell you if adding capacitors across the output will send it into a frenzy of oscillation.

I repeat! When in doubt, consult the manufacturer.

ham radio

More Details? CHECK—OFF Page 98

7400

SN7400N	.25	SN7472N	.29	SN74156N	.79
SN7401N	.20	SN7473N	.35	SN74157N	.69
SN7402N	.25	SN7474N	.35	SN74160N	.89
SN7403N	.25	SN7475N	.49	SN74161N	.89
SN7404N	.25	SN7476N	.35	SN74162N	.89
SN7405N	.29	SN7479N	5.00	SN74163N	.89
SN7406N	.35	SN7480N	.50	SN74164N	.89
SN7407N	.35	SN7482N	.99	SN74165N	.89
SN7408N	.29	SN7483N	.69	SN74166N	1.25
SN7409N	.29	SN7485N	.89	SN74167N	2.79
SN7410N	.25	SN7486N	.35	SN74170N	1.95
SN7411N	.29	SN7489N	1.75	SN74172N	4.95
SN7412N	.35	SN7490N	.49	SN74173N	1.39
SN7413N	.40	SN7491N	.59	SN74174N	.99
SN7414N	.69	SN7492N	.45	SN74175N	.89
SN7416N	.29	SN7493N	.45	SN74176N	.79
SN7417N	.29	SN7494N	.69	SN74177N	.79
SN7420N	.25	SN7495N	.69	SN74179N	1.49
SN7421N	.29	SN7496N	.69	SN74180N	.79
SN7422N	.45	SN7497N	3.00	SN74181N	2.25
SN7423N	.29	SN74100N	1.49	SN74182N	.79
SN7425N	.29	SN74104N	.89	SN74184N	2.49
SN7426N	.29	SN74105N	.89	SN74185N	2.49
SN7427N	.25	SN74107N	.35	SN74190N	1.25
SN7428N	.49	SN74109N	.39	SN74191N	1.25
SN7430N	.25	SN74116N	1.95	SN74192N	.89
SN7432N	.29	SN74121N	.39	SN74193N	.89
SN7437N	.25	SN74122N	.55	SN74194N	.89
SN7438N	.40	SN74123N	.59	SN74195N	.69
SN7439N	.25	SN74125N	.49	SN74196N	.89
SN7440N	.20	SN74126N	.49	SN74197N	.89
SN7441N	.89	SN74132N	.75	SN74198N	1.49
SN7442N	.59	SN74136N	.75	SN74199N	1.49
SN7443N	1.10	SN74141N	.99	SN74221N	1.25
SN7444N	1.10	SN74142N	3.25	SN74251N	.99
SN7445N	.89	SN74143N	3.49	SN74276N	1.95
SN7446N	.79	SN74144N	3.49	SN74279N	.79
SN7447N	.69	SN74145N	.79	SN74283N	1.49
SN7448N	.79	SN74147N	1.95	SN74284N	3.95
SN7450N	.20	SN74148N	1.29	SN74285N	3.95
SN7451N	.20	SN74150N	1.25	SN74365N	.69
SN7453N	.20	SN74151N	.69	SN74366N	.69
SN7454N	.20	SN74152N	.69	SN74367N	.69
SN7459A	.25	SN74153N	.79	SN74368N	.69
SN7460N	.20	SN74154N	1.25	SN74390N	1.49
SN7470N	.29	SN74155N	.79	SN74393N	1.49

74LS

74LS00	.29	74LS92	.75	74LS192	1.15
74LS01	.29	74LS93	.75	74LS193	1.15
74LS02	.29	74LS95	.99	74LS194	1.15
74LS03	.29	74LS96	1.15	74LS195	1.15
74LS04	.35	74LS107	.45	74LS197	1.15
74LS05	.35	74LS109	.45	74LS221	1.19
74LS08	.35	74LS112	.45	74LS240	1.49
74LS09	.35	74LS113	.49	74LS241	1.49
74LS10	.35	74LS114	.49	74LS242	1.49
74LS11	.39	74LS122	.89	74LS243	1.49
74LS12	.35	74LS123	1.25	74LS244	1.49
74LS13	.59	74LS125	.89	74LS245	2.95
74LS14	.99	74LS126	.59	74LS247	1.19
74LS15	.35	74LS132	.99	74LS248	1.19
74LS20	.35	74LS133	.89	74LS249	1.19
74LS21	.35	74LS136	.45	74LS251	.99
74LS22	.35	74LS138	.89	74LS253	.99
74LS26	.35	74LS139	.89	74LS257	.89
74LS27	.35	74LS151	.89	74LS258	.69
74LS28	.35	74LS153	.89	74LS260	.69
74LS30	.35	74LS154	1.75	74LS266	.69
74LS32	.35	74LS155	.89	74LS273	1.95
74LS33	.59	74LS156	.89	74LS279	.89
74LS37	.45	74LS157	.89	74LS283	.89
74LS38	.45	74LS158	.89	74LS290	.99
74LS40	.35	74LS160	1.15	74LS293	.99
74LS42	.89	74LS161	1.15	74LS298	1.25
74LS47	.89	74LS162	1.15	74LS352	1.29
74LS48	1.15	74LS163	1.15	74LS353	1.29
74LS49	1.15	74LS164	1.15	74LS365	.69
74LS51	.35	74LS165	1.15	74LS366	.69
74LS54	.35	74LS168	1.19	74LS367	.69
74LS55	.35	74LS169	1.19	74LS368	.69
74LS73	.45	74LS170	1.95	74LS373	1.95
74LS74	.45	74LS173	.99	74LS374	1.95
74LS75	.59	74LS174	.99	74LS375	.89
74LS76	.45	74LS175	.99	74LS386	.69
74LS78	.49	74LS181	2.95	74LS393	2.49
74LS83	.89	74LS190	1.25	74LS399	2.49
74LS85	1.25	74LS191	1.25	74LS670	2.49
74LS86	.49			81LS95	1.95
74LS90	.69			81LS97	1.95

74S

74S00	.45			74S243	3.25
74S02	.45			74S244	3.25
74S03	.45	74S124	3.95	74S251	1.45
74S04	.55	74S133	.55	74S253	1.45
74S05	.55	74S134	.69	74S257	1.35
74S08	.50	74S135	1.19	74S258	1.35
74S09	.50	74S136	1.75	74S260	.79
74S10	.45	74S138	1.35	74S280	2.95
74S11	.45	74S139	1.35	74S287	3.25
74S15	.45	74S140	.79	74S288	2.75
74S20	.45	74S151	1.35	74S373	3.49
74S22	.45	74S153	1.35	74S374	3.49
74S30	.45	74S157	1.35	74S387	2.95
74S32	.55	74S158	1.35	74S471	19.95
74S38	1.25	74S160 *	2.95	74S472	10.95
74S40	.50	74S174	1.59	74S473	10.95
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74S64	.50	74S188	2.95	74S475	12.95
74S65	.50	74S194	1.95	74S570	5.95
74S74	.75	74S195	1.95	74S571	5.95
74S86	.79	74S196	1.95	74S572	9.95
74S112	.79	74S240	2.95	74S573	9.95
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74S114	.79	74S242	3.25	74S941	3.15

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CA3035H	2.49	CA3081N	2.00	CA3140H	1.25
CA3039H	1.35	CA3082N	2.00	CA3160H	1.25
CA3046N	1.30	CA3083N	1.60	CA3401N	.59
CA3059N	3.25	CA3086N	.85	CA3600N	3.50

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CD4001	.39			CD4506	.75
CD4002	.39			CD4507	.99
CD4006	1.19	CD4041	1.49	CD4508	3.95
CD4007	.25	CD4042	.99	CD4510	1.39
CD4009	.49	CD4043	.89	CD4511	1.29
CD4010	.49	CD4044	.89	CD4512	1.49
CD4011	.39	CD4046	1.79	CD4514	3.95
CD4012	.25	CD4047	2.50	CD4515	2.95
CD4013	.49	CD4048	1.35	CD4516	1.49
CD4014	1.39	CD4049	.49	CD4518	1.79
CD4015	1.19	CD4050	.69	CD4519	.89
CD4016	.59	CD4051	1.19	CD4520	1.29
CD4017	1.19	CD4052	1.19	CD4526	1.79
CD4018	.99	CD4053	1.19	CD4528	1.79
CD4019	.49	CD4056	2.95	CD4529	1.95
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CD4021	1.39	CD4060	1.49	CD4562	11.95
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CD4023	.29	CD4068	.39	CD4583	2.49
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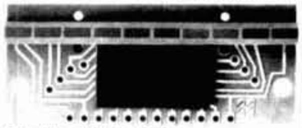

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NSM39156	Logarithmic Func. (6 grn./2 yell./2 rd.)	6.95
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XC556Y	.200"	yellow	4/$1	XC209G	.125"	green	4/$1
XC556C	.200"	clear	4/$1	XC209Y	.125"	yellow	4/$1
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XC22G	.200"	green	4/$1	XC526G	.185"	green	4/$1
XC22Y	.200"	yellow	4/$1	XC526Y	.185"	yellow	4/$1
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C.C. — Common Cathode
RHD — Right Hand Decimal

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MAN 2	5x7 D.M.—red	.300	4.95	DL704	C.C.—red	.300	1.25
MAN 3	C.C.—red	.125	.25	DL707	C.A.—red	.300	1.25
MAN 52	C.A.—green	.300	.99	DL728	C.C.—red	.500	1.49
MAN 54	C.C.—green	.300	.99	DL741	C.A.—red	.600	1.25
MAN 71	C.A.—red	.300	.75	DL747	C.A.—red	.600	1.49
MAN 72	C.A.—red	.300	.75	DL750	C.C.—red	.600	1.49
MAN 74	C.C.—red	.300	1.25	DLO847	C.A.—orange	.800	1.49
MAN 82	C.A.—yellow	.300	.49	DLO850	C.C.—orange	.800	1.49
MAN 84	C.C.—yellow	.300	.99	DL338	C.C.—red	.110	.35
MAN 3620	C.A.—orange	.300	.49	FND358	C.C. ± 1	.357	.99
MAN 3630	C.A.—orange ± 1	.300	.99	FND357	C.C.	.357	.75
MAN 3640	C.C.—orange	.300	.99	FND500	C.C. (FND503)	.500	.99
MAN 4610	C.A.—orange	.400	.99	FND507	C.A. (FND510)	.500	.99
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MAN 6630	C.A.—orange ± 1	.560	.99	HDSP-3403	C.C.—red	.800	1.50
MAN 6640	C.C.—orange—DD	.560	.99	HDSP-3406	C.C. red ±1	.800	1.50
MAN 6650	C.C.—orange ± 1	.560	.99	5082-7751	C.A.,R.H.D.—red	.430	1.25
MAN 6660	C.A.—orange	.560	.99	5082-7760	C.C.,R.H.D.—red	.430	1.25
MAN 6710	C.A.—red—DD	.560	.99	5082-7300	4x7Numeric(RHD)	.600	22.00
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MAN 6750	C.C.—red ± 1	.560	.99	5082-7340	4x7Hxdcl.(0-9/A-F)	.600	22.50
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24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
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18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.59	1.45	1.30

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14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
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16 pin WW	.85	.77	.70
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7106EV/Kit*	IC, Circuit Board, Display	34.95
7107CPL	3½ Digit A/D (LED Drive)	15.95
7107EV/Kit*	IC, Circuit Board, Display	29.95
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7242IJA	CMOS Divide-by-256 RC Timer	2.05
7250IJE	CMOS BCD Prog. Timer/Counter	6.00
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7556IPD	CMOS 556 Timer (14 pin)	2.20
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7631CCPE	CMOS Tri Op Amp Comp. 10MV	5.35
7641CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	Voltage Converter	2.95
8038CCPD	Waveform Generator	4.95
8048CCPE	Monolithic Logarithmic Amp	21.60
8069CCQ	50ppm Band—GAP Volt Ref. Diode	2.50
8211CPA	Volt Ref/Indicator	2.95
8212CPA	Volt Ref/Indicator	2.95

74C

74C00	.39			74C221	1.95
74C02	.39	74C95	1.59	74C240	2.25
74C04	.39	74C107	1.89	74C244	2.25
74C08	.39	74C151	2.95	74C373	2.49
74C10	.39	74C154	3.95	74C374	2.59
74C14	.75	74C157	2.25	74C901	.69
74C20	.39	74C160	1.69	74C903	.69
74C30	.39	74C161	1.60	74C911	10.95
74C42	1.39	74C162	1.49	74C912	10.95
74C48	1.95	74C163	1.69	74C915	1.69
74C73	.79	74C164	1.59	74C917	10.95
74C74	.79	74C173	1.39	74C922	5.49
74C85	1.95	74C174	1.39	74C923	5.75
74C86	.99	74C175	1.19	74C925	7.50
74C89	6.95	74C192	1.69	74C926	7.50
74C90	1.29	74C193	1.69	80C95	.79
74C93	1.29	74C195	1.59	80C97	.79

LINEAR

LH0002CN	6.85			LM702H	.79
LM10CLH	4.50	LM340T-5	1.25	LM703CN	.89
LM11CLH	4.75	LM340T-12	1.25	LM709N	.29
LH0070-0H	4.95	LM340T-15	1.25	LM710N	.79
TL071CP	.79	LM341P-5	.75	LM711N	.79
TL072CP	1.39	LM341P-12	.75	LM723N	.49
TL074CN	2.49	LM341P-15	.75	LM733N	1.00
LH0082CD	35.80	LM342P-5	.69	LM739N	1.19
TL082CP	1.19	LM342P-12	.69	LM741CN	.35
TL084CN	2.19	LM342P-15	.69	MC1741SCG	3.00
LH0094CD	36.80	LM348N	1.25	LM747N	.79
LM300H	.99	LM350K	5.75	LM748N	.59
LM301CN	.35	LF351N	.60	LM1014N	2.75
LM302H	1.95	LF353N	1.00	LM1310N	1.95
LM304H	1.95	LF355N	1.10	LM1458CN	.59
LM305H	.99	LF356N	1.10	LM1488N	1.25
LM307CN	.45	LM358N	1.00	LM1489N	1.25
LM308CN	1.00	LM359N	1.79	LM1496N	1.95
LM309H	1.95	LM370N	4.49	LM1556V	1.75
LM309K	1.25	LM373N	3.25	LM1800N	2.95
LM310CN	1.75	LM377N	2.95	LM1871N	5.49
LM311/CN	.90	LM380N	1.25	LM1872N	5.49
LM312H	2.49	LM381N	1.95	LM1877N-9	3.25
LM317MP	1.15	LM382N	1.79	LM1889N	3.20
LM317T	1.75	LM384N	1.95	LM1896N	1.75
LM317K	3.95	LM386N-3	1.29	LM2002T	1.49
LM318CN	1.95	LM387N	1.45	LM2877P	2.05
LM319N	1.95	LM389N	1.35	LM2878P	2.25
LM320K-5	1.35	LM392N	.69	LM2896P-1	2.25
LM320K-12	1.35	LF398N	4.00	LM3189N	2.95
LM320K-15	1.35	LM399H	5.00	LM3900N	.69
LM320T-5	1.25	TL494CN	4.49	LM3905CN	1.25
LM320T-12	1.25	TL496CP	1.75	LM3909N	1.15
LM320T-15	1.25	NE510A	6.00	LM3914N	3.95
LM323K	5.95	NE529A	4.95	LM3915N	3.95
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LM329DZ	.65	NE536H	6.00	RC4136N	1.25
LM331N	3.95	NE540H	6.00	RC4151NB	3.95
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LM335Z	1.40	NE550A	1.30	RC4195TK	5.49
LM336Z	1.75	NE555V	.39	LM4500A	3.25
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LM337MP	1.15	NE564N	1.95	LM13080N	1.29
LM338K	6.95	LM565N	1.25	LM13600N	1.49
LM339N	.99	LM566CN	1.95	75138N	1.95
LM340K-5	1.35	LM567V	1.25	75450N	.89
LM340K-12	1.35	NE570N	4.95	75451CN	.39
LM340K-15	1.35			75492	.89

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22 pf	.08	.06	.05	.0047µF	.08	.06	.05
47 pf	.08	.06	.05	.01µF	.08	.06	.05
100 pf	.08	.06	.05	.022µF	.09	.07	.06
220 pf	.08	.06	.05	.047µF	.09	.07	.06
470 pf	.08	.06	.05	.1µF	.15	.12	.10

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022mf	.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

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.15/35V	.39	.34	.29	2.2/35V	.51	.45	.34
.22/35V	.39	.34	.29	3.3/25V	.53	.47	.37
.33/35V	.39	.34	.29	4.7/25V	.63	.56	.45
.47/35V	.39	.34	.29	6.8/25V	.79	.69	.55
.68/35V	.39	.34	.29	15/25V	1.39	1.25	.95
1.0/35V	.39	.34	.29	22/6V	.79	.69	.55

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1.0/50V	.19	.16	.12	.47/50V	.16	.14	.13
3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.17	.15	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.21	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.79	.69	.61	220/16V	.25	.21	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

More Details? CHECK—OFF Page 98

the how and why of multiplexing

An interesting communications technique with practical suggestions for Amateur use

Those who have studied for an Amateur license know that radio signals are modulated to transmit intelligence. Such modulation may be thought of as one form of multiplexing — transmitting and receiving simultaneously two or more messages or signals over a common medium.

To consider modulation and multiplex systems, it's best to consider electromagnetic radiation in two different forms or domains. Engineers look at such signals in the time domain, as in a waveform displayed on an oscilloscope; and in the frequency domain, as in a signal displayed on a spectrum analyzer.

Fortunately, there's a convenient way to transform the information contained in one form to that contained in another. It is called the Fourier transform. Any college text on communications systems will have a description of the Fourier transform and its use. The complete derivation of such a transform is mathematically complex and difficult to handle. For the purposes of this article, we'll say that signals can be described in both time and frequency domains. **Fig. 1** shows a few examples of how signals look in these domains. The acronyms used in the article are defined at the end of this article.

There are a number of ways to modulate a carrier with intelligence. Before discussing multiplexing, let's look at the advantages and disadvantages of the different modulation types.

signal modulating systems

The simplest form of modulation suitable for voice transmission is amplitude modulation (a-m). This form of modulation is created by modulating the strength, or amplitude, of a carrier-frequency wave at an audio rate. The simplest case of a-m is shown in the modulated waveform of **fig. 1C**. Amplitude modulation has advantages and disadvantages. One advantage is in the simplicity of the receiver. This is why this form of modulation was used in the first commercial broadcasts and continues to be used today. Among the disadvantages are a waste of transmitter power and a signal-to-noise ratio that can be improved.

The term "signal-to-noise ratio" is used here to denote the quality of a communications system. All communications systems contain some amount of noise. With more signal and less noise, the signal-to-noise ratio increases. All modulation methods can be compared mathematically on the basis of the expected signal-to-noise ratio. In commercial applications, this comparison often determines what is suitable and what is not.

Double sideband. Other derivatives of the amplitude-modulation technique are used by Amateurs. Double-sideband, suppressed carrier, and single-sideband, suppressed carrier are forms based on amplitude modulation. They can, in fact, be created by filtering unwanted components from a normal a-m signal. Double-sideband, suppressed carrier has

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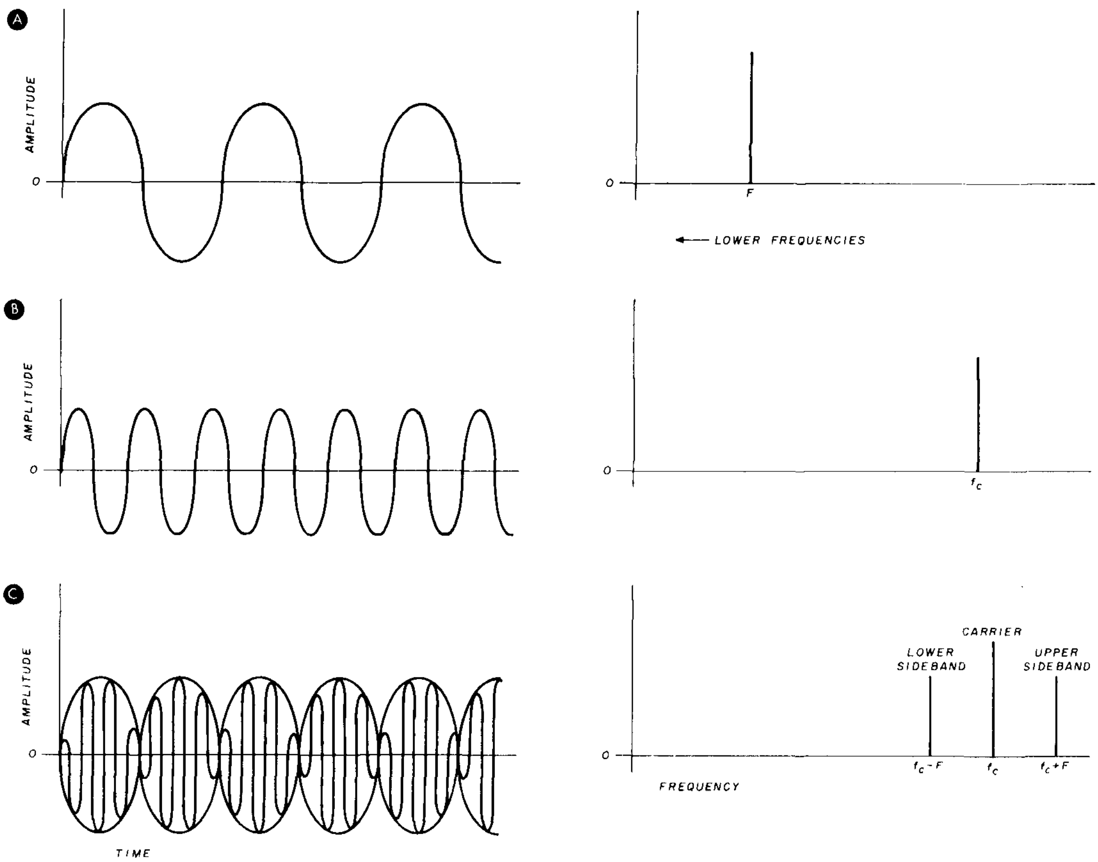

fig. 1. Examples of radio signals in terms of time and frequency domains. In (A), left, a modulating frequency (sine wave) is shown as it would be displayed on an oscilloscope in the time domain. The same signal is shown at right as it would be displayed on a spectrum analyzer in the frequency domain. Drawing (B) shows a carrier signal (also a sine wave) in the time domain (left) and the same signal in the frequency domain (right). A 100-percent a-m carrier, modulated by a single tone of frequency F, is depicted in (C) in the time domain (left) and in the frequency domain (right). F is modulation frequency; f_c is carrier frequency.

the advantage of transmitting information on the signal and eliminating wasted power created by transmitting the carrier signal. It does, however, duplicate the transmission of the information signal by transmitting the same information in both sidebands.

Single-sideband. Single-sideband, suppressed carrier transmission provides some of the most efficient use of the radio spectrum. The intelligence is not transmitted in duplicate, and the power used in transmitting the carrier in other modulation systems is used instead for intelligence.

There is one disadvantage, however. Single-sideband, suppressed carrier provides no reference signal for the receiver to determine accurately the signal center frequency. In many control and signalling applications, this is a serious shortcoming. Without accurate frequency control, for example, Touch-Tone™* signalling is not possible. In Amateur high-frequency applications, the advantages of this mode far outweigh the disadvantages. Operators become accustomed to the sound of single sideband and can eventually understand the signal, even when tuned off frequency.

In critical commercial and military applications, this problem is overcome in a different way. Cesium frequency standards with exceptional accuracy and stability control both transmitter and receiver.

Frequency modulation. Another of the most common modulation forms is fm. It is formed by varying the instantaneous frequency of the transmitted signal at an audio rate (or more precisely, at an intelligence rate). The frequency of the modulating signal

*Touch-Tone is a registered trademark of The American Telephone and Telegraph Company.

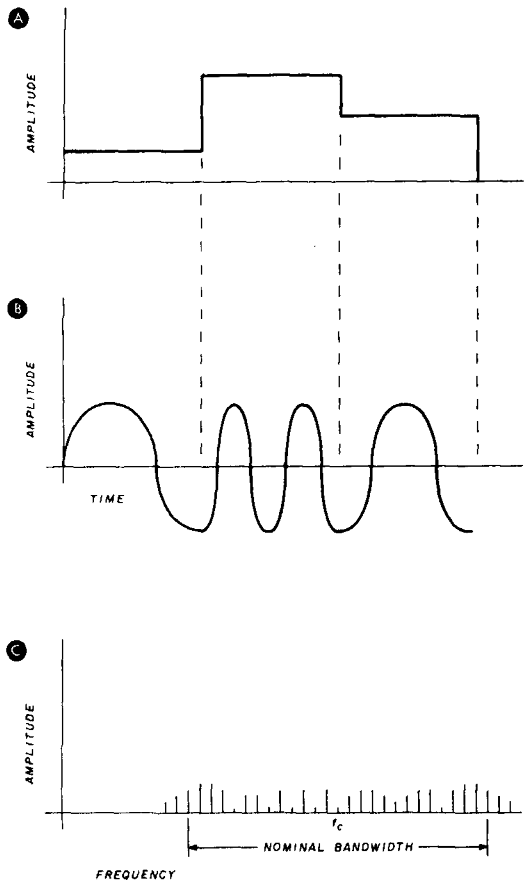

fig. 2. A comparison of an fm signal in the time domain (top two drawings) and in the frequency domain (bottom drawing). The modulating signal is depicted in (A), with the resultant transmitted signal shown in (B). The same signal and its nominal bandwidth, which is a function of deviation, is shown in (C).

is determined by how many excursions across the center frequency are made in a given period. The amplitude of the modulating signal is determined by the amount of actual frequency change. A wider frequency excursion is indicative of a higher modulating amplitude. The comparison of an fm signal in the time and frequency domains is more complex than that of an a-m signal (**fig. 2**).

Frequency modulation can take on different characteristics depending upon the width of the signal, or deviation.* When the signal is modulated to produce a signal approximately the same width as a standard double-sideband a-m signal, it provides a signal-to-noise ratio equal to that of an a-m signal. This is the case with the modulation used on 2-meter fm.

It does have some advantages over a-m, however. One of the advantages is that fm can be amplified by a class-C amplifier. On first inspection this may not seem to be such a tremendous advantage. There are cases, however, where it's either impossible or impractical to create a good class-A or class-B amplifier. It's much easier in most cases, for example, to operate a microwave system with fm rather than a-m. In the past, it was not possible to produce and amplify an a-m signal at these frequencies.

Fm exhibits a very interesting threshold effect. In the reception of fm, once the signal level has increased beyond a particular level, there is no significant improvement in signal-to-noise ratio that can be obtained by an increase in power. This effect can be used to advantage in an fm system.

Where fm really comes into its own is in wide-band applications. An improvement in signal-to-noise ratio

*That is, the excursion of the modulated signal in the frequency domain. **Editor**

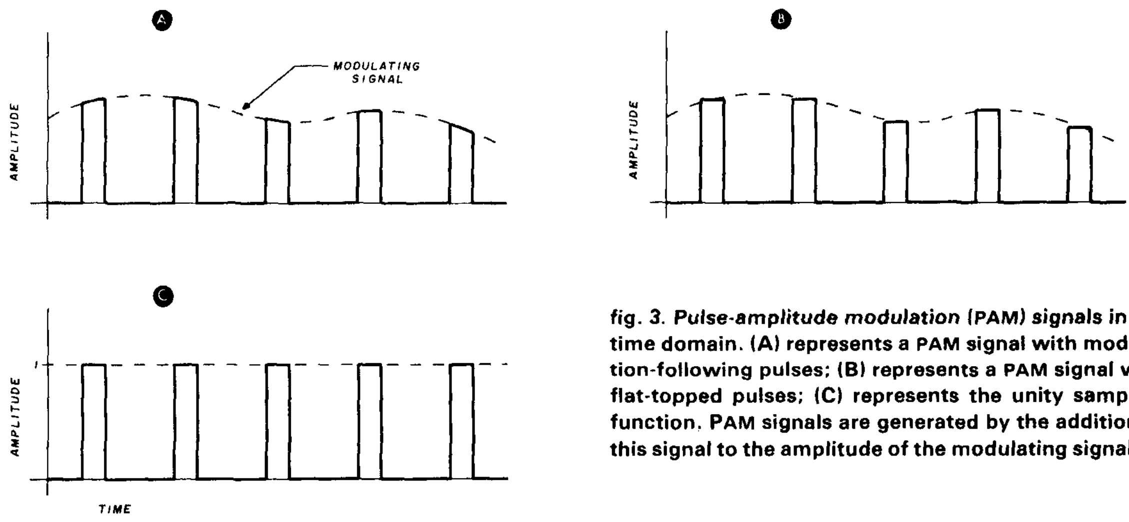

***fig. 3. Pulse-amplitude modulation* (PAM) signals in the time domain. (A) represents a PAM signal with modulation-following pulses; (B) represents a PAM signal with flat-topped pulses; (C) represents the unity sampling function. PAM signals are generated by the addition of this signal to the amplitude of the modulating signal.**

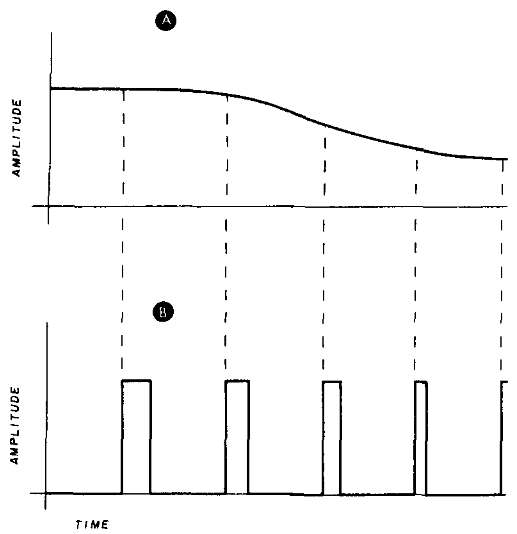

fig. 4. Example of pulse-duration modulation (PDM). The amplitude of the modulation signal controls the width of the transmitted pulse. The modulating waveform is represented in (A); the PDM waveform in (B).

can be achieved at a sacrifice of bandwidth. For many years this phenomenon was not appreciated. After all, it doesn't make sense that a wider bandwidth, which allows more noise energy to enter the system, would allow better reception. There are a couple of ways to implement this effect, and it usually involves detectors in the receiver that apply frequency-compression feedback. In this process, the receiver i-f bandwidth is made to look narrower than the transmitted signal. Many critical commercial applications make use of this method when the spectrum bandwidth is available.

digital-modulation methods

Some of the greatest technical strides have recently been made in digital modulation techniques. There are a number of different methods:

Pulse-amplitude modulation. This form of modulation, as in all digital methods, relies upon a principle called sampling. The sampling theorem states that, if the information signal is sampled at a fast enough rate, the signal can be reconstructed on the basis of the sample values. This is further refined in the Nyquist theorem, which states that the minimum frequency at which the samples may be taken is twice the frequency of the highest frequency component in the information signal.

The samples may be thought of as having been taken instantaneously and transmitted in the same way. This, then, provides the amplitude of the information waveform at discrete intervals of time. In pulse-amplitude modulation, this information is used to determine the amplitude of the transmitted pulse, as the name implies. This modulation method is shown in **fig. 3**. Note that the pulses can be modulated as flat-topped pulses (**fig. 3B**) or following the signal waveform during its period of transmission (**fig. 3A**). If the pulses are transmitted sufficiently fast that time is still available between them, the possibility exists to put other information in the spaces. (We will examine this in more detail a little later.) PAM is one of the easiest forms of digital modulation to recover, since a lowpass filter will recover the original modulating waveform. In fact, most forms of digital modulation are converted back into PAM in the demodulation process to recover the signals.

Pulse-duration modulation. The next modulation form we will consider is *pulse-duration modulation* (PDM). In this method, the amplitude of the modulating signal controls the width of the transmitted pulse. An example is shown in **fig. 4**. The simplest way to generate the pulses is to allow a time-constant circuit to charge or discharge to the modulating signal amplitude and allow the duration of this process to control the pulse length. In the demodulation-process, as stated above, the PDM signal is usually converted into a PAM signal, then demodulated as a PAM signal.

The PDM signal has a very interesting advantage. The receiver must make a relatively simple decision — is the pulse there or is it not? This can be compli-

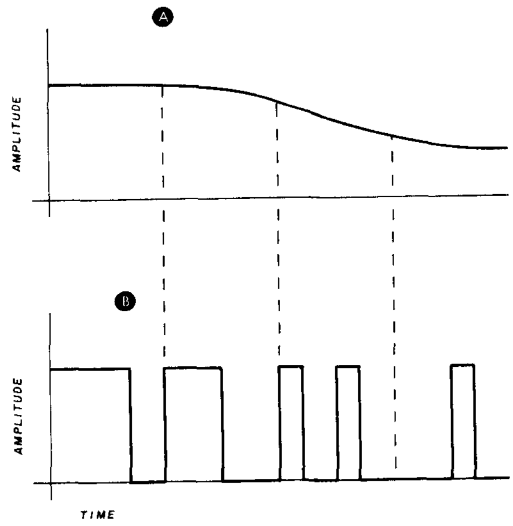

fig. 5. Pulse-code modulation. The modulation waveform, (A), results from the digital representation of the signal, (B).

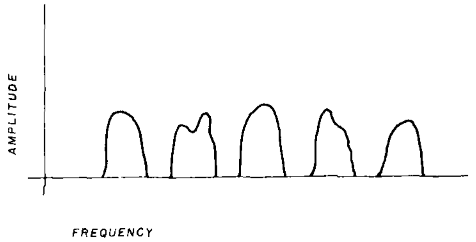

fig. 6. *Example of frequency-division multiplexing (FDM) depicted in the frequency domain. Individual SSB signals are combined and transmitted by one transmitter. An example might be an OSCAR downlink.*

cated by noise; but in general, it allows for improvement of the signal-to-noise ratio in otherwise marginal conditions. The received signal can be hard-limited, removing all amplitude information, to overcome a fairly large amount of amplitude variation or QSB.

Pulse-code modulation. Another form of digital modulation is pulse-code modulation (PCM). It is produced by transmitting some digital representation of the signal rather than the signal itself (**fig. 5**). For example, the binary-coded decimal value of the voltage at the time of the sampling could be transmitted directly. This would result in the transmission of a series of pulses for each sample rather than the single transmitted pulse for each sample as in PAM and PDM. PCM has the advantage, shown by PDM, in that the detector must make the simple decision of whether the pulse was, or was not, transmitted.

Other interesting properties may also be used in PCM. The transmitted code can be specially formulated to improve the signal-to-noise response of the system. In this way, the code predicts what a typical noise burst would do to the received signal and attempts to provide a received signal that will allow less ambiguity. This system is presently the subject of much interest and research in commercial and military areas.

Well, this has been a fairly rough overview of most of the modulation systems. All can and are used in multiplexing. So what is this multiplexing, anyway?

multiplexing

The dictionary defines multiplex as "...a system for transmitting or receiving simultaneously two or more messages or signals over a common circuit, carrier wave, etc." Amateur Radio operators, in general, don't know too much about this technology. In general, we don't have much need for it. Most Amateur communications are conducted on one simplex circuit with no need for simultaneous transmission. Let's look at some ways we can make use of multiplex systems.

In commercial and military communications areas, multiplex is a necessity. These users are concerned with the transmission of many messages at the same time. Imagine the expense it would require to use a separate radio for each telephone conversation! Many different multiplex methods are used to accomplish this requirement.

We've seen that signals can be represented in both the frequency and time domains; this suggests two ways to multiplex signals. In fact, methods are used in which signals are multiplexed in both time and frequency. First let's look at methods of multiplexing signals in the frequency domain.

One method involves the placement of many different signals side-by-side in frequency in the transmitted signal — called frequency-division multiplex, or FDM. A way of looking at this is to consider a number of fm signals being transmitted in a given band. All these signals could be transmitted by a single transmitter rather than the many signals required for single-signal transmission.

The individual information signals could also be modulated by amplitude-modulation-based techniques. This could use single-sideband modulation to reduce the spectrum space required by the signals. In this way the transmitter of the OSCAR satellites could be thought of as a multiplex system. All of the input signals are combined and transmitted by one transmitter on the downlink side. **Fig. 6** shows how the transmitted signal might look in the frequency domain with separate single-sideband signals multiplexed.

There is another form of frequency multiplexing — the frequency modulation of the main carrier with frequency-modulated subcarriers. The representation of the final modulated signal is much more complex than that of normal FDM as shown in **fig. 6**. This is due to the rather complex nature of the display of fm in the frequency domain, as shown in **fig. 2**. This is the most common of multiplex systems used in common-carrier microwave systems, as we shall see later. It can be referred to as fm-fm.

Digital-modulation types offer relatively simple

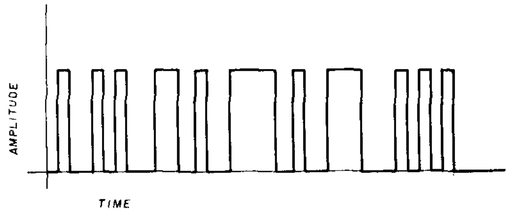

fig. 7. *One time-division multiplex (TDM) interval or frame, which combines digital signals of different types and data rates.*

multiplexing in the time domain. Taking another look at **figs. 3**, **4**, and **5** we see that there is space between the transmitted pulses in each case. If the pulses are transmitted in a short enough period of time, there is enough room to insert many additional signals. This is called time-division multiplex, or TDM. All this requires is that each individual signal be sampled (and the sample transmitted) faster than the Nyquist rate (discussed previously). The samples can be transmitted as they are taken, or they can be stored to be transmitted at an appropriate time.

Any of the digital modulation types can be used in TDM. All that is required of them is that they be separated from the other signals in the time domain at the receive demultiplexer. In fact, digital signals of different types and different data rates can be combined in one TDM signal. The entire combination of signals transmitted in one interval is called a frame. An example of a TDM frame is shown in **fig. 7**. Often a group of signals can be combined into a TDM frame before they are combined with another similar group for the final transmitted frame. This can be referred to as low-speed and high-speed TDM. The low-speed TDM frames are combined to be transmitted as one high-speed TDM frame.

commercial multiplex applications

Now that we know what multiplex is, what are some of the commercial applications? Broadcast television can be thought of as a form of FDM. The video and audio information is transmitted by the same transmitter using separate carriers for the two signals. In this particular case, the audio is transmitted using fm and the video with a form of a-m — vestigial sideband amplitude modulation. In vestigial sideband, one of the sidebands is suppressed beyond a certain cutoff frequency but the carrier is transmitted at full power.

Broadcast fm stereo (often called fm multiplex) uses another special form of multiplex technique. In this type of signal, the main frequency-modulated signal carries the information for the left plus the right channels. A monophonic receiver detects only this signal. A double-sideband, suppressed-carrier signal transmitted with the fm signal carries the left minus the right channel information. The stereo receiver detects this signal, then algebraically subtracts it from the fm signal to produce the right and left channel information.

Another form of multiplex with commercial applications is voice frequency carrier telegraph, or VFCT. In this system a group of FSK (frequency shift keying) signals are combined in a form of FDM. The individual FSK signals are produced by shifting them over a narrow range of frequencies in the audio range. The resultant signals are then combined and transmitted with a single transmitter. The most common use of this system is in the simultaneous transmission of a group of teletypewriter signals. Different standards exist for the number of channels and the audio frequencies used, based upon the speed and necessary quantity of individual circuits.

In an earlier paragraph I made reference to an fm-fm system. This is the most common type of multiplex used in normal microwave circuits. In this method individual circuits are combined into groups. The groups are then combined into supergroups, and the supergroups are combined into a mastergroup. The normal commercial standard calls for twelve channels to be combined to form one group. Five groups are combined into one supergroup. Eleven supergroups are then combined into one mastergroup. This produces a link that will support 660 circuits (or channels) on one mastergroup. Mastergroups can then be combined to form multimastergroups. One commercial standard calls for the combination of six such mastergroups.

It can be seen that the resultant signal that is finally transmitted will be quite complex. It requires extensive frequency modulation detection, and the modulation for any given channel is effectively distributed across the entire transmitted spectrum. This system was the standard for many years because of the relative ease of modulating a tube microwave system with fm signals. In later years TDM techniques have proven more desirable.

With the advent of low-cost digital integrated circuits, TDM systems have been able to demonstrate distinct advantages at an over-all reduction in price over analog techniques. Standards have been developed to modulate the audio signals from a telephone and process them through the complete telephone exchange and send them out on long-distance microwave links, still in digital form.

One form of TDM gaining wide commercial acceptance calls for the combination of a group of audio signals, reduced to PCM data streams, onto a single PCM signal at a rate of 1.544 megabits per second (1.544×10^6 binary digits per second). These signals can then be further combined into larger PCM systems before transmission.

Commercial systems are also being created to handle digital information; that is, information which is already in digital form, using PCM networks. This technique is ideal for computer or teleprinter traffic. Systems have been demonstrated that allow signals of various data rates to be supported by a common system. The possible uses of such a system are limited only by the imagination of the users.

Amateur applications

Now that we have seen the different multiplex sys-

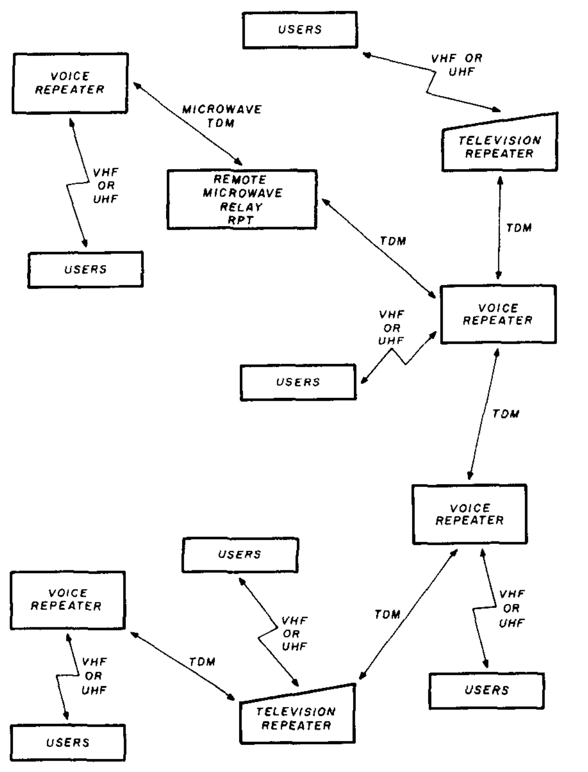

fig. 8. Suggested repeater interconnection network using time-division multiplex.

tems and how they are being used commercially, how can we as hams make use of them? Many possible applications are with us now, and many more are just a short time away.

Traffic nets. Let's look at the possible applications in the Amateur traffic nets. For years the Navy has used a form of high-frequency radioteletype broadcast. In this system the traffic for a whole group of ships is transmitted over a common VFCT. This VFCT multiplex group is even relayed to various points and retransmitted in its entirety to enable reception over a larger area. In this way, Amateur traffic for a large area could be transmitted over one VFCT system. Individual channels could be designated for certain sub-areas or for a particular net handling a certain type of traffic. Confirmations could be received over a different frequency in duplex fashion, and channels could be designated as reroute channels for traffic that was earlier transmitted and not confirmed. With a network of such VFCTs, the different traffic areas could be interconnected. In the long run, a computer could be used to receive the messages on individual circuits then combine them into the VFCT and wait for confirmations. It would determine either independently or with manual direction which route to send the message.

Repeater links. Another possible Amateur application is the interconnection of a group of repeaters. In this system users could select, through a remote-control system, which of the repeaters would be interconnected. A multiplex link could be provided from each of the repeaters in the group to each of the others. The control system would then decide which of the multiplex channels to interconnect. The multiplex system itself could use either the FDM or TDM techniques described above.

Now we can examine some firm proposals for such a repeater interconnecting multiplex system. TDM systems are taking over as the preferred method in the commercial field and would probably be best for us to use as well. TDM has some very real advantages for our uses. Foremost is its capability to support various data rates in one TDM system. This would allow normal voice repeaters to be connected to other similar repeaters in the system as well as provide separate channels for signaling applications. These signaling channels could use much lower data rates than those required for voice yet provide superior interconnecting control reliability. The same TDM system could also support interconnections of RTTY repeaters. Many RTTY channels could be placed in the same space as that required for one voice channel. In the long run, the same TDM system could support television repeaters. The video and audio signals could be digitized and transmitted as just another TDM component.

Hardware and bandwidth considerations. TDM equipment from commercial manufacturers is presently quite expensive, and few or no surplus sources exist. Fortunately, though, the equipment is fairly easy for Amateurs to construct to their specifications. The primary ingredients are digital integrated

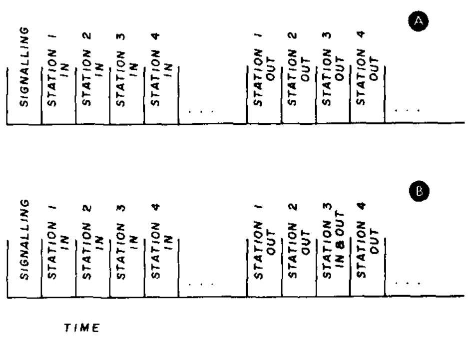

fig. 9. Example of TDM time-frame exchange at a particular repeater station. The incoming and outgoing TDM time frames at Station 3 are depicted in (A) and (B) respectively.

circuits, which are not all that expensive. Also, their use is fairly well understood by many Amateurs. About the only disadvantage to the use of TDM is the need to place the TDM signal on an Amateur frequency where pulse transmission is permitted. In general, the spectrum bandwidth necessary to transmit the digital representation of speech is wider than that required to transmit a normal amplitude-modulation representation.

Fig. 8 shows how some of these repeaters could be interconnected. This is just an example of the way the interconnection would be made. Many more repeaters of all types could be provided, rather than the limited number shown. Let's consider how this would be put in use to provide interconnections for twenty repeaters all along the West Coast.

Suggested repeater interconnection system. Each repeater would have the primary capacity of operating as an independent repeater — just as an existing repeater would do now whether the modulation is audio, RTTY, or television. In addition to this capability, each repeater would have a microwave radio transmitter and receiver, which would provide a link to the TDM interconnection. The microwave equipment would transmit all the TDM channels just as they had been received except for a) one channel designated as the incoming channel, and b) one channel designated as the outgoing channel for that particular repeater. On those channels, the multiplex equipment would demodulate the incoming signal and modulate the outgoing one. This in itself would be a tremendous advantage over FDM systems.

In FDM systems, a separate modulator system would be required for each channel, when in fact only one channel would be used at a particular time. This requirement exists because the individual channel modulators would have to be tuned to the subcarrier to be used. It would be very difficult to have the system function with a single modulator that would be somehow made to retune to the desired channel. In a TDM system, all that is required is that the system wait for another period of time before extracting or inserting the desired channel information from the TDM frame. A single-channel TDM multiplexer and demultiplexer would be all that the station required. As an alternative, a second channel could also be used for signaling, both incoming and outgoing. This channel would be shared by all the stations and be a common signaling channel. **Fig. 9** shows an example of the TDM frame received and transmitted at a particular station.

Note that in **fig. 9** the only real change in the frame is the contents of the TDM channel designated for Station 3 out. Station 3 combines the signal coming into the station on the Station 3 in channel with the normal output of the repeater. In this method, all the switching is done at the station originating the interconnection. Let's look at how this action would be performed.

Operation. To initiate the process, a user would call in to the repeater connected to the system that would be most easily accessed. Upon hearing no traffic on the repeater, the user would initiate the control sequence requesting the interconnection. This could consist of Touch-Tone™ digits for the address of the repeater requested. A TDM system at the repeater used by the caller would then select the channel from the TDM frame that carried the information for the requested repeater's output channel. This would be connected to the normal downlink transmitter from the originating repeater. The system would also transmit a short tone on the downlink from the repeater to indicate that the interconnection had been made. It would then connect the input signal from the user to the originating repeater to the in channel on the TDM frame for the requested repeater. When traffic is heard on the requested repeater, the user could make the call. Or, the user could just listen to the distant repeater and make no call — just wait for his party to show up.

Other uses. In the long run the system could be standardized, and even the frequencies of the repeaters themselves could be reused. This would allow a user with a small crystal-controlled handheld radio to access the system from many of the repeater locations and communicate through the entire system.

The uses of such a repeater interconnection are again limited only by our own imagination. It would be possible to interconnect many different types of repeaters with the same TDM network, as shown in **fig. 8**. A repeater that had become a part of the system (and had a microwave TDM system with a radio relay) could decide not to participate for some reason. All that would be necessary to remain out of the interconnection net would be to block the output TDM channel from that station.

The system could also be used to provide a very wide area of autopatch access for participating stations. This could be of tremendous value in remote areas during disasters. When normal commercial telephone communications are lost in an area, the interconnection system could be used to access an autopatch at any of the participating repeaters.

In the Amateur traffic area, such a system could have great value. The system could support data to many different points at very different data rates in an automated teleprinter traffic environment. Particular nodal stations could guard a given TDM channel and relay the traffic into other traffic nets, either with high-frequency radio or VHF into repeaters within range of the nodal station. A high-volume nodal station may be assigned a 1200-baud circuit, with a single 75-baud circuit assigned to a station with relatively light traffic loads. Dedicated channels could be used to transmit traffic to a nodal station through various other transmission media.

With all the advantages such a system could provide, there are many other factors that would indicate that now is the time for the Amateur community to begin operations. The technology is now available to construct a TDM system with relative ease. Problems that had proven just too costly to deal with in the past have been overcome with integrated circuits. Such a TDM system is well within the realm of Amateur construction.

The Federal Communications Commission has recently taken very permissive views toward regulation. Many of the restrictions that had previously eliminated repeater interconnections have been done away with. It remains up to us to put the system in operation and work out any technical details — after all, that is one of the goals of Amateur Radio. The opportunity exists for us to demonstrate the capability of such a system for commercial use. So what are we waiting for?

As in all modes, the increased communications possibilities open questions of how to use them, which will have to be worked out by the using groups — political problems. The basic philosophy of how the system will be used will have to be determined. Some groups will welcome wide use by visitors, for instance, while others will wish to receive the benefits of their investment themselves. This is nothing new to us. It just provides many more possibilities for increased technical capabilities and increased public service.

glossary of terms

PAM	pulse-amplitude modulation
PDM	pulse-duration modulation
PCM	pulse-code modulation
FDM	frequency-division multiplex
TDM	time-division multiplex
VFCT	voice-frequency carrier telegraph

bibliography

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Taub, Herbert and Schilling, Donald L., *Principles of Communications Systems,* McGraw-Hill Book Co., 1971.

Reference Data for Radio Engineers, Howard W. Sams & Co., Sixth Edition, 1977.

Many other college-level textbooks are available containing detailed descriptions of multiplex techniques.

ham radio

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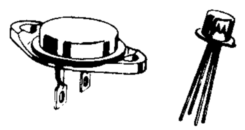

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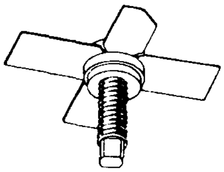

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Questions and Answers

Entries must be by letter or postcard only. No telephone requests will be accepted. All entries will be acknowledged when received. Those judged to be most informative to the most Amateurs will be published. Questions must relate to Amateur Radio.

Readers are invited to send a card with the question they feel is most useful that appears in each issue. Each month's winner will receive a prize. We will give a prize for the most popular question of the year. In the case of two or more questions on the same subject, the one arriving the earliest will be used.

radio waves

How fast does a radio wave travel, at the speed of light or slower? — Eugene Gabry, WB9VTF.

The velocity of a radio wave depends on the dielectric constant of the medium through which the wave travels. Air has a dielectric constant of unity, and radio waves travel through this medium at a speed very near to that of light in a vacuum, which is approximately 186,000 miles per second (3×10^8 meters per second).

In a medium that has a dielectric constant greater than unity, the radio wave travels at a lower velocity. For example, coaxial transmission line using polyethylene foam insulation has a dielectric constant of about 1.08, so radio waves propagate through this coax at something less than the speed of light through a vacuum. Thus when determining the electrical length of a transmission line, the velocity of propagation of the radio wave through the line, as well as other factors, must be taken into account.

FCC rules

I would like a correct interpretation of the FCC rules concerning third-party traffic. — Ralph R. Schlick, NØBOQ.

As of this writing, the FCC rules pertaining to third-party traffic consist of section 97.79, "Control Operator Requirements," and section 97.114, "Third-Party Traffic."

Section 97.79 states:

"The licensee of an amateur radio station may permit any third party to participate in amateur radio communication from his station, provided that a control operator is present and continuously monitors and supervises the radio communication to insure compliance with the rules."

Section 97.114 states:

"The transmission or delivery of the following amateur radiocommunication is prohibited.

"(a) International third party traffic except with countries which have assented thereto."

"(b) Third-party traffic involving material compensation, either tangible or intangible, direct or indirect, to a third party, a station licensee, a control operator, or any other person."

The FCC has proposed a revision of all the rules governing the Amateur Radio service, including those quoted above, in an effort to make them more understandable. Called the "plain-language" revision (Docket 80-729), the new rules might well become effective in the foreseeable future.

Reading the sections regarding third-party traffic in the existing rules, it is easy to understand how they could be confusing. In its new, "plain-language" revision, the FCC has attempted to define "third-party messages" and has simplified the existing rules. They have also added information on transmitting one-way communications for third parties, the reason being that one-way communications do not meet the existing definition of third-party messages. Other changes have been made to make the proposed rule consistent with Article 41 of the ITU rules, which refers only to the transmission of third-party communications being prohibited.

It's hoped that the new "plain language" rules will be easier to interpret. We'll just have to wait and see.

SWR meter

Is there any way to troubleshoot a defective SWR meter without a manual? I knew the instrument was defective after having placed a second meter that I know was OK in the line. The meter was made in Japan and the only name on it is "MARS Standing Wave Indicator SW-10." — Lewis I. Hegyi, N2BPO.

Without knowing anything about your meter, I find it difficult to offer any definite advice. If it is an inexpensive reflectometer, it probably contains a bridge circuit and a meter to indicate when bridge balance has been achieved. Most are not calibrated and therefore cannot be used to measure actual standing-wave ratio. Such instruments are generally used in conjunction with matching networks to indicate minimum reflected voltage or power.

Assuming there is no mechanical damage of components, you can make some simple tests to determine if the bridge elements are defective, either by substitution or by measuring resistance and capacitance. The resistors making up the bridge arms should be equally matched to obtain a good null on the meter. It's possible that the meter movement is burned out, as these simple reflectometers are usually designed to be operated at very low power. **ham radio**

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WANTED: Sturdy Tower tapered or wide leg guyable design, 80 feet or higher. John Thomas, 58 Albert North, Lindsay, Ontario, Canada K9V 4J8. (705) 324-3709.

ROHN TOWER — direct to you from worldwide distributor, all products available. Sample prices - 25 G sections $40.54 each, 45 G sections $91.85 each. BX 48 Tower $231.00 each. Hill Radio, Box 1405, 2503 G.E. Rd., Bloomington, IL 61701. (309) 663-2141.

WANTED: Microwave Test Equipment, 2 to 12 GHz, sweep generators, network analyzer, signal generators, counters, etc. John Thomas, 58 Albert North, Lindsay, Ontario, Canada K9V 4J8. (705) 324-3709.

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MANUALS for most ham gear made 1937/1970. Send $1.00 for 18 page "Manual List", postpaid. HI-MANUALS, Box H802, Council Bluffs, Iowa 51502.

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

WANTED: CQ Surplus Conversion Handbook. Advise edition, condition, price. M. Potter, RR 1, Box 43, Limoges, Ontario, Canada K0A 2M0.

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FOR SALE: Heathkit HW-12 80 meter transceiver with HP-13B mobile power supply, 80 meter mobile resonator and both manuals. Good condition, $125.00. 715-223-2135, WA9ZCO, Box 278, Abbotsford, Wisconsin 54405.

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FOR SALE: YAESU FT-101 MARK I XCVR, excellent condition with original manual; $450. HEATHKIT SB-301 RCVR also in excellent condition; $230. EICO 722 VFO; $25. HEATHKIT Electronic Keyer, HD-1410, LN; $45. Jack Thompson, 2504 Beaverbrook Dr., Greensboro, NC 27406. 919-274-8831.

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

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

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

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

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

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

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Coming Events

ACTIVITIES

"Places to go..."

ALABAMA: The Calhoun County Amateur Radio Association's second annual Hamfest, Saturday, September 26, 9 AM to 5 PM, and Sunday, September 27, 9 AM to 3 PM, Municipal Auditorium, 1128 Gurnee Avenue, Anniston. Admission and parking free. Donations: $1 for one, $5 for 6. Tables $3 one day; $5 two days. Free overnight parking available for self-contained RVs. Air-conditioned exhibits, free bingo, hourly door prizes and more. Sunday drawing: Ten-Tec Delta 580. Talk-in on 69/09. Reduced rates and hospitality room Saturday evening at Anniston Downtowner Motor Inn. Information: Dale Boothe, KA4LRL, c/o CCARA, P.O. Box 1624, Anniston, AL 36202.

CALIFORNIA: The Golden Empire Flying Club jointly with Radio Systems Technology, announces the annual Fly-In and Avionics Swap Meet, Sunday, September 27, Nevada County (CA) Airpark. Swap Meet free. Table space limited.

COLORADO: The Boulder Amateur Radio Club's BARC-FEST/81, Sunday, September 27, 9 AM, Boulder National Guard Armory, 4750 North Broadway, Boulder city limits. Donation: $2.00 per family includes swap space and door prize drawing. There will be a snack bar and auction. Talk-in on 146.10/70 and 146.52. For further information: Mark Call, NØMC, 4297 Redwood Ct., Boulder, CO 80301. (303) 442-2616.

FLORIDA: The Florida Gulf Coast Amateur Radio Council's "Suncoast Convention" (formerly Clearwater Convention), October 3 and 4, Sheraton Sand Key Hotel (same location as 1979). For information: Florida Gulf Coast Amateur Radio Council, Inc., P.O. Box 157, Clearwater, FL 33517.

GEORGIA: Augusta Amateur Radio Club's annual Hamfest will be held September 20, 1981, at the Julian Smith Casino. Prizes will be a DenTron Clipperton L, a Cushcraft A4 Tribander, and an Icom IC2A. Bingo for the family. Talk-in 34-94. Tailgating $3.00 includes one ticket. Tickets $1.00 each. Further information call Diane, WB4YHT, (404) 860-3700.

GEORGIA: The 8th annual Lanierland ARC Hamfest, September 27, 9 AM, Gainesville, Holiday Hall at Holiday Inn. Free tables, inside display area for dealers and distributors. Flea Market. Boat anchor auction. Prizes, activities. Doors open 8 AM for dealer set-up. Activities and facilities free. Prize tickets $1.00 each, 6/$5.00. Talk-in on 146.07/.67. For information: Paul Watkins, W4FDK, Rt. 11, Box 536, Gainesville, GA 30501. (404) 536-8280.

ILLINOIS: The Sangamon Valley Radio Club of Springfield's Sixth annual Hamfest, Sunday, September 27, Sangamon County Fairgrounds, New Berlin. Flea Market, exhibits, kids' activities, food available. Overnight camping. Tickets: $2.00 advance, $2.50 gate. First prize: ICOM Synth. HT. For information: S.V.R.C., c/o Red Cross Bldg., 1025 S. Sixth St., Springfield, IL 62703.

INDIANA: The Marshall County Amateur Radio Club's 6th annual Hamfest and Electronic Flea Market, Sunday, September 20, 4-H Fairgrounds, Argos. Tickets: $2.00 advance; $2.50 door. Door prizes, refreshments. Grand Prize $200.00. Hourly drawings. Dealers 6 AM, public 8 AM to 4 PM. Talk-in 146.52, 146.07 - 146.67 and 222.9 - 224.5. For information: Paul R. DeVos, WB9VFJ, 109 Maple Avenue, North Liberty, IN 46554. (219) 656-4631.

IOWA: The Cedar Valley Amateur Radio Club's 7th annual Hamfest, Sunday, September 27, Hawkeye Downs Exhibition Building, Cedar Rapids. Tickets: $2.00 advance, $3.00 door. Prizes: Kenwood, ICOM, Collins and more. Overnight camping area. ARRL representatives, movies. Talk-in 146.16-.76, .52, 223.34-.94. For tickets, reservations: CVARC Hamfest, P.O. Box 994, Cedar Rapids, IA 52406.

More Details? CHECK—OFF Page 98

KENTUCKY: The eleventh annual Greater Louisville Hamfest and Great Lakes Division Convention, September 26 and 27, East Hall, Kentucky Fair and Exposition Center, Louisville. Air-conditioned exhibit area and flea market. For information: Greater Louisville Hamfest, P.O. Box 34444, Louisville, KY 40232. (502) 634-0619.

LOUISIANA: Amacom '81, the New Orleans Hamfest-Computerfest, sponsored by the Jefferson Amateur Radio Club, October 17 and 18, Airport Hilton Inn, across from New Orleans International Airport, Kenner. For information: New Orleans Hamfest-Computerfest, P.O. Box 73665, Metairie, LA 70033.

MARYLAND: The Columbia Amateur Radio Association's 5th annual Hamfest, Sunday, October 11, 8 AM, Howard County Fairgrounds. Admission: $3.00. Tailgating and tables $6.00. Food available. Prizes. Talk-in 147.735/135; 146.52/52. For table reservations and information: Dennis Parra, 6955 Spinning Seed, Columbia, MD 21045.

MASSACHUSETTS: The 19-79 Repeater Association of Chelsea will hold its annual Flea Market, Sunday, October 4, 11 AM to 4 PM (sellers 10 AM), Beachmont VFW Post, 150 Bennington Street, Revere. Admission $1.00. Sellers' tables $6.00 advance; $8.00 door. Talk-in on 19-79 and 52. For table reservations send check to: 19-79 Repeater Association, P.O. Box 171, Chelsea, MA 02150.

MICHIGAN: The Grand Rapids Amateur Radio Association's annual Swap and Shop, Saturday, September 19, Hudsonville Fairgrounds. Door prizes, dealers, indoor/outdoor swap area. Gates open 8 AM. Talk-in on 146.16 - 146.76. For information: Grand Rapids Amateur Radio Association, P.O. Box 1248, Grand Rapids, MI 49501.

MICHIGAN: Adrian Amateur Radio Club's 9th annual Hamfest, Sunday, September 27, Lenawee County Fairground, Adrian. Tickets: $1.50 advance, $2.00 door. Prizes, games, programs, bingo and more. For information and reservations: Adrian Amateur Radio Club, P.O. Box 26, Adrian, MI 49221.

MICHIGAN: Blossomland Amateur Radio Association's 16th annual Hambash, Sunday, October 5, 8 AM to 3:30 PM EST, Lake Michigan College Convention Center, Benton Harbor. Giant flea market, interesting programs. Tables $5.00 each. Tickets: $2.00 advance, $3.00 door. Children under 12 (with families) free. Enjoy a Michigan weekend: cohofishing, Oktoberfest and more. Talk-in on 22/82 or 52 simplex. For tickets and information: SASE to BARA, P.O. Box 175, St. Joseph, MI 49085.

MICHIGAN: L'Anse Creuse A.R.C.'s 9th annual Swap and Shop, September 20, 0900-1500, L'Anse Creuse High School, Mt. Clemens. Tickets: $1.00 advance, $2.00 door. Prizes: First, $250.00, second $100.00, third, $50.00 plus prize drawings hourly. ARRL, FCC. Talk-in 147.69/09 and 146.52. For information: SASE Mike Corcoran, 650 Chippewa, Mt. Clemens, MI 48043.

MICHIGAN: The Big Rapids Area Amateur Radio Club's First Annual FOX HUNT, October 17, 10 AM, Hemlock Park, Big Rapids. Bring the family; sell or swap Ham gear; win prizes. Refreshments, tables, grills available. Advance/door $3.50 per vehicle. Talk-in 146.52. For information/registration: B.R.A.A.R.C., P.O. ox 1073, Big Rapids, MI 49307.

NEW HAMPSHIRE: The 5th annual Connecticut Valley FM Association's Hamfest/Flea Market, Sunday, September 27, 9 AM to 5 PM, King Ridge Ski Area, New London. Adult admission: $1.00, children under 16 free, flea market set-up $5.00. For information: Connecticut Valley FM Assn., Box 173, E. Wallingford, VT 05742.

NEW YORK: The Radio Amateurs of Greater Syracuse Hamfest, October 3, Art & Home Building, New York State Fairgrounds, Syracuse. For information: RAGS, P.O. Box 88, Liverpool, NY 13088.

NEW YORK: Giant Electronics Flea Market sponsored by the Yonkers Amateur Radio Club, Sunday, October 4, 9 AM to 5 PM, Loral Electronics Parking Lots, Fullerton Avenue, Yonkers. Hourly prizes. Live demonstrations. Free coffee to 10 AM. Auction 3 PM. Admission: Advance $1.50, $2.00 door. Sellers: Advance $4.00, $5.00 door. Bring tables. For further information: Call (914) 969-1053.

NEW YORK: The Long Island Mobile Amateur Radio Club's ARRL Hamfair '81, Part II, September 27, Islip Speedway, Islip. Refreshments available. Awards presented all day. No reservations needed for space. Free parking. General admission: $2.00. Ladies and children free. All licensed Amateurs must pay admission. Heavy rain date October 4. For information: Sid Wolin, K2LJH, (516) 379-2861 or Hank Wener, WB2ALW, (516) 484-4322 nights.

NORTH CAROLINA: The Western North Carolina ARS will hold its Autumnfest, October 10, Asheville Civic Center. Admission: $3.00 advance; $3.50 door. McElroy Memorial CW competition, dealers, flea market, demon-

NEW products

Econo-Pak resistor organizer

Century Electronics offers a wide assortment of fixed resistors in an attractive and convenient storage case. The GL-25 Econo-Pak Resistor Organizer contains 840 top-quality 1/4-watt resistors in forty-two of the most commonly used resistance values for the experimenter as well as for the shop and laboratory repairman.

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Model C10 is designed to protect up to ten data line pairs employing BNC connectors that connect to computers, modems, terminals, and other sensitive electronic equipment from the effects of transients caused by lightning, switching surges, and heavy machinery. The protector interfaces between the signal lines and sensitive circuits to provide a sophisticated blend of high speed voltage limiting and brute force protection. The signal line protector recovers automatically to standby in preparation for further protection. Clamping can be provided from 6 volts to 200 volts, depending on customer requirements.

The dual line protector has a clamp voltage to ±50 volts (in 5-volt steps), an energy handling capacity of 50 joules (min)/circuit, and a maximum frequency to 3 MHz. Contact MCG, 160 Brook Avenue, Deer Park, New York 11729.

strations. Talk-in 81/91, 16/76 and 52. For information: WCARS, P.O. Box 1488, Asheville, NC 28802.

OHIO: The 39th Annual Findlay Hamfest, Sunday, September 13, Hancock Recreational Center, east of I-75, exit 161, north edge of Findlay. Prizes include a deluxe low band rig, two Icom IC-2A handhelds, memory keyer, and much more. Tickets $2.00 advance; $2.50 gate. Tables $2.50 per 1/2. Saturday 5 PM to 9 PM for set-up. Sunday 6 AM. For tickets, information and reservations, SASE to P.O. Box 587, Findlay, OH 45840.

OHIO: The Original Forty-fourth Annual Hamfest, Sunday, September 20, 1981, at Stricker's Grove on State Route 128, one mile west of Venice (Ross) Ohio. Exhibits, prizes, food and refreshments available. Flea Market (radio related products only), music, talks, hidden transmitter hunt and sensational air show. Admission and registration $4.00. For information: Lillian Abbott, K8CKI,317 Greenwell Road,Cincinnati, Ohio 45238.

OHIO: The Cleveland Hamfest Association's seventh annual Hamfest, Sunday, September 27, Cuyahoga County Fairgrounds, Berea, 0800 to 1500. Indoor exhibits, forums, ladies' program and outdoor flea market. Three main prizes and a mobile check-in prize. Talk-in on 146.52 with W8QV. Advance tickets $2.50 prior to August 31. $3.00 door. Cleveland Hamfest Association, P.O. Box 27211, Cleveland, OH 44127.

OREGON: The Walla Walla Valley Amateur Radio Club's 35th annual Hamfest, Saturday, September 26 and Sunday, September 27, Milton-Freewater Community Building. Over 100 prizes, Swap Shop both days, displays. Free registration. 52-52, 19-79, 04-64, 28-88, 16-76 and 3960 KC monitored. For further information: W7DP, Walla Walla Valley ARC, P.O. Box 321, Walla Walla, WA 99362.

PENNSYLVANIA: The Uniontown Amateur Radio Club's annual Gabfest, Saturday, September 12, Old Pittsburgh Road, off Route 51/119 bypass, Uniontown, 40 miles south of Pittsburgh. Pre-registration $2.00 ea./3 for $5.00. Nice prizes. Free swap and shop set-ups/own tables. Starts at noon. Free parking. Talk-in on 147.045/.645 and 146.52 simplex. For information and pre-registration: U.A.R.C. Gabfest Committee, John T. Cermak, WB3DOD, P.O. Box 433, Republic, PA 15475.

PENNSYLVANIA: The 26th annual York County Hamfest, Sunday, September 27, York Fairgrounds, York. 8 AM registration $3.00. Tailgating $2.00. Inside tables $5.00 Fly-in to York Airport. Hourly limo service to Hamfest beginning 9 AM. Hourly door prizes drawn beginning 10 AM. QSL contest. Talk-in on 146.37/97 or 52/52 simplex. For more info: Leroy Frey, 170 S. Albemarle Street, York, PA 17403. (717) 854-1203.

PENNSYLVANIA: The Skyview Radio Club's Swap and Shop, Sunday, September 27, 12 noon to 4 PM, Sokol Camp, 700 Wild Life Road, Lower Burrel. Rain or shine (plenty of shelter in case of rain). Refreshments available. First prize winner need not be present. Check-in on 04-64. Registration $1.00/gate. XYLs, YLs and children no charge. For information: Jim Jackson, K3VRU, RD #1, Box 7A, Apollo, PA 15613.

PENNSYLVANIA: The Pack Rats fifth annual Mid-Atlantic States VHF Conference October 3, Warrington Motor Lodge, Rt. 611, Warrington. Advance registration $3.00, $4.00 door includes admission to HAMARAMA flea market October 4, 8 AM to 4 PM, Bucks County Drive-in Theater, Rt. 611, Warrington. Flea market only $2.00. Tailgating $3.00 per space, own table. Talk-in W3CCX on 52. Information: Ron Whitsel, WA3AXV, P.O. Box 311, Southampton, PA 18966. (215) 355-5730.

SOUTH CAROLINA: The York County Amateur Radio Society's 30th annual Hamfest, Sunday, October 4, Joslin Park, Rock Hill. For information and registration: Y.C.A.R.S., P.O. Box 4141CRS, Rock Hill, SC 29730.

VIRGINIA: ARRL Roanoke Division Convention September 26 and 27 in the Virginia Beach, Virginia Pavillion. Free transportation to the oceanfront where the Neptune Festival is also taking place. FCC Amateur Exams given to those sending form 610 request in advance. Admission $3.50. Advance ticket drawing for FM transceiver. Flea market tables, $5 day, $7 both days. TRC PO Box 7101, Portsmouth, Virginia 23707. 804-587-1695.

OPERATING EVENTS
"Things to do..."

SEPTEMBER 7: The Tri-County ARC will be operating a special events station from Clark, Missouri, birthplace of the late 5-star General, Omar N. Bradley, 10 AM to 6 PM, Labor Day. Contacts will receive a commemorative certificate honoring General Bradley. Operation on the General portion of 40, 20 and 15 meters. Send QSL with SASE to: Tri-County ARC, 601 McKinley, Moberly, MO 65270.

SEPTEMBER 12 & 13: The Cray Valley Radio Society of Great Britain's 11th S.W.L. Contest from 1800 GMT Saturday to 1800 GMT Sunday. 1.8, 3.5, 7, 14, 21 and 28 MHz bands may be used any mode. SASE for log sheets to Owen Cross, G4DFI, 28 Garden Avenue, Bexleyheath, Kent DA7 4LF England. Entries should be sent to Contest Manager, Owen Cross, at above address to arrive not later than November 2, 1981.

SEPTEMBER 12 & 13: The Sweetwater Amateur Radio Club will be conducting a mini-DXpedition to old Ft. Bridger, Wyoming, September 12, 1800 GMT to September 13, 1800 GMT. Ft. Bridger, located in southwestern Wyoming and established in the mid 1800s, is famous for its early day meetings of well-known explorers and mountain men of that time. Frequencies: ± 5 kHz, 7.250, 3.950, 14.300, 21.400, 28.580. CW frequencies will be announced on phone frequencies. A special certificate, depicting the old fort, will be awarded for each contact. A donation of $1.00 is requested for printing, handling and mailing. Mail QSLs to: KB7LZ, D.L. Zwemke, 1010 Bridger Dr., Green River, WY 82935.

SEPTEMBER 19 & 20: The 2nd Annual Dwight Harvest Days QSO party, 0900 to 2000 CDT. 10 through 40 meters SSB and CW on request. 20 meter CW both days on 14.200 ± 5 kc. Call signs: WB9VEL, WD9FGD, WD9FGI, WD9IBF, N9AEE, N9BBE, N9BCC. Certificates to the first 500 contacts on receipt of your QSL.

SEPTEMBER 26 & 27: The Portland (Maine) Amateur Wireless Association's QSO Party. 2300Z Saturday to 2359Z Sunday. Suggested frequencies: CW: 1805 and 55 kHz up from low end of band. Phone: 1815, 3930, 7280, 14280, 21380, 28580 kHz. Novice: 3720, 7120, 21120, 28120. Mail entries by December 1 to: PAWA, Box 1605, Portland, Maine 04104.

SEPTEMBER 26: The Schenectady Amateur Radio Association will operate a special event station, K2AE, commemorating the 150th anniversary of the opening of the Mohawk & Hudson Railroad. Time: 1600Z Saturday to 1700Z Sunday. Frequencies: 7235, 14285 and 21360. Amateurs desiring QSL from contact with K2AE SASE to K2AE.

SEPTEMBER 26: *The twelfth annual Delta QSO party* sponsored by the Delta Division of the ARRL from 1800Z Sept. 26 to 2400Z Sept. 27. Suggested frequencies: CW: 3550, 7050, 14050, 21050, 28050. SSB: 3990, 7290, 14290, 21390, 28590. Novice: 3725, 7125, 21125, 28125. Logs must be postmarked no later than October 21 to be eligible for awards and will be returned if requested. Send logs to: Malcolm P. Keown, W5XX, 213 Moonmist, Vicksburg, MS 39180.

SEPTEMBER 26 & 27: The Beaumont (Texas) Amateur Radio and Repeater Club's station, W5RIN, will be operating during the 80th anniversary of Spindletop, the famous Lucas gusher. Times for both days 1700Z to 2300Z. *Time allotted for CW in the low 25 kHz of the Novice* 10-15-40 meter band. Phone contact in the low 25 kHz of the General portion of 10-15-20-40 meter band. Listen for CQ Spindletop on phone and CQ SP on CW. For a beautiful certificate and brochure on the history of Spindletop send QSL and $1.00 to Certificate Manager, BAR&RC, 3090 S. Major Drive, Beaumont, TX 77707.

OCTOBER 10 & 11: The Hamfesters Radio Club will be operating on the General phone portion of 10 and 40 meters and the Novice portion of 10 meters from 1700 UTC October 10 to 1700 UTC October 11. Applicants wishing a WAHM (Worked All Hamfesters Members) award send list of contacts to: P.O. Box 42792, Chicago, IL 60642.

OCTOBER 17 & 18: 24th Jamboree on the Air. Hams and Scout groups get-together. Scouts — Amateur radio clubs have lists of members or SASE to American Radio Relay League, Sally O'Dell, Youth Activities Director, 225 Main St., Newington, CT 06111. Time: Generally 0001 *UTC Saturday to 2400 UTC Sunday. Contacts: No re*quired format. Scout frequencies: 3740, 7090, 14290, 21360, 28990, (phone). 3590, 7030, 14070, 21140, 28190, (CW). SSTV and RTTY on usual frequencies. For certificates SASE to: JOTA Coordinator, Harry Harchar, W2GND, 216 Maxwell Avenue, Hightstown, NJ 08520.

OCTOBER 17: *The 24th annual Pennsylvania WSO party,* 1700Z October 17 to 0400Z October 18; 1300Z October 18 to 2200Z October 18. Frequencies: SSB: 3980, 7280, 14280, 21380, 28580. CW: 40 kHz up from bottom of CW bands. Mail logs with SASE by November 15 to: Douglas R. Maddox, W3HDH, 1187 S. Garner Street, State College, PA 16801.

NEW products

vertical, fixed-station antenna

The new Hustler 220-MHz vertical fixed-station Amateur antenna, designated the Model G7-220, has 7-dB gain for both transmitting and receiving, making it the most powerful omnidirectional 1-1/4 meter antenna available. The all-new design of the Hustler G7-220 antenna keeps the signal radiation pattern at the lowest possible angle to the horizon for maximum efficiency and longest range.

The Model G7-220 has an SWR of 1.5:1 across its entire 5-MHz bandwidth, with SWR at resonance of 1.2:1 at the antenna. The radiating element of the Hustler G7-220 is dc grounded and the antenna has a 50-ohm base impedance.

The G7-220 weighs 7 pounds and is easily mounted on any capable vertical support up to 1-3/4" OD. Wind loading of the antenna is only 26 pounds at 100 mph velocities.

The Hustler G7-220 MHz (1-1/4 meter) Amateur vertical fixed-station antenna has a suggested list price of $142.95 and is available now. For further information write Sales Department, Hustler, Inc., 3275 North B Avenue, Kissimmee, Florida 32741.

Kantronics varifilter

You can vary the frequency and the bandwidth of the Kantronics Varifilter,™ a new addition to the "family-design line" of products. The varifilter can be set to maximize one signal (peaking), or to minimize an interfering signal (notching), and it works with CW, single-sideband, and a-m signals. The varifilter circuitry is designed to provide optimum results without ringing, oscillating, or instability.

The bandwidth is variable from less than 30 Hz to over 1000 Hz. The frequency range runs from less than 150 Hz to over 3000. Once it has been set,

the bandwidth will remain constant regardless of changes in the frequency-range setting. This feature has not been readily available in variable filters until now.

The varifilter has its own internal power supply which is switchable from 115 Vac to 230 Vac. It is able to run from 12 to 18 Vdc as well. Each unit has a tuning eye that lets the operator see when he has filtered the signal he wants to.

A full-year warranty backs the varifilter. It is available from Kantronics dealers and from the factory. Suggested retail price of the varifilter is $139.95.

For further information contact Kantronics, Inc., 1202 E. 23rd Street, Lawrence, Kansas 66044.

mobile antenna

Avanti Communications has recently modified its 5 dB gain on-glass mobile antenna designed for use in two-way and Amateur Radio communications.

The new 3/4-meter, 410-512 MHz AP450.5G featues a straight 30-inch whip with a small center-position phasing coil. By popular request the former loop section has been eliminated and replaced with a small, sleek coil measuring only 1-1/2 inches in length and a maximum diameter of 3/8-inch, making it the smallest UHF 5-dB-gain whip and phasing coil combination on the market.

As with each of Avanti's on-glass communications antennas, the new AP450.5G offers improved performance, requires no holes be drilled, features shorter installation time, and requires no metal ground plane. Thus it may be used in many more applications than conventional mobile antennas.

For more information contact Avanti Communications, 340 Stewart Avenue, Addison, Illinois 60101.

More Details? CHECK—OFF Page 98

MHz electronics

RF TRANSISTORS

TYPE	PRICE	TYPE	PRICE	TYPE	PRICE
2N1561	$15.00	2N5590	$8.15	MM1550	$10.00
2N1562	15.00	2N5591	11.85	MM1552	50.00
2N1692	15.00	2N5637	22.15	MM1553	56.50
2N1693	15.00	2N5641	6.00	MM1601	5.50
2N2632	45.00	2N5642	10.05	MM1602/2N5842	7.50
2N2857JAN	2.52	2N5643	15.82	MM1607	8.65
2N2876	12.35	2N6545	12.38	MM1661	15.00
2N2880	25.00	2N5764	27.00	MM1669	17.50
2N2927	7.00	2N5842	8.78	MM1943	3.00
2N2947	18.35	2N5849	21.29	MM2605	3.00
2N2948	15.50	2N5862	51.91	MM2608	5.00
2N2949	3.90	2N5913	3.25	MM8006	2.23
2N2950	5.00	2N5922	10.00	MMCM918	20.00
2N3287	4.30	2N5942	46.00	MMT72	1.17
2N3294	1.15	2N5944	8.92	MMT74	1.17
2N3301	1.04	2N5945	12.38	MMT2857	2.63
2N3302	1.05	2N5946	14.69	MRF245	33.30
2N3304	1.48	2N6080	7.74	MRF247	33.30
2N3307	12.60	2N6081	10.05	MRF304	43.45
2N3309	3.90	2N6082	11.30	MRF420	20.00
2N3375	9.32	2N6083	13.23	MRF450	11.85
2N3553	1.57	2N6084	14.66	MRF450A	11.85
2N3755	7.20	2N6094	7.15	MRF454	21.83
2N3818	6.00	2N6095	11.77	MRF458	20.68
2N3866	1.09	2N6096	20.77	MRF502	1.08
2N3866JAN	2.80	2N6097	29.54	MRF504	6.95
2N3866JANTX	4.49	2N6136	20.15	MRF509	4.90
2N3924	3.34	2N6166	38.60	MRF511	8.15
2N3927	12.10	2N6439	45.77	MRF901	5.00
2N3950	26.86	2N6459/PT9795	18.00	MRF5177	21.62
2N4072	1.80	2N6603	12.00	MRF8004	1.80
2N4135	2.00	2N6604	12.00	PT4186B	3.00
2N4261	14.60	A50-12	25.00	PT4571A	1.50
2N4427	1.20	BFR90	5.00	PT4612	5.00
2N4957	3.62	BLY568C	25.00	PT4628	5.00
2N4958	2.92	BLY568CF	25.00	PT4640	5.00
2N4959	2.23	CD3495	15.00	PT8659	10.72
2N4976	19.00	HEP76/S3014	4.95	PT9784	24.30
2N5090	12.31	HEPS3002	11.30	PT9790	41.70
2N5108	4.03	HEPS3003	29.88	SD1043	5.00
2N5109	1.66	HEPS3005	9.95	SD1116	3.00
2N5160	3.49	HEPS3006	19.90	SD1118	5.00
2N5179	1.05	HEPS3007	24.95	SD1119	3.00
2N5184	2.00	HEPS3010	11.34	TRWMRA2023-1.5	42.50
2N5216	47.50	HEPS5026	2.56	40281	10.90
2N5583	4.55	HP35831E/		40282	11.90
2N5589	6.82	HXTR5104	50.00	40290	2.48
		MM1500	32.20		

FAIRCHILD VHF AND UHF PRESCALER CHIPS

95H90DC	350 MHz Prescaler Divide by 10/11	$9.50
95H91DC	350 MHz Prescaler Divide by 5/6	9.50
11C90DC	650 MHz Prescaler Divide by 10/11	16.50
11C91DC	650 MHz Prescaler Divide by 5/6	16.50
11C83DC	1 GHz Divide by 248/256 Prescaler	29.90
11C70DC	600 MHz Flip/Flop with reset	12.30
11C58DC	ECL VCM	4.53
11C44DC/MC4044	Phase Frequency Detector	3.82
11C24DC/MC4024	Dual TTL VCM	3.82
11C06DC	UHF Prescaler 750 MHz D Type Flip/Flop	12.30
11C05DC	1 GHz Counter Divide by 4	50.00
11C01FC	High Speed Dual 5-4 input NO/NOR Gate	15.40

TRW BROADBAND AMPLIFIER MODEL CA615B

Frequency response 40 MHz to 300 MHz
Gain: 300 MHz 16 dB Min., 17.5 dB Max.
50 MHz 0 to − 1 dB from 300 MHz
Voltage: 24 volts dc at 220 ma max. $19.99

CARBIDE — CIRCUIT BOARD DRILL BITS FOR PC BOARDS

Size: 35, 42, 47, 49, 51, 52	$2.15
Size: 53, 54, 55, 56, 57, 58, 59, 61, 63, 64, 65	1.85
Size: 66	1.90
Size: 1.25 mm, 1.45 mm	2.00
Size: 3.20 mm	3.58

CRYSTAL FILTERS: TYCO 001-19880 same as 2194F

10.7 MHz Narrow Band Crystal Filter
3 dB bandwidth 15 kHz min. 20 dB bandwidth 60 kHz min. 40 dB bandwidth 150 kHz min.
Ultimate 50 dB: Insertion loss 1.0 dB max. Ripple 1.0 dB max. Ct. 0 + / − 5 pf 3600 ohms. $5.95

MURATA CERAMIC FILTERS

Models: SFD-455D 455 kHz	$3.00
SFB-455D 455 kHz	2.00
CFM-455E 455 kHz	7.95
SFE-10.7 10.7 MHz	5.95

TEST EQUIPMENT — HEWLETT PACKARD — TEKTRONIX — ETC.

Hewlett Packard:		
491C	TWT Amplifier 2 to 4 Gc 1 watt 30 dB gain	$1150.00
608C	10 to 480 mc .1 uv to .5 V into 50 ohms Signal Generator	500.00
608D	10 to 420 mc .1 uV to .5 V into 50 ohms Signal Generator	500.00
612A	450 to 1230 mc .1 uV to .5 V into 50 ohms Signal Generator	750.00
614A	900 to 2100 mc Signal Generator	500.00
616A	1.8 to 4.2 Gc Signal Generator	400.00
616B	1.8 to 4.2 Gc Signal Generator	500.00
618A	3.8 to 7.2 Gc Signal Generator	400.00
618B	3.8 to 7.2 Gc Signal Generator	500.00
620A	7 to 11 Gc Signal Generator	400.00
623B	Microwave Test Set	900.00
626A	10 to 15 Gc Signal Generator	2500.00
695A	12.4 to 18 Gc Sweep Generator	900.00
Alltech:		
473	225 to 400 mc AM/FM Signal Generator	750.00
Singer:		
MF5/VR-4	Universal Spectrum Analyzer with 1 kHz to 27.5 mc Plug In	1200.00
Keltek:		
XR630-100	TWT Amplifier 8 to 12.4 Gc 100 watts 40 dB gain	9200.00
Polarad:		
2038/2436/1102A	Calibrated Display with an SSB Analysis Module and a 10 to 40 mc Single Tone Synthesizer	1500.00

CHIP CAPACITORS

We can supply any value chip capacitors you may need.

1pf	27pf	220pf	1200pf
1.5pf	33pf	240pf	1500pf
2.2pf	39pf	270pf	1800pf
2.7pf	47pf	300pf	2200pf
3.3pf	56pf	330pf	2700pf
3.9pf	68pf	360pf	3300pf
4.7pf	82pf	390pf	3900pf
5.6pf	100pf	430pf	4700pf
6.8pf	110pf	470pf	5600pf
8.2pf	120pf	510pf	6800pf
10pf	130pf	560pf	8200pf
12pf	150pf	620pf	.010mf
15pf	160pf	680pf	.012mf
18pf	180pf	820pf	.015mf
22pf	200pf	1000pf	.018mf

PRICES

1 to 10	$1.49
11 - 50	1.29
51 - 100	.89
101 - 1,000	.69
1,001 up	.49

HAMLIN SOLID STATE RELAYS

120 Vac at 40 Amps.
Input Voltage 3 to 32 Vdc.

240 Vac at 40 Amps.
Input Voltage 3 to 32 Vdc.
Your Choice $4.99

ATLAS CRYSTAL FILTERS FOR ATLAS HAM GEAR

5.52-2.7/8
5.595-2.7/8/U
5.595-.500/4/CW
5.595-2.7LSB
5.595-2.7USB
5.645-2.7/8
9.0USB/CW

YOUR CHOICE $24.95

NEW — TOLL-FREE NO. 800-528-0180 — please, orders only!

More Details? CHECK—OFF Page 98

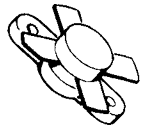
MHz electronics

MOTOROLA Semiconductor **The RF Line**

MRF454 $21.83

NPN SILICON RF POWER TRANSISTORS

. . . designed for power amplifier applications in industrial, commercial and amateur radio equipment to 30 MHz.



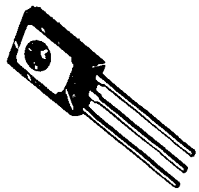
- Specified 12.5 Volt, 30 MHz Characteristics –
  Output Power = 80 Watts
  Minimum Gain = 12 dB
  Efficiency = 50%

MRF458 $20.68

NPN SILICON RF POWER TRANSISTOR

. . . designed for power amplifier applications in industrial, commerical and amateur radio equipment to 30 MHz.

- Specified 12.5 Volt, 30 MHz Characteristics –
  Output Power = 80 Watts
  Minimum Gain = 12 dB
  Efficiency = 50%
- Capable of Withstanding 30:1 Load VSWR @ Rated P_{out} and V_{CC}



MRF472

$2.50

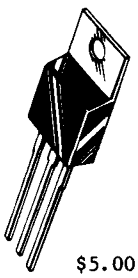
NPN SILICON RF POWER TRANSISTOR

. . . designed primarily for use in large-signal output amplifier stages. Intended for use in Citizen-Band communications equipment operating at 27 MHz. High breakdown voltages allow a high percentage of up-modulation in AM circuits.

- Specified 12.5 V, 27 MHz Characteristics –
  Power Output = 4.0 Watts
  Power Gain = 10 dB Minimum
  Efficiency = 65% Typical

MRF475

NPN SILICON RF POWER TRANSISTOR



$5.00

. . . designed primarily for use in single sideband linear amplifier output applications in citizens band and other communications equipment operating to 30 MHz.

- Characterized for Single Sideband and Large-Signal Amplifier Applications Utilizing Low-Level Modulation.
- Specified 13.6 V, 30 MHz Characteristics –
  Output Power = 12 W (PEP)
  Minimum Efficiency = 40% (SSB)
  Output Power = 4.0 W (CW)
  Minimum Efficiency = 50% (CW)
  Minimum Power Gain = 10 dB (PEP & CW)
- Common Collector Characterization

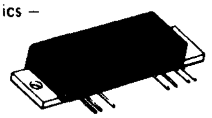
MHW710 - 2

$46.45
440 to 470MC

UHF POWER AMPLIFIER MODULE

. . . designed for 12.5 volt UHF power amplifier applications in industrial and commercial FM equipment operating from 400 to 512 MHz.

- Specified 12.5 Volt, UHF Characteristics –
  Output Power = 13 Watts
  Minimum Gain = 19.4 dB
  Harmonics = 40 dB



- 50 Ω Input/Output Impedance
- Guaranteed Stability and Ruggedness
- Gain Control Pin for Manual or Automatic Output Level Control
- Thin Film Hybrid Construction Gives Consistent Performance and Reliability

Tektronix Test Equipment

8	Wideband High Gain Plug In	$ 51.00
CA	Dual Trace Plug In	120.00
K	Fast Rise DC Plug In	63.00
N	Sampling Plug In	200.00
R	Transistor Risetime Plug In	116.00
W	High Gain Differential Comparator Plug In	283.00
TU-2	Test Load Plug In for 530/540/550 Main Frames	50.00
1A2	Wideband Dual Trace Plug In	216.00
1S1	Sampling Unit With 350PS Risetime DC to 1GHZ	730.00
2A61	AC Differential Plug In	133.00
3S3	Dual Trace Sampling DC to 1GHZ Plug In	250.00
3S76	Dual Trace Sampling DC to 875MHZ Plug IN	250.00
3T77A	Sampling Sweep Plug In	250.00
3L10	Spectrum Analyzer 1 to 36MHZ Plug IN	1000.00
50	Amplifier Plug In	50.00
51	Sweep Plug In	50.00
53/54B	Wideband High Gain Plug In	45.00
53/54C	Dual Trace Plug In	112.50
53/54D	High Gain DC Differential Plug In	38.00
53/54G	Wideband DC Differential Plug In	68.00
84	Test Plug In For 580/581 Main Frames	75.00
107	Square Wave Generator .4 to 1MHZ	48.00
RM122	Preamplifier 2Hz to 40KHZ	63.00
123	AC Coupled Preamplifier	25.00
131	Current Probe Amplifier	50.00
184	Time Mark Generator	363.00
R240	Program Control Unit	150.00
280	Trigger Countdown Unit	84.00
535A	DC to 15MHZ Scope Rack Mount	263.00
543	DC to 33MHZ Scope	300.00
561	DC to 10MHZ Scope Rack Mount	150.00
561A	DC to 10MHZ Scope Rack Mount	200.00

Scopes with Plug-ins

561A	DC to 10MHZ Scope with a 3S76 Dual Trace DC to 875MHZ Sampling Plug In and a 3T77A Sweep Plug In. Rack Mount	600.00
565	DC to 10MHZ Dual Beam Scope with a 2A63 Diff. and a 2A61 Diff. Plug In's	900.00
581	DC to 80MHZ Scope with a 82 Dual Trace High Gain Plug In	650.00

Tubes

2E26	$ 5.00	4CX350FJ	$116.00	6146W	12.00
3-500Z	102.00	4CX1000A	300.00	6159	10.60
3-1000Z	268.00	4CX1500B	350.00	6161	75.00
3B28/866A	5.00	4CX15000A	750.00	6293	18.50
3X2500A3	150.00	4E27	50.00	6360	6.95
4-65A	45.00	4X150A	41.00	6907	40.00
4-125A	58.50	4X150D	52.00	6939	14.75
4-250A	68.50	4X150G	74.00	7360	12.00
4-400A	71.00	572B/T160L	39.00	7984	10.40
4-1000A	184.00	6LF6	5.00	8072	49.00
5-500A	145.00	6LQ6	5.00	8106	2.00
4CX250B	65.00	811A	12.95	8156	7.85
4CX250F/G	55.00	813	29.00	8226	127.70
4CX250K	113.00	5894/A	42.00	8295/PL172	328.00
4CX250R	92.00	6146	5.00	8458	25.75
4CX300A	147.00	6146A	6.00	8560A/AS	50.00
4CX350A	107.00	6146B/8298A	7.00	8908	9.00
				8950	9.00

NEW — TOLL-FREE NO. 800-528-0180 — please, orders only!

MHz electronics

MICROWAVE COMPONENTS

ARRA

ARRA	DESCRIPTION	PRICE
2416	Variable Attenuator	$ 50.00
3614-60	Variable Attenuator 0 to 60 dB	75.00
KU520A	Variable Attenuator 18 to 26.5 GHz	100.00
4684-20C	Variable Attenuator 0 to 180 dB	100.00
6684-20F	Variable Attenuator 0 to 180 dB	100.00

General Microwave

Directional Coupler 2 to 4 GHz 20 dB Type N	75.00

Hewlett Packard

H487B	100 ohms Neg. Thermistor Mount (NEW)	150.00
H487B	100 ohms Neg. Thermistor Mount (USED)	100.00
477B	200 ohms Neg. Thermistor Mount (USED)	100.00
X487A	100 ohms Neg. Thermistor Mount (USED)	100.00
X487B	100 ohms Neg. Thermistor Mount (USED)	125.00
J468A	100 ohms Neg. Thermistor Mount (USED)	150.00
478A	200 ohms Neg. Thermistor Mount (USED)	150.00
J382	5.85 to 8.2 GHz Variable Attenuator 0 to 50 dB	250.00
X382A	8.2 to 12.4 GHz Variable Attenuator 0 to 50 dB	250.00
NK292A	Waveguide Adapter	65.00
8436A	Bandpass Filter 8 to 12.4 GHz	75.00
8471A	RF Detector	50.00
H532A	7.05 to 10 GHz Frequency Meter	300.00
G532A	3.95 to 5.85 GHz Frequency Meter	300.00
J532A	5.85 to 8.2 GHz Frequency Meter	300.00
809A	Carriage with a 444A Slotted Line Untuned Detector Probe and 809B Coaxial Slotted Section 2.6 to 18 GHz	175.00
X347A	8.2 to 12.4 GHz Noise Source	500.00
S347A	2.6 to 3.95 GHz Noise Source	600.00
G347A	3.95 to 5.85 GHz Noise Source	500.00
J347A	5.85 to 8.2 GHz Noise Source	500.00
H347A	7.05 to 10 GHz Noise Source	540.00
349A	400 to 4000 MHz Noise Source	310.00
P532A	12.4 to 18 GHz Frequency Meter	400.00
M532A	Frequency Meter	500.00
P382A	0-50 dB Attenuator	520.00
355C	.5 Watts, 50 Ohm DC to 1,000 MC Attenuator	132.50
NK292A	Adapter	100.00
3503	Microwave Switch	100.00
33001C	Pin Absorption Modulator	295.00
11660A	Tracking Generator Shunt	50.00
11048C	Feed-through Termination	25.00
10100B	Termination	25.00
H421A	7.05 to 10 GHz Crystal Detector	75.00
H421A	7.05 to 10 GHz Crystal Detector — Matched Pair	200.00

Merrimac

AU-26A/	801162 Variable Attenuator	100.00

Microlab/FXR

X638S	Horn 8.2 to 12.4 GHz	60.00
601-B18	X to N Adapter 8.2 to 12.4 GHz	35.00
Y610D	Coupler	75.00

Narda

4013C-10/	22540A Directional Coupler 2 to 4 GHz 10 dB Type SMA	90.00
4014-10/	22538 Directional Coupler 3.85 to 8 GHz 10 dB Type SMA	90.00
4014C-6/	22876 Directional Coupler 3.85 to 8 GHz 6 dB Type SMA	90.00
4015C-10/	22539 Directional Coupler 7.4 to 12 GHz 10 dB Type SMA	95.00
4015C-30/	23105 Directional Coupler 7 to 12.4 GHz 30 dB Type SMA	95.00
3044-20	Directional Coupler 4 to 8 GHz 20 dB Type N	125.00
3040-20	Directional Coupler 240 to 500 MC 20 dB Type N	125.00
3043-20/	22006 Directional Coupler 1.7 to 4 GHz 20 dB Type N	125.00
3003-10/	22011 Directional Coupler 2 to 4 GHz 10 dB Type N	75.00
3003-30/	22012 Directional Coupler 2 to 4 GHz 30 dB Type N	75.00
3043-30/	22007 Directional Coupler 1.7 to 3.5 GHz 30 dB Type N	125.00
22574	Directional Coupler 2 to 4 GHz 10 dB Type N	125.00
3033	Coaxial Hybrid 2 to 4 GHz 3 dB Type N	125.00
3032	Coaxial Hybrid 950 to 2 GHz 3 dB Type N	125.00
784/	22380 Variable Attenuator 1 to 90 dB 2 to 2.5 GHz Type SMA	550.00
22377	Waveguide to Type N Adapter	35.00
720-6	Fixed Attenuator 8.2 to 14.4 GHz 6 dB	50.00
3503	Waveguide	25.00

PRD

U101	12.4 to 18 GHz Variable Attenuator 0 to 60 dB	300.00
X101	8.2 to 12.4 GHz Variable Attenuator 0 to 60 dB	200.00
C101	Variable Attenuator 0 to 60 dB	200.00
205A/367	Slotted Line with Type N Adapter	100.00
195B	8.2 to 12.4 GHz Variable Attenuator 0 to 50 dB	100.00
185BS1	7.05 to 10 GHz Variable Attenuator 0 to 40 dB	100.00
196C	8.2 to 12.4 GHz Variable Attenuator 0 to 45 dB	100.00
170B	3.95 to 5.85 GHz Variable Attenuator 0 to 45 dB	100.00
588A	Frequency Meter 5.3 to 6.7 GHz	100.00
140A, C, D, E	Fixed Attenuators	25.00
109J, I	Fixed Attenuators	25.00
WEINSCHEL ENG.	2692 Variable Attenuator + 30 to 60 dB	100.00

COMPUTER I.C. SPECIALS

MEMORY	DESCRIPTION	PRICE
2708	1K x 8 EPROM	$ 7.99
2716/2516	2K x 8 EPROM 5 Volt Single Supply	20.00
2114/9114	1K x 4 Static RAM 450ns	6.99
2114L2	1K x 4 Static RAM 250ns	8.99
2114L3	1K x 4 Static RAM 350ns	7.99
4027	4K x 1 Dynamic RAM	3.99
4060/2107	4K x 1 Dynamic RAM	3.99
4050/9050	4K x 1 Dynamic RAM	3.99
2111A-2/8111	256 x 4 Static RAM	3.99
2112A-2	256 x 4 Static RAM	3.99
2115AL-2	1K x 1 Static RAM 55ns	4.99
6104-3/4104	4K x 1 Static RAM 320ns	14.99
7141-2	4K x 1 Static RAM 200ns	14.99
MCM6641L20	4K x 2 Static RAM 200ns	14.99
9131	1K x 1 Static RAM 300ns	10.99

C.P.U.'s ETC.

MC6800L	Microprocessor	13.80
MCM6810AP	128 x 8 Static RAM 450ns	3.99
MCM68A10P	128 x 8 Static RAM 360ns	4.99
MCM68B10P	128 x 8 Static RAM 250ns	5.99
MC6820P	PIA	8.99
MC6820L	PIA	9.99
MC6821P	PIA	8.99
MC68B21P	PIA	9.99
MCM6830L7	Mikbug	14.99
MC6840P	PTM	8.99
MC6845P	CRT Controller	29.50
MC6845L	CRT Controller	33.00
MC6850L	ACIA	10.99
MC6852P	SSDA	5.99
MC6852L	SSDA	11.99
MC6854P	ADLC	22.00
MC6860CJCS	0-600 BPS Modem	29.00
MC6862L	2400 BPS Modem	14.99
MK3850N-3	F8 Microprocessor	9.99
MK3852P	F8 Memory Interface	16.99
MK3852N	F8 Memory Interface	9.99
MK3854N	F8 Direct Memory Access	9.99
8008-1	Microprocessor	4.99
8080A	Microprocessor	8.99
Z80CPU	Microprocessor	14.99
6520	PIA	7.99
6530	Support For 6500 Series	15.99
2650	Microprocessor	10.99
TMS1000NL	Four Bit Microprocessor	9.99
TMS4024NC	9 x 64 Digital Storage Buffer (FIFO)	9.99
TMS6011NC	UART	9.99
MC14411	Bit Rate Generator	11.99
AY5-4007D	Four Digit Counter/Display Drivers	8.99
AY5-9200	Repertory Dialer	9.99
AY5-9100	Push Button Telephone Dialers	7.99
AY5-2376	Keyboard Encoder	19.99
AY3-8500	TV Game Chip	5.99
TR1402A	UART	9.99
PR1472B	UART	9.99
PT1482B	UART	9.99
8257	DMA Controller	9.99
8251	Communication Interface	9.99
8228	System Controller & Bus Driver	5.00
8212	8 Bit Input/Output Port	5.00
MC14401CP	2 of 8 Tone Encoder	9.99
MC14412	Low Speed Modem	14.99
MC14408	Binary To Phone Pulse Converter	12.99
MC14409	Binary To Phone Pulse Converter	12.99
MC1488L	RS232 Driver	1.00
MC1489L	RS232 Receiver	1.00
MC1405L	A/D Converter Subsystem	9.00
MC1406L	6 Bit D/A Converter	7.50
MC1408/6/7/8	8 Bit D/A Converter	4.50
MC1330P	Low Level Video Detector	1.50
MC1349/50	Video IF Amplifier	1.17
MC1733L	LM733 OP Amplifier	2.40
LM565	Phase Lock Loop	2.50

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More Details? CHECK—OFF Page 98

HAM MART Ham Radio's guide to help you find your local

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HAM CALENDAR

September

Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday

1

2

AMSAT Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning)
AMSAT Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning)
AMSAT Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning)

3

4

5

ILLIANA REPEATER SYSTEM'S 12TH ANNUAL DANVILLE AREA HAMFEST - Georgetown Fairgrounds, Georgetown IL WD9AFG **5-6**

6

BLOOMINGTON ARC "HOOSIER BACKYARD HAMFEST" – 2335 Vernal Pike, Bloomington, IN – K9KTH **6**

7

TRI-COUNTY ARC – Special Events Station from 10 AM to 6 PM around 40, 20, and 15 meters. For certificate send QSL with SASE to Tri-County ARC, 601 McKinley, Moberly, MO 65270 **7**

WEST COAST BULLETIN 8 PM EST (0400 UTC) 3540 kHz, A-1 22 WPM **7**

8

9

AMSAT Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning)
AMSAT Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning)
AMSAT Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning)

10

YLRL "HOWDY DAYS" PARTY 9-11

11

12

UNIONTOWN ARC ANNUAL GABFEST – Held on the club grounds on the old Pittsburgh Road off Rtes. 51 & 119 in Uniontown PA – WB3DOD **12**

SWEETWATER ARC DXPEDITION – to Ft. Bridger, WY. Operation from 1800 GMT on the 12th to 1800 GMT on the 13th – KB7LZ **12**

SUSSEX COUNTY ARC 3RD ANNUAL HAMFEST – Sussex County Farm & Horse Show grounds off Rte. 206, Augusta, NJ – WA2LHX **12**

CRAY VALLEY RADIO SOCIETY (UK) 11TH ANNUAL SWL CONTEST from 1800 GMT on Sept. 12th to 1800 GMT on Sept. 13th. 1.8, 3.5, 7, 14, 21 *and 28 MHz bands may be used* - G4DFI **12-13**

EUROPEAN PHONE CONTEST - **12-13**

13

SOUTH JERSEY RADIO ASSOCIATION 65TH ANNUAL HAMFEST – Pennsauken H.S., Remington Ave. & U.S. Rte. 73 Pennsauken, NJ – W2SPV **13**

SUFFOLK COUNTY RADIO CLUB'S 4TH ANNUAL ELECTRONIC FLEA MARKET – Odd Fellows Hall, Jayne Blvd. Port Jefferson, L.I., NY. Contact Floyd Davis at 516-234-9376 **13**

HALL OF SCIENCE ARC SIXTH ANNUAL HAMFEST – Municipal Parking Garage one block North of Queens Blvd., 80-25 126 St. Kew Gardens, Queens, NY. Contact Tom Doyle, KA2DTB **13**

39TH FINDLAY HAMFEST – Hancock Recreational Ctr. east of I-75 exit 161 on North edge of Findlay. SASE to P.O. Box 587 Findlay, OH 45840 **13**

BRISTOL COUNTY AMATEUR RADIO ASSOCIATION FLEA MARKET – V.F.W. hall in Tiverton, RI. Contact Ann Carro WKA2DNB (SASE) **13**

14

WASHINGTON STATE QSO PARTY – **12-14**

W1AW QUALIFYING RUN **14**

15

16

AMSAT Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning)
AMSAT Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning)
AMSAT Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning)

17

18

HAM-O-RAMA 81 Erie County Fairgrounds south of Buffalo, NY. Contact Nelson Oldfield, 126 Greenway Blvd Cheektowaga, NY 14225 or Mike Merrick, 419 Summerville Ave., Tonawanda, NY 14150 **18-19**

19

GRAND RAPIDS AMATEUR RADIO ASSOCIATION'S ANNUAL SWAP & SHOP - Hudsonville, MI Fairgrounds. Contact Grand Rapids ARA, P.O. Box 1248, Grand Rapids, MI 49501 **19**

DWIGHT O.A.R.S. SPECIAL OPERATING EVENT – 0900 to 2000 CDT 10m thru 40m and will work 20m CW on 14.200 N9AEE **19-20**

CHICAGO FM CLUB'S RADIO EXPO 81 – Lake County Fairgrounds, Rtes. 45 and 120, Grayslake, IL. Call (312) BST EXPO **19-20**

PEORIA ARC SUPERFEST 81 Exposition Gardens, W. North [illegible] Rd., Peoria, IL - WD9EGW **19-20**

ANNUAL DAKOTA DIV. CONVENTION OF THE ARRC – Rochester, MN. Downtown Holiday Inn. N0BJQ **19-20**

NEW ENGLAND DIVISION CONVENTION - Hartford, CT **19-20**

20

CANDLEWOOD AMATEUR RADIO ASSOCIATION'S FLEA MARKET – Essex House, Rte. 6, Newtown, CT WB2THN **20**

GREATER CINCINNATI AMATEUR RADIO ASSN. 44TH ANNUAL HAMFEST – Stricker's Grove on Ohio State Rte 128 – K8CKI **20**

AUGUSTA, GA. ARC ANNUAL HAMFEST Julian Smith Casino, Diane WB4YHT **20**

L'ANSE CREUSE A.R.C. SWAP SHOP L'Anse Creuse H.S. Mt. Clemens, MI. Contact Mike Corcoran, N8CEN (SASE) **20**

6TH ANNUAL HAMFEST & ELECTRONIC FLEA MARKET 4-H Fairgrounds, Argos, IN. Contact Paul DeVos, WB9VFJ **20**

21

WEST COAST BULLETIN 8 PM EST (0400 UTC) 3540 kHz, A-1, 22 WPM **21**

22

23

AMSAT Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning)
AMSAT Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning)
AMSAT Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning)

W1AW QUALIFYING RUN **23**

24

25

26

W7DP 35TH ANNUAL HAMFEST Milton-Freewater Community Bldg. Milton-Freewater, OR **26**

SCHENECTADY AMATEUR RADIO ASSN. - Special Event Station K2AE. 1600Z Sat. to 1700Z Sun. on the following plus or minus QRM 7235, 14.285 & 21.360. Send SASE to K2AE for QSL card **26**

MAINE QSO PARTY from 2300Z Sat. to 2359Z Sun. Contact B.G. Cohen K1SA, 980 Forest Ave., Portland, ME 04103 **26**

GREAT LAKES DIVISION CONVENTION & 11TH ANNUAL GREATER LOUISVILLE HAMFEST – East Hall of Kentucky Fair & Expo Center, Louisville, KY 40232 – K4GDU **26-27**

ARRL ROANOKE DIVISION CONVENTION - Virginia Beach Pavilion. Contact TRC, P.O. Box 7101, Portsmouth, VA 23707 **26-27**

DELTA QSO PARTY **26-27**

27

CALHOUN COUNTY AMATEUR RADIO ASSN. 2ND ANNUAL HAMFEST – Municipal Auditorium, 1128 Gurnee Ave. Anniston, AL – KA4LRL **26-27**

GOLDEN EMPIRE FLYING CLUB'S ANNUAL FLY-IN & AVIONICS SWAP MEET – Nevada County (CA) Airpark. Contact Golden Empire Flying Club, P.O. Box 375, Grass Valley, CA 95945 **27**

7TH ANNUAL CLEVELAND HAMFEST – Cuyahoga County Fairgrounds in Berea, OH. Contact Cleveland Hamfest Association, P.O. Box 27211, Cleveland, OH 44127 **27**

LANIERLAND A.R.C. HAMFEST – Gainesville, GA, at the Holiday Inn. Contact Paul Watkins, W4FDK **27**

SANGAMON VALLEY RADIO CLUB'S SIXTH ANNUAL HAMFEST – Sangamon County Fairgrounds, U.S. Rte. 36, New Berlin, IL **27**

7TH ANNUAL CEDAR VALLEY ARC HAMFEST – Hawkeye Downs Exhibition Bldg., Cedar Rapids, IA. Contact CVARC Hamfest, P.O. Box 994, Cedar Rapids, IA 52406 **27**

CONNECTICUT VALLEY FM ASSOCIATION'S 5TH ANNUAL HAMFEST – King Ridge Ski Area, New London, NH KA1BWE **27**

LONG ISLAND MOBILE ARC ARRL HAMFAIR 81 PART II Islip Speedway, Islip, NY at Exit 43 of Southern State Pkwy. Contact Sid Wolin, K2LJH **27**

SKYVIEW RADIO CLUB SWAP & SHOP Sokol Camp, 700 Wildlife Rd., Lower Burrel, PA. Contact Jim Jackson, K3VRU **27**

ADRIAN ARC HAMFEST – Lenawee County Fairgrounds Adrian, MI. Contact Adrian ARC, P.O. Box 26, Adrian, MI 49221 **27**

28

29

30

AMSAT Eastcoast Net 3850 kHz 9:00 PM EDST (0100Z Wednesday Morning)
AMSAT Mid-Continent Net 3850 kHz 9:00 PM CDST (0200Z Wednesday Morning)
AMSAT Westcoast Net 3850 kHz 8:00 PM PDST (0300Z Wednesday Morning)

W1AW Schedule

April 26-October 25, 1981

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

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

For more details see Coming Events

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255 Power Supply/Spkr.	170.00
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283 Vfo—Delta	169.00
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CUBIC Astro 103	1175.00
HY-GAIN V2 2meter vertical	40.00
ICOM 720/A Power Sup./Mic.	1299.00
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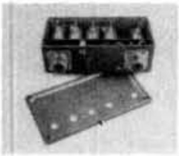

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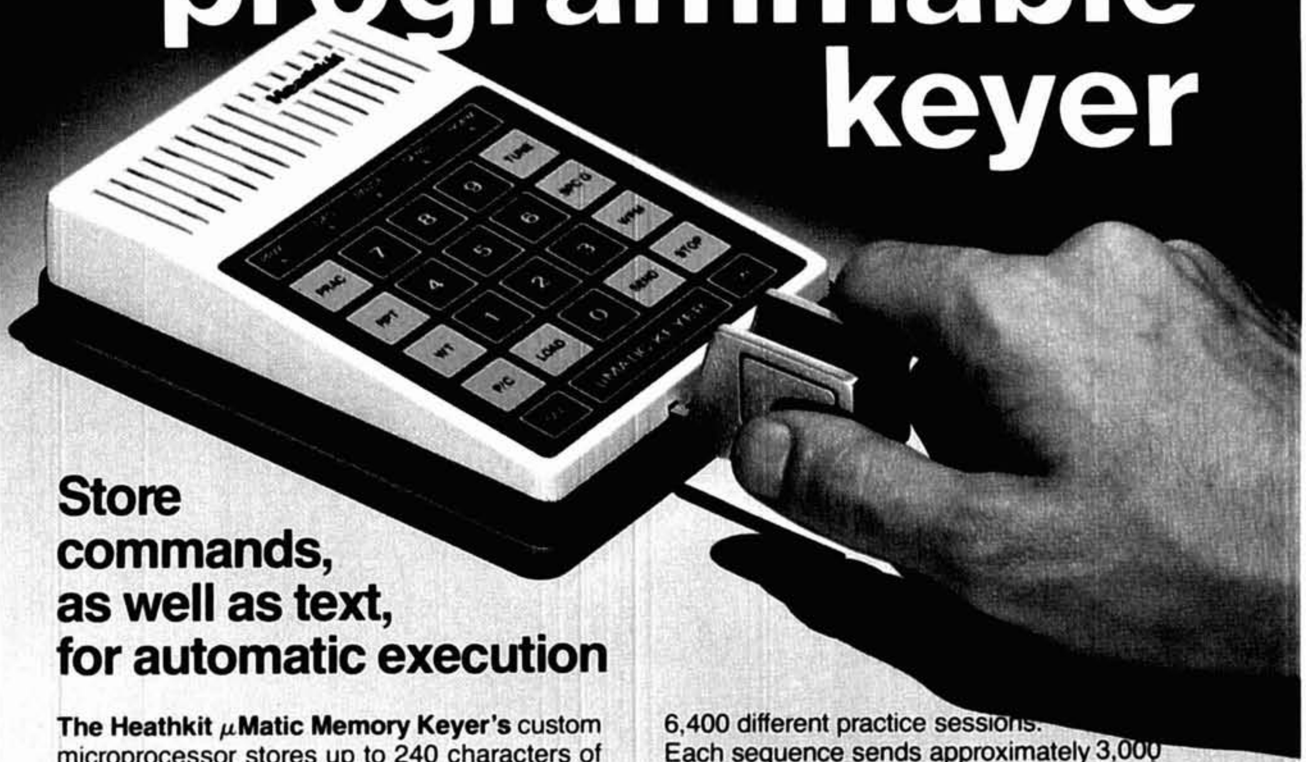

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