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225 Main St, Newington, CT 06111 USA
Telephone: 203-666-1541
Telex: 650215-5052 MCI
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COLUMNS

ABOUT THE COVER

A full moon or a new moon? At apogee or at perigee? Moonbouncers' opinions seem to vary on when the time is right for a successful QSO. Turn to page 4 for the details. *(Moon photo by Dennis Milon)*

Purposes of *QEX*:

1) provide a medium for the exchange of ideas and information between Amateur Radio experimenters

2) document advanced technical work in the Amateur Radio Field

3) support efforts to advance the state of the Amateur Radio art.

All correspondence concerning *QEX* should be addressed to the American Radio Relay League, 225 Main Street, Newington, CT USA 06111. Envelopes containing manuscripts and correspondence for publication in *QEX* should be marked: Editor, *QEX*.

Both theoretical and practical technical articles are welcomed. Manuscripts should be typed and double spaced. Please use the standard ARRL abbreviations found in the 1985 and 1986 ARRL Handbooks and in the January 1984 issue of *QST*. Photos should be glossy, black-and-white positive prints of good definition and contrast, and should be the same size or larger than the size that is to appear in *QEX*.

Empirically Speaking. . .

Standards Alternatives for HF Packet Modems

Things meant to be temporary often end up as "standards." So it is with the use of 200-Hz FSK on HF packet radio. Back in the early days (a relatively few years ago), it was a simple choice. RTTY 170-Hz shift modems were good performers on HF and were available in some shacks. The alternative was the Bell 103 modem with 200-Hz shift which was readily available to computer hobbyists and inexpensive. Bell 103 won the contest and became the de facto "standard" for HF packet operation at 300 bauds. The narrow shift, lack of visual tuning indicators and some of the older transceivers having 100 Hz frequency resolution made Bell 103 packeting on HF a sport only for those with determination and steady hands. Nevertheless, problems have been solved one by one, and it has been working for a growing list of active stations.

We need to look forward to a day when the FCC rules can be amended to permit 1200-baud operation on HF rather than sticking with the 300-baud speed limit indefinitely. A few among us have theories that 1200-baud operation won't work at HF because of multipath causing intersymbol interference (ISI). It's encouraging to see that 1200-baud HF packet is in use in several countries outside FCC jurisdiction. In fact, there are voice-frequency modems operating as fast as 9600 bit/s at HF, but they have sophisticated signal processing, learning and the like. It goes without saying that frequencies need to be chosen as close to the MUF as possible to minimize ISI.

The ARRL Digital Committee has sent a letter to packet modem designers to call for inputs toward developing a new modem standard capable of 1200-baud operation on HF. Probably the most attractive candidate system, for reasons of spectrum conservation, is minimum-shift keying (MSK). It is a continuous phase modulation method that should occupy only about 1.4 kHz with proper filtering and good transmitter linearity. Its bandwidth is considerably less than that for 800-Hz (CCITT V.23) or 1000-Hz (Bell 202) shift FSK. Give a listen just above 14.100 MHz on weekends to the growing amount of HF packet activity to gain an appreciation for the need to conserve spectrum while improving data rates.

MX-COM and several Japanese manufacturers have single-chip MSK modems, which were developed for 900-MHz personal radio services. In fact, they are used in the Digital Coded Squelch systems offered by major Japanese Amateur Radio manufacturers. It will be interesting to see how these chips made for UHF will handle the bumpier HF fading and QRM.

A case could be made for trying Bell 212A/CCITT V.22 modems, which are now readily available and inexpensive. Tom Clark, W3IWI, is interested in HF experiments with the PSK modem designed for Fuji OSCAR-12. Tom would also like to hear from experimenters who would like to do developmental work (on modems and other applications) using digital signal processing (DSP). Once we have some common DSP hardware available at reasonable prices, all it takes is software to make your modem behave differently. In fact, DSP offers the possibility of making an adaptive modem that is capable of changing its modulation and demodulation tactics according to instantaneous signal conditions.

If you have something to contribute toward developing new HF packet modem standards, please send a letter to Chairman, ARRL Ad Hoc Committee on Amateur Radio Digital Communication c/o ARRL HQ.—W4RI

Correspondence

First AMSAT Phase 4 Meeting Successful

On April 4-6, a group of engineers and scientists sharing a common bond gathered in Denver, CO. Each attendee is a member of AMSAT and each has a desire to donate his or her time and expertise to new design concepts for a different breed of Amateur Radio satellite called Phase 4.

Phase 4 will be AMSAT's first geosynchronous satellite. Communications modes would include Mode JL and several versions of Mode S—general linear communications transponder, voice gateway interconnect, packet gateway interconnect, receive only gateway interconnect-broadcast mode. A Mode S video transponder (integrated services digital network transponder) and microwave-beacon experiment are currently under study.

Fig 1—Jan King, W3GEY, (left) and Dick Jansson, WD4FAB, discuss the spacecraft's thermal design. The use of a heat pipe design on the spacecraft will allow precise temperature control across its entire surface.[3] (Photos courtesy of Dick Daniels, W4PUJ.)

Fig 2—Gordon Hardman, KE3D, spoke on the design of the Phase 4 satellite transponders.

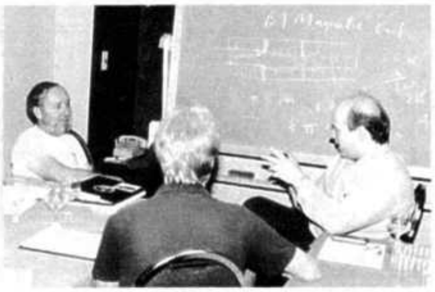


Fig 3—Lou McFadin, W5DID, (left) and Bob McGwier, N4HY, (right) describe how Fluid Momentum Control (FMC) works. The FMC concept will pump a ferro-magnetic fluid around the spacecraft for momentum transfer and control. The pumping would be done magnetically to eliminate a motor driven pump. Brent Helleckson, center, listens in.

AMSAT's Phase 4 plan calls for a one-year study period. During this time, participating engineers and scientists will be assigned specific tasks to research. The team will look at each facet of the design, then advance the initial concept to a workable preliminary design. If at the end of the one-year period the team has a design to meet the objectives, the AMSAT Board of Directors will be asked to authorize initial construction activities. Jan King, W3GEY, AMSAT's Engineering Vice President, envisions a 1991 initial operational capability for the first Phase 4 bird.

About 25 participants were present at the three-day meeting to exchange ideas and commit themselves to specific action assignments. Such a large-scale project includes management, people, money and a launch opportunity. If you have something to offer to aid the development of the Phase 4 project, contact Dick Jansson, WD4FAB, tel 305-644-9008.[2] *—Maureen Thompson, KA1DYZ, Asst Editor, QEX*

Fig 4—Jan King, W3GEY, addresses the attendees. As AMSAT's Engineering Vice President, Jan completed a study of the Phase 4 Engineering Study Plan in Sept 1986. He will oversee team activities.

Notes

[1]J. King, V. Riportella and R. Wallio, "OSCAR at 25: Beginning of a New Era," *QST*, Jan 1987, p 41.

[2]P. Rinaldo, "Phase 4 Initial Design Review," *QEX*, May 1987, p 2.

[3]V. Riportella, "Phase Four Initial Design Proceeding Very Well," *Amateur Satellite Report*, Apr 6, 1987, No. 146.

Microwave Update 1987

If you're an amateur microwave enthusiast, you'll be interested in attending the Microwave Update 1987. This year's activities will be held at The Inn at Estes Park, CO on Sept 12 and 13. Talks will be given by Hans Peters, VE3CRU, Al Ward, WB5LUA, Jim Davey, WA8NLC and others. A swap session, equipment displays and noise figure and antenna gain measurements are included. The pre-registration fee is $32 until Aug 1, or $38 after this date. Attendees are encouraged to prepare a paper in their area of research for publication in the Proceedings. Complete information on Microwave Update 1987 is available from Don Hilliard, WØPW, PO Box 563, Boulder, CO 80306.*—Tnx Don, WØPW*

The Central States VHF Society Plans Their 21st Annual Conference

The 21st annual Central States VHF Society conference will be held in Arlington, TX during July 24-26, 1987. Held at the Rodeway Inn off Interstate 30, it is located midway between the Dallas-Ft Worth metroplex.

Topics of discussion include getting started in VHF, propagation, how to take advantage of meteor scatter, and what to expect from the present and upcoming OSCAR satellites. An antenna gain measurement and noise figure testing session will be open to any attendee who'd like to participate.

Continued on page 16.

Position and Phase of the Moon, 1987-2000

By Michael R. Owen, W9IP/2
Geology Department
St. Lawrence University
Canton, NY 13617

Most Amateur Radio operators enjoy hours of nighttime operation during the weekend, unhindered by the need to go to their jobs the following morning. Many VHF/UHF operators take advantage of this time to bounce their signals off the lunar surface to make QSOs with other operators living up to 11,000 miles away. This activity is called EME (earth-moon-earth) or moonbounce.

Moonbounce activity is greatest during weekends. Prearranged schedules (skeds) are commonplace because EME is a weak-signal communications mode. Two stations that want to work each other set up a specific time and frequency to meet; this eliminates a lot of searching for weak signals through the noise.

How can VHF/UHF operators determine the best dates for EME activity? What factors make one weekend better for moonbounce operation than others? What is the outlook for the moon's position for the rest of this century?

Sked weekends are often chosen long in advance so as to coincide with the best position of the moon for EME communications. They are determined by three main factors: *distance* to the moon, lunar *declination*, and *phase* of the moon.

Distance

The distance from the Earth to the moon varies throughout the month because the moon's orbit is elliptical, not circular. The moon's closest approach is known as *perigee* and its farthest point is *apogee*. The difference between perigee and apogee is important, particularly to small EME stations, because moonbounce path loss can vary 2 decibels between perigee and apogee. The extra loss of signal that occurs during apogee can make the difference between a successful contact and none at all. Consequently, it is desirable to schedule EME activity when the moon is closest to the Earth (near perigee).

Declination

If the Earth's equator is extended into space, an imaginary plane (the *equatorial plane*) is formed. At any given time, the angle between the equatorial plane and the moon is called the moon's *declination*. The moon may have a positive (northern), zero, or negative (southern) declination; this varies during the month. If you live in the Northern Hemisphere, you can make an estimate of the moon's declination by noting how high it is in the sky when it is due south of you. If it is high in the sky, the moon's declination is positive; if it is close to the horizon, its declination is negative.

Most moonbounce stations are located in the Northern Hemisphere, where high values of positive declination are preferred and a positive declination takes the moon high in the sky. With negative declination, the moon travels in a path low to the horizon, where it is more easily blocked by trees and harder to track. EME signals must pass through more of the Earth's atmosphere (with its attenuation, noise, and Faraday rotation). In addition, the center of our noisy galaxy has a negative declination, and this noise can make EME signals more difficult to detect. Stations in the Southern Hemisphere generally prefer negative moon declination because it carries the moon high overhead in their sky. Stations near the equator are content with any declination.

Phase

Moon phases are familiar to almost everyone. When the moon is full, it rises at about sunset and remains in the sky all night. During the new moon, the moon rises at around sunrise and travels invisibly near the sun all day. If the moon is close to the sun (as during or near a new moon), relatively narrow-beam EME antennas will "see" both objects. The sun is a powerful source of radio noise and can easily blot out weak EME echos. Therefore, little EME work takes place near the time of a new moon.

Choice of Skeds Weekend

Our discussion thus far suggests that an ideal time for EME activity is during a weekend when the moon is at *perigee*, at a *high positive declination*, and in the *full* phase. Such weekends are rare. Often, sked coordinators must settle for a weekend with a near-zero declination, between perigee and apogee, and an off-full moon. Interestingly, 2-m coordinators seem to favor operation during perigee over other considerations, whereas 70-cm coordinators place higher priority on positive lunar declination.

The Graphs

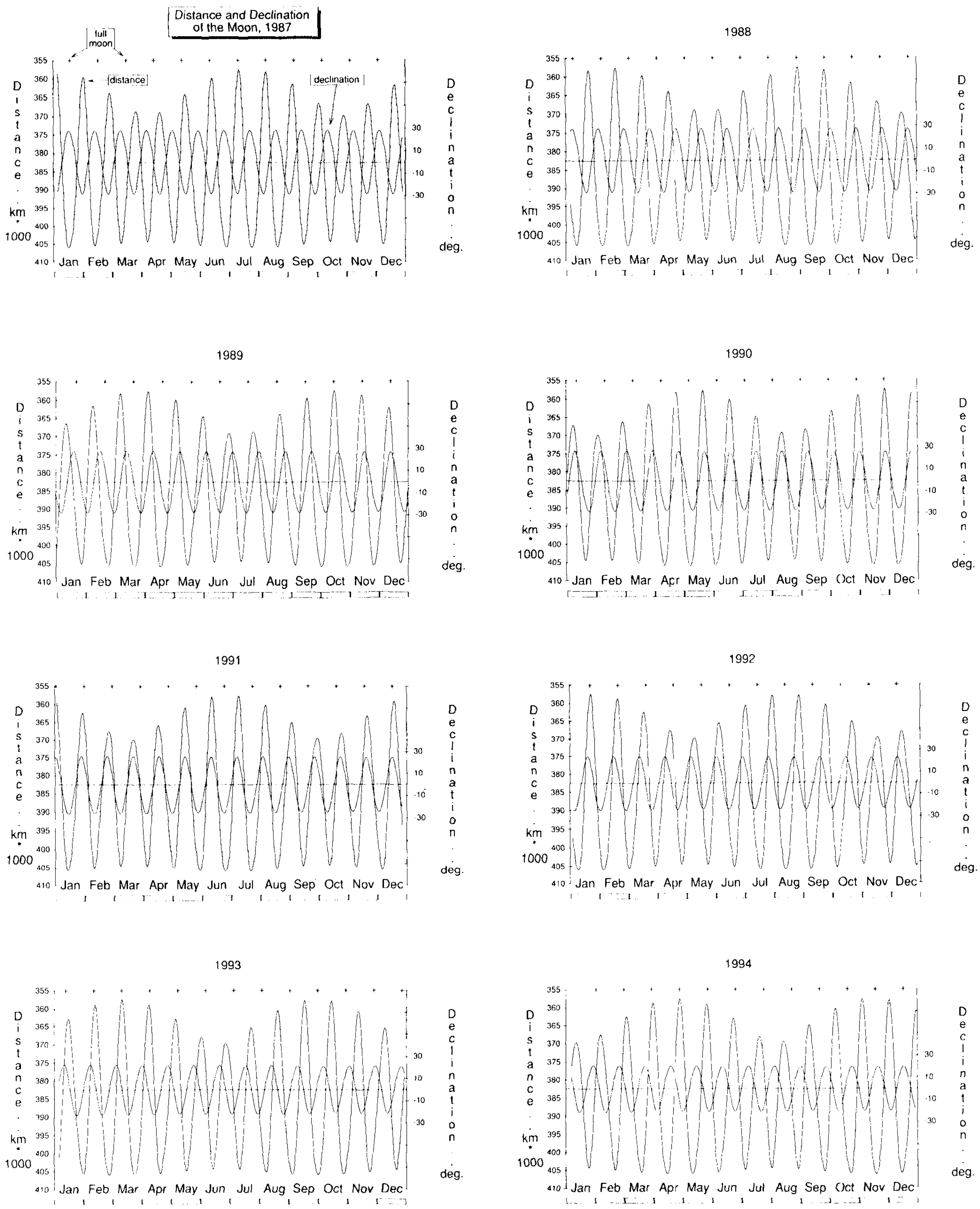
Figs 1 through 14 reveal interesting aspects of the moon's orbit; these graphs will help EMEers plan their activities *long* in advance. They display the distance and declination of the moon annually through the year 2000. The graphs were drawn from equations presented in the *Astronomical Almanac.*[1] For each graph, geocentric distance and declination of the moon were calculated and plotted for 0000 UTC each day. Full moons were calculated using a synodic month (full moon to full moon) of 29.530589 days and a starting date of September 29, 1985 (0000 UTC).

In each graph, distance is portrayed by the tall curve, declination by the short one. Full moons are indicated by a + sign across the top axis. Note that the distance axis is *upside-down*; perigee is at the top. This makes it easier to find the times when positive declination coincides with perigee and a full moon.

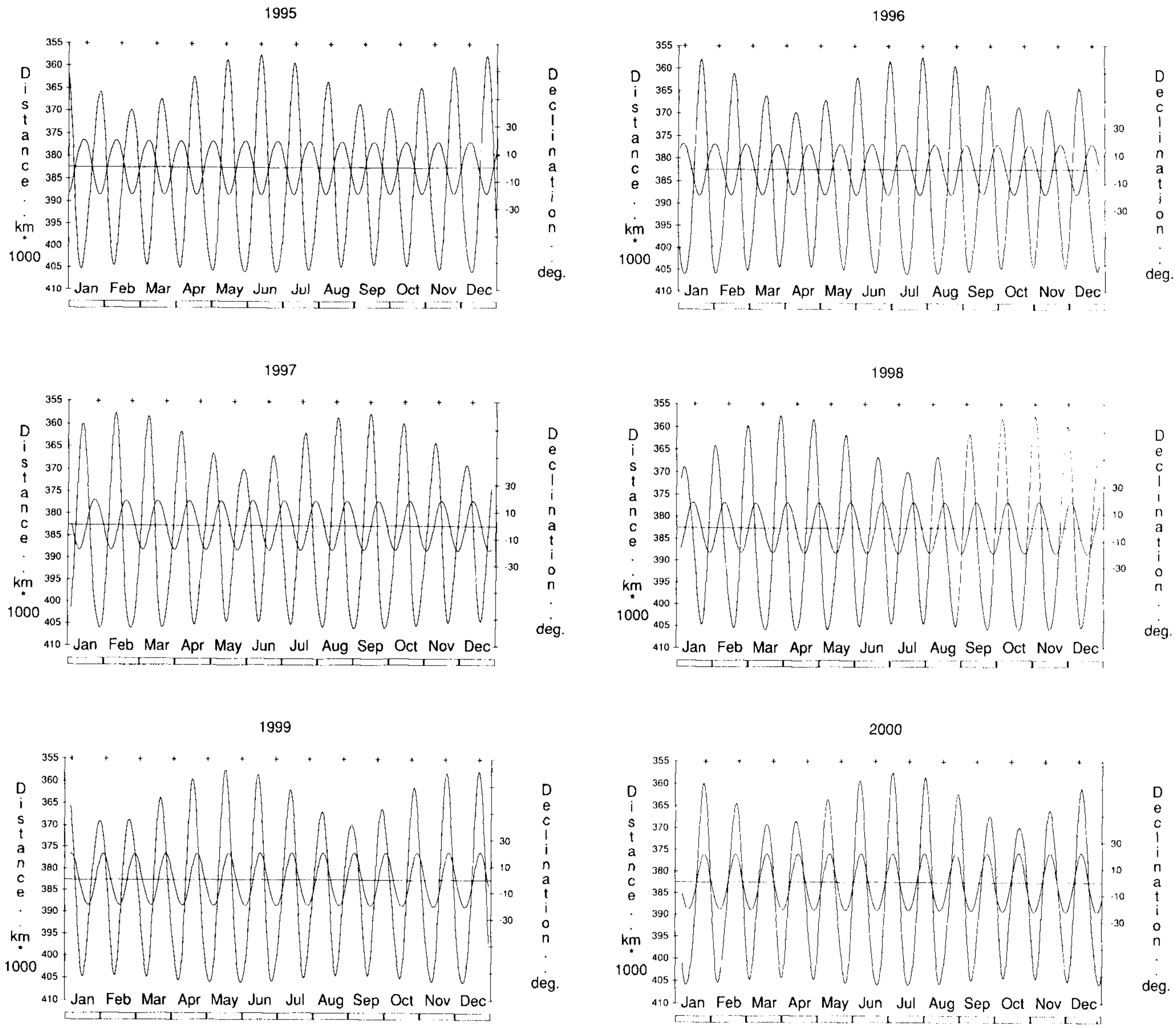
The most important feature of the moon's orbit, from a moonbouncer's viewpoint, is that distance, declination, and phase all have different periods of change, much like frequencies of oscillation. The time between two successive perigees is about 27.555 days, between two nodes of declination, 27.212 days, and between two full moons, 29.531 days. Because each period is slightly different, distance, declination, and lunar phase must shift relative to each other through the years.

For example, consider only distance and declination (the two curves on the graphs). Notice that during the first half of 1987, perigee occurs during periods of very negative (southerly) declination. You could say that distance and declination seem "180° out of phase" during these months. By the end of the year, however, they have "slipped" relative to each other and during most of 1988 and 1989 they are about 90° out of phase. By the end of 1990, distance and declination are "in phase"—maximum positive declination occurs at nearly the same time as perigee. This condition is good for EME

[1]*Astronomical Almanac*, 1985. The book is published annually and is available from the Superintendent of Documents, US Government Printing Office, Washington, DC 20402.



Figs 1-14—The distance and declination of the moon annually through the year 2000.



Figs 1-14 continued

operation! Even better, perigee, high positive declination, *and* a full moon occur together for about 6 months—an ideal situation for EMEers.

These good conditions can't remain fixed forever, of course. By mid-1991, distance and declination are still approximately "in phase," but they occur between full moons (during a new moon). EME operation may become scarce during the middle of 1991. At a full moon, the moon will be at apogee and have a very negative (southerly) declination—a difficult time for moonbounce.

Ideal EME conditions do not return until the end of 1999 and early 2000. However, don't despair! If your antennas can reach low (zero and negative) declinations, then mid-1995 and mid-1996 offer a good opportunity to work southern-hemisphere stations. For our neighbors to the south, these months present the best conditions for EME because the moon will be high in their sky. For most of the remainder of the century, EMEers will have to muddle through with compromise conditions of lunar position.

An interesting feature of the moon's orbit, apparent in these graphs, is that perigee distance is not the same from month to month. The actual *distance* of perigee varies cyclically through the year; a difference of 9322 miles (15,000 km) is not unusual. The effect of variable perigee distance on EME path loss is about 0.4 dB. Perhaps this accounts for some of the difference between EME conditions in different months. The distance of apogee varies much less.

Although difficult to see on the annual graphs, the angle of most positive (or most negative) declination per month is not constant through the years, either. For example, during 1987 the moon reaches almost +29 and −29 degrees declination, whereas in 1996 it will hardly reach +19 and −19 degrees. This means that the maximum elevation of the moon, as seen from the Earth, will be about 10° less during 1996 than during 1987.

You might find it useful to photocopy these pages and cut out the individual years' graphs. Taping them end-to-end will show the cyclic nature of the moon's complex orbit at a glance. Then, as you struggle through the awkward months of mid-1990, it may be encouraging to see the better lunar positions in the years to come.

Computer Interface for the KR-400 and KR-500—Part 2

By Frank H. Perkins, Jr, WB5IPM
2010 Arborcrest
Arlington, TX 76012

The computer interface for the KR-5400A presented in last month's *QEX*[1] can be adapted for use with the KR-400 azimuth rotator and KR-500 elevation rotator by adding a relay card to the basic interface circuitry. From a software point of view, operation remains the same. The specifics for operating the KR-400 and KR-500 are covered in this article.

Main Circuit Board Modifications

The only modifications required on the main circuit board are changes in the values of several resistors. R48 and R50 are changed to 22 kΩ, 5% values, and R49 and R51 are changed to 10 kΩ, 5% values. Eyelets E14 and E15 are "wired out" to external circuitry in this version.

Relay Board

Fig 6 details the schematic of the relay board. K1 and K2 control the azimuth rotator, and are basically wired in parallel with the switches in the KR-400 control unit. Note that K1 and K2 are interconnected such that drive voltage will be supplied to only one rotator winding at a time, regardless of the state of each relay. Elevation control relays K3 and K4 operate in a similar manner. D3-D6 protect Q1-Q4 on the main board from relay coil voltage spikes.

KR-400 and KR-500 Modifications

It is necessary to make a small modification to the KR-400 and KR-500 controller units for use with the interface. Refer to the schematic of the controller unit in either the KR-400 or the KR-500 instruction manual. Note the connection between the "hot" lead of the 29-V ac secondary winding of the transformer and the two control switches. Connect a no. 20 AWG wire between this point and (unused) terminal 7 on the controller unit terminal strip. This allows power for the rotator unit to be supplied to the relay board. *Be sure the controller unit is unplugged from the power line before making the modification!*

[1]F. Perkins, "Computer Interface for the Kenpro KR-5400A—Part 1," *QEX*, May 1987, p 7.

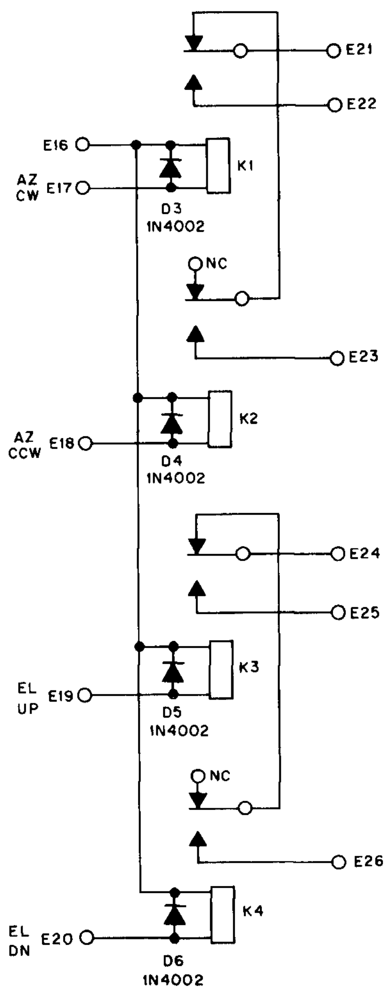


Fig 6—Relay board schematic.
Parts List
K1-K4—SPDT relay, 12-V dc coil (RS 275-0247).
D3-D6—1N4002 diode.
Parts may be purchased from your local Radio Shack store or through Digi-Key, PO Box 677, Thief River Falls, MN 56701, tel 1-800-344-4539; Jameco Electronics, 1355 Shoreway Rd, Belmont, CA 94002, tel 415-592-8097; and Allied Electronics, 401 E 8th St, Ft Worth, TX 76102, tel 817-336-5401.

Assembly

Except for the resistor value changes mentioned, the main circuit board is assembled as described in Part 1. Fig 7 details the assembly of the relay circuit board; Fig 8 is the etching pattern. The two boards should be housed together in an aluminum chassis or box.

Fig 9 shows the interconnections between the main circuit board, the relay board and the controller units. Use DIN sockets and plugs for P3, J3, P4 and J4. Rotator cable can be used for the cabling between J3 and the KR-400 controller unit, and between J4 and the KR-500 controller unit. Note that the wiring from the interface is paralleled with the existing wiring on the controller units. Fig 10 shows the contents of a completed computer interface board for the Kenpro KR400/500 antenna rotator unit.

Interface Testing and Adjustment

Turn on the interface and check the power supply voltages before connecting it to your computer or the KR-400 and KR-500 controller units. If all seems well, turn off the interface. Load and store the test program (Fig 2 of last month's article). Turn off the computer and connect the flat cable between the computer and the interface. Turn on the computer and the interface. Run the test program, setting the azimuth to 180° (full clockwise) and the elevation to 180°. Answer "Y" to the "GO AGAIN (Y/N)" prompt, but do not input additional data. Adjust R21 on the main circuit board until the voltage

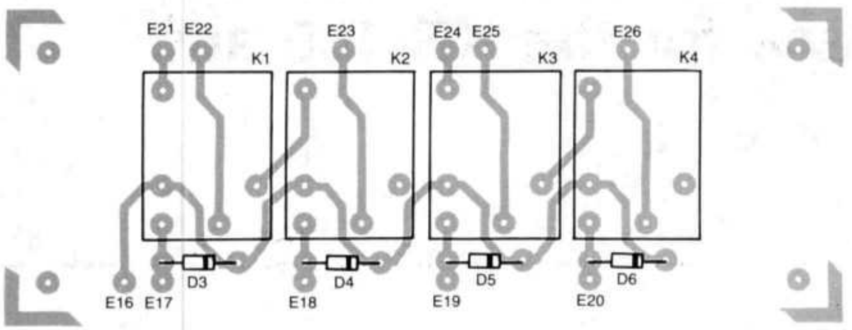


Fig 7—Parts-placement guide for the relay circuit board. Parts are placed on the nonfoil side of the board; gray areas represent unetched copper.

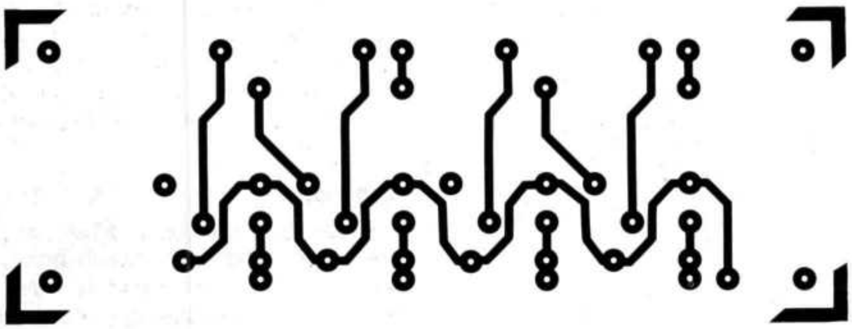


Fig 8—Etching pattern for the relay circuit board. The pattern is shown from the foil side of the board. Black areas represent unetched copper foil.

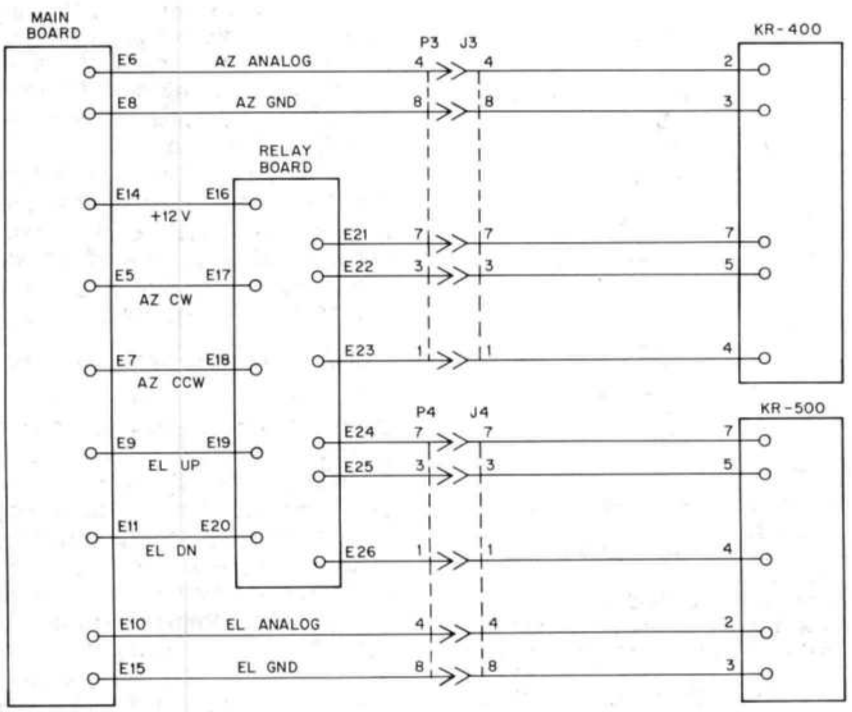


Fig 9—This diagram shows the interconnections between the main circuit board, the relay board and the controller units. Note that the wiring is *in parallel* with the existing wiring on the KR-400 (az) and KR-500 (el) terminal blocks.

at pin 1 of U7 reads 3.60 V dc on your digital voltmeter. Then, adjust R23 for a 3.60 V dc reading on pin 7 of U7. As additional azimuth and elevation data is entered, you should observe voltages proportional to a 3.60 V dc full-scale reading on pin 1 of U7 for azimuth, and pin 7 of U7 for elevation.

Turn off the computer and the interface and plug in the DIN connectors from the KR-400 and KR-500 controller units. Be sure the AUTO/MANUAL switch (S2) is in the MANUAL position. Turn on everything, and allow a five-minute warm-up period. Bring the azimuth rotator fully clockwise to 180° using the switches on the KR-400 controller unit.

Adjust VR-1 on the KR-400 controller unit so that the meter reads exactly full-scale. This should produce a voltage of about 1.9 V dc on pin 4 of U8 in the interface unit. Run the test program, setting the azimuth to 180° (clockwise) and the elevation to 0°. Readjust R21 until the voltage on pin 5 of U8 is 5-10 mV less than the voltage on pin 4, U8.

If your satellite antennas are rigged so that they can be inverted completely, place them at 180° elevation using the controls on the KR-500. If your antennas cannot be inverted, point them straight up (90°). Adjust VR-1 on your KR-500 for the proper meter reading. Run the test program, setting azimuth to 0° and elevation to match the position of your antennas (90° or 180° as determined above). Readjust R23 until the voltage on pin 7, U8 is 5-10 mV less than the voltage on pin 6, U8.

Run the test program and enter 45° azimuth and 30° elevation (display should read "GO AGAIN (Y/N)"). Place the AUTO/MANUAL switch in the AUTO position. The antennas should obey. When not using the interface for computer tracking, leave the AUTO/MANUAL switch in the MANUAL position. Unlike the KR-5400A system, the rotators used with the KR-400 and KR-500 are not protected from thermal overload. Turn off the interface, the KR-400 and the KR-500 when they are unattended. There is no point in taking a chance on cooking a rotator system! Also, be sure to connect the enclosure of your interface to your station safety ground. Unplug J3 and J4 from the interface when not in use for protection against lightning damage.

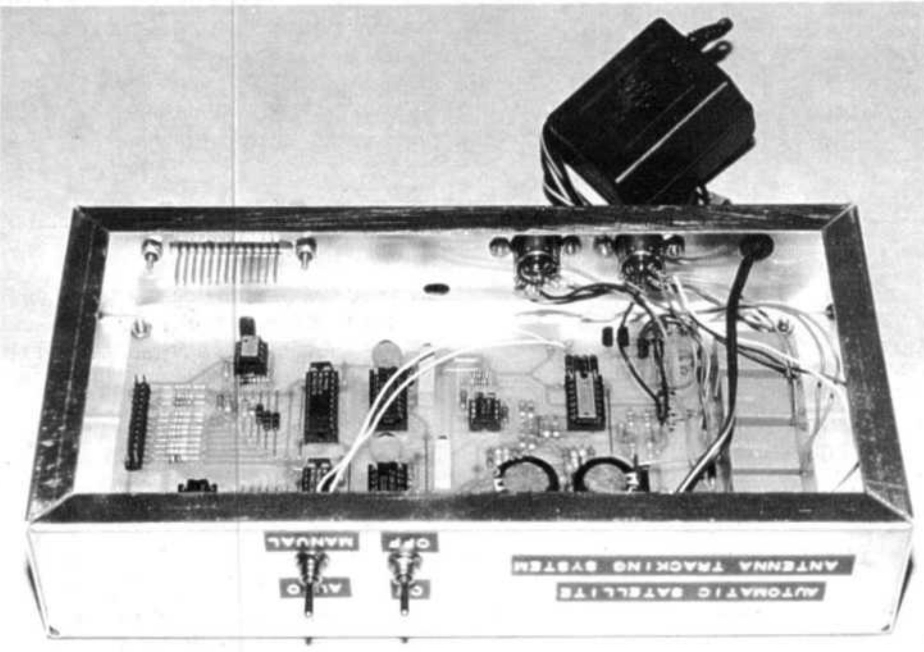


Fig 10—The computer interface for the Kenpro KR-400/500 antenna rotator units. This board was built by Allen D. Brinckerhoff, WB5PMR, AMSAT Area Coordinator for N TX. (Photo courtesy of Doug Loughmiller, KO5I.)

Bits

Ceramic Circuits—More Functions, Smaller Packages

New ceramic circuit technology is a major development in component packaging that integrates conductors, resistors, capacitors and semiconductors into a single package. It improves performance and reliability, lowers component cost and reduces package size. Ceramic circuit processes combine versatility of thick-film materials with the complexity and integrity of multi-layer co-fired manufacturing. Many passive functions can be integrated into the substrate itself, so significant space is saved on the motherboard, and chip-to-chip spacing on the board is reduced with improvements in total circuit performance. Exterior surfaces of Multilythic circuits only need to support active devices and special components like crystal oscillators or those components requiring precision trimming. Typical Multilythic circuits consist of low-K dielectric cover layers, high-K dielectric capacitor layers, low-K capacitor/conductor layers, thick-film conductor and resistance layers and semiconductor components. Contact Sprague Electric Co, 92 Hayden Ave, Lexington, MA 02173 for further information. [This material was excerpted from *Industrial Equipment News*, vol 54, no. 7, Jul 1986, p 23.]—*KA1DYZ*

International Standard On The Subjective Testing of Loudspeakers

The International Electrotechnical Commission has available the IEC Publication 268-13: Sound System Equipment, Part 13: Listening tests on loudspeakers. This compilation was done by leading researchers in the acoustical field.

The standard includes recommendations for the dimensions and acoustic characteristics of the listening room, descriptions of test procedures that have proved satisfactory in practice and considerable information on the statistical methods appropriate for the analysis of the results. Particularly important are the statistical tests that show whether the results are reliable, ie, differences between loudspeakers rather than random scoring by listeners, and the confidence level at which the results are significant. The standard is largely based on research undertaken in Sweden and Canada, but experts from many countries have made valuable contributions.

Subjective testing of loudspeakers is an important activity pursued by both manufacturers and technical journalists (statistics have a significant effect on the market performance of new products). Tests carried out in accordance with the new standard will give results far more reliable than those generally obtained in the past. For a copy of the publication write to Information Officer, Central Office of the IEC, Geneva, Switzerland. —*KA1DYZ*

New Book on Digital Communications Focuses on Technological Advances in the Communications Industry

Author Thomas C. Bartee has done it again—written an investigative publication on *Digital Communications*. The 448-page text is devoted to topics such as fiber-optic transmission technology and system evolution, satellite communications, cellular networks, computer-based messaging, electronic mail systems and much more. *Digital Communications* was developed as a comprehensive reference source resulting from the growth and significant advances in the communications industry. Nine experts detail each subject with an in-depth perspective reflecting their many years of experience and contributions.

For more information on *Digital Communications*, contact Howard W. Sams & Co, 4300 W 62nd St, Indianapolis, IN 46268 or call 800-428-SAMS. Price: $44.95.—*KA1DYZ*

Cable Counting

By Paul Newland, AD7I
ARRL Technical Advisor
PO Box 205
Holmdel, NJ 07733

Do you wonder how the telephone company's technicians identify one particular pair of wires from a cable composed of many, especially when the only information about the identity of the wires is denoted by the color of the plastic with which they are insulated? The system used to identify the wires is fairly simple and can be remembered easily or reconstructed from a crib sheet. So, whether you want to expand your horizons or are considering constructing a super-station with many interconnections between points using cables, this information will show you how the pros keep from getting lost among the jumble of wires.

In telephone parlance, signals travel on a *pair* of wires. One wire of the pair is for the signal to travel out on and the other is for the signal to return on. The system is usually operated in a balanced manner and neither wire of the pair is connected directly to ground. In control applications, as opposed to audio applications, one might choose to ground a particular lead, provided that it doesn't induce ground noise in other pairs within the cable.

Any particular pair consists of two wires that are twisted together, perhaps with 3 to 6 twists per foot. One wire is termed the *ring*, while the other is called the *tip*. This terminology dates back to the days when all phone lines terminated in jacks (similar to a ¼-inch phone jack) on an operator's console. When a plug was inserted into the jack, the tip of the plug made contact with one of the wires of the pair. That wire was known as the *tip wire*. The ring of the plug made contact with the other wire and was known as the *ring wire*. Today, few such consoles with jacks are still in use, but the tip and ring terminology remains.

Although you won't see numbers printed on each pair within a cable, the pairs are numbered by use of a color code. Table 1 lists the colors allowed for tip and ring wires. Table 2 shows how they are combined within a 25-pair cable.

From Table 2, note that the first five pairs have a tip color of white. In some cables where the insulation of each wire is one solid color, the only way to know which tip goes with which ring is by noting that they are twisted together. If the sheath is sliced off a cable and the wire pairs unravel so that each pair's tip and ring are no longer twisted together, it is almost impossible to know which wires you have. In this case (and it does happen), the cable splicer tries to do his or her best to determine which wires go together. If things really get fouled up, continuity tests and capacitance tests can be performed to find each wire's mate within the cable. If two pairs swap the same tip or ring wires at both ends, continuity checks will say that everything is okay. Yet, when audio signals are put on one pair, a large amount of cross-talk will be present from that pair to another. This condition of swapping the same wire at both ends of the cable is called a *split* (Fig 1)—an undesirable condition!

Table 1
Color Code For Cable

Tip	*Ring*
Blue (Bl)	White (W)
Orange (O)	Red (R)
Green (G)	Black (Bk)
Brown (Br)	Yellow (Y)
Slate (S)	Violet (V)

Table 2
Color Assignments For Pairs

	Pair Colors	
Pair No.	*Tip*	*Ring*
1	*Blue*	*White*
2	*Orange*	*White*
3	*Green*	*White*
4	*Brown*	*White*
5	*Slate*	*White*
6	*Blue*	*Red*
7	*Orange*	*Red*
8	*Green*	*Red*
9	*Brown*	*Red*
10	*Slate*	*Black*
11	*Blue*	*Black*
12	*Orange*	*Black*
13	*Green*	*Black*
14	*Brown*	*Black*
15	*Slate*	*Yellow*
16	*Blue*	*Yellow*
17	*Orange*	*Yellow*
18	*Green*	*Yellow*
19	*Brown*	*Yellow*
20	*Slate*	*Yellow*
21	*Blue*	*Violet*
22	*Orange*	*Violet*
23	*Green*	*Violet*
24	*Brown*	*Violet*
25	*Slate*	*Violet*

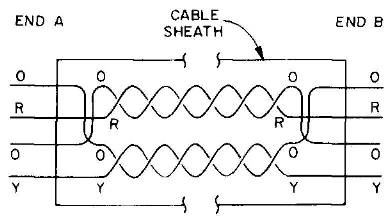


Fig 1—An example of a split between pairs 7 (orange/red) and 17 (orange/yellow). Dc continuity checks would show that all is well; yet, for voice there would be considerable cross talk because of the cross coupling caused by the twisted wires. The cross talk would be worse the longer the cable was.

In more expensive cables, and in those for use in indoor installations, an insulation color coding consisting of stripes or splotches over solid colors is often used. In the case of the tip wire, the base color (ie, the most prevalent color) is that of the tip color. Additionally, small splotches or strips of its mate's (ring) color are also shown. In a similar manner for a ring wire, the base color is that of the ring color with small splotches or strips of its mate's (tip) color also present. With this type of insulation, provided the splotches cover less of the area than the base color, it is easy to spot and correct a split condition.

In control applications, it isn't so important that pairs not be split. You could just assign wires any way you please. However, if you are using them to transmit voice or balanced data (maybe using RS-422), you should ensure that you are using a true transmission line formed by a twisted pair. If you use a split pair, your system could be subject to unwanted cross talk. And, to make it look like a professional job, you should assign the cable pairs in numerical ascending order, just like the professionals would, by using the standard color code.

By Bill Olson, W3HQT
Box 1655A, RFD 1
Burnham, ME 04922

Solid-State Construction Practices, Part 6: The Exam

As promised, here is the long-awaited solid-state construction project. It's time to put all of that new-found >50 knowledge to work. The following pages describe a 35-watt, solid-state linear amplifier for the 23-cm band. Drive requirements are about 7-10 W, making it ideal for use with the popular transceivers and transverters available in that power range. The amplifier can be used barefoot or as a driver for a tube-type amplifier to generate some serious power. The beauty of this design is that it requires only a single 13.8-V, 6-A power supply. There are certainly possibilities of remote (tower-top) mounting. Thirty-five watts at the antenna feed point is a *big* signal on 1296 MHz. Interested? Read on.

Circuit Description

As shown in Fig 1, the amplifier uses a pair of NEC NEL1320-81 transistors (Q1 and Q2). Although the NEC transistors are supposed to be 20-W devices, they usually max out at 18-20 W in a single-ended design. With combiner losses in this design, output is typically 32-34 W at the 1-dB compression point and 35-36 W at saturation.

The transistors are connected in push-pull with 90° hybrid combiners (W1 and W2). The "trick" in this amplifier is the use of Sage Wireline® to make a very compact, broadband 3-dB coupler. Only 1.5 inches of Wireline are needed for a 23-cm combiner. See the accompanying sidebar. R1 and R4 terminate the combiner isolation ports. This design uses 10-W, microstrip flange-mount terminations.

Q1 and Q2 are biased for class-AB operation using a standard diode biasing circuit (D1, D2). Quiescent current is set at approximately 150 mA per device by adjusting the values of R2 and R3. The bias voltage is brought in on a separate line so that the amplifier can be biased off during receiving periods.

Most of the matching is done with microstriplines etched on the circuit board. The first matching section on both input and output is accomplished with fixed-value chip capacitors soldered to the transistor leads (C11, C12, C13, C14). Input tuning is accomplished with C9 and

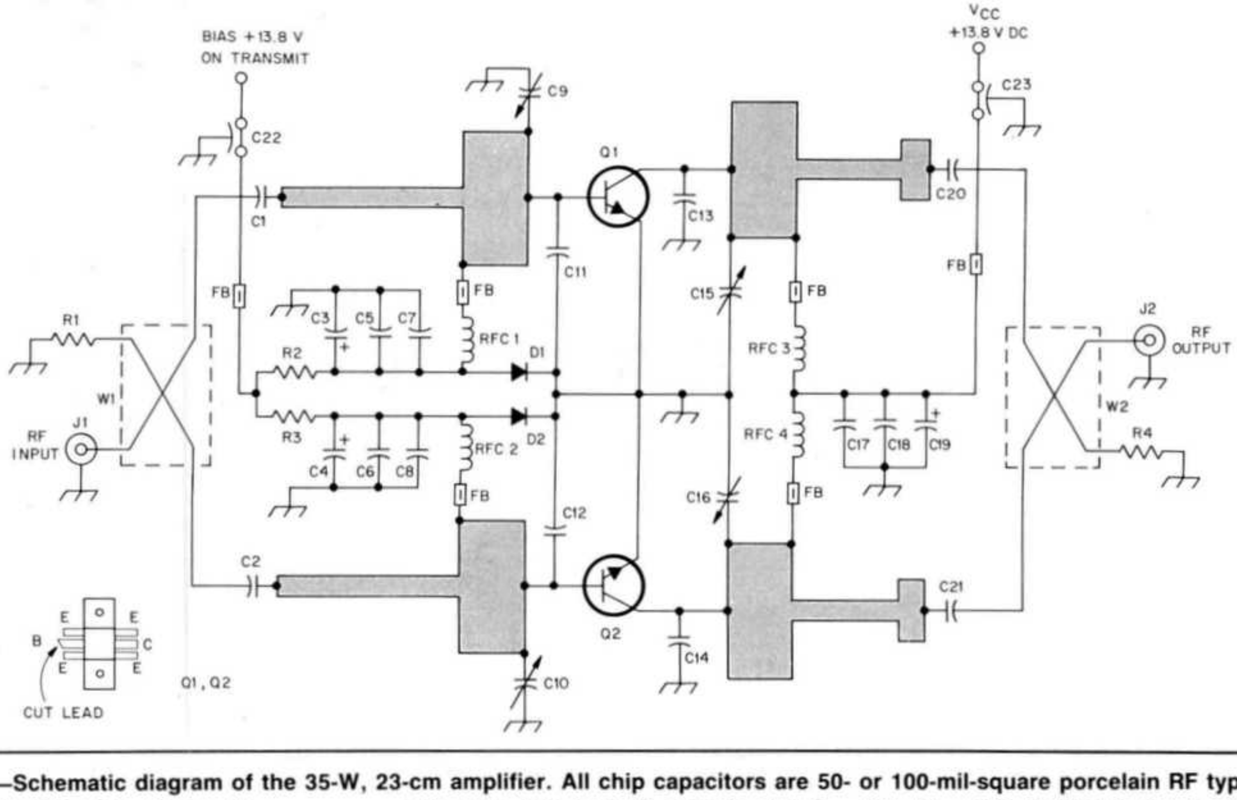


Fig 1—Schematic diagram of the 35-W, 23-cm amplifier. All chip capacitors are 50- or 100-mil-square porcelain RF types.

C1, C2, C20, C21—27-pF chip capacitor.
C3, C4, C19—3.3-μF, 25-V Tantalum capacitor.
C5, C6, C18—0.1-μF disc-ceramic capacitor.
C7, C8, C17—100-pF chip capacitor.
C9, C10—5-pF, 5-mm ceramic rotary trimmer capacitor.
C11, C12—5.6-pF chip capacitor.
C13, C14—5.1-pF chip capacitor.
C15, C16—0.6- to 7-pF ceramic piston trimmer capacitor.
C22, C23—500- to 1000-pF feed-through capacitor.
D1, D2—Pair of 1N4001 diodes in parallel.
FB—Ferrite bead.
J1, J2—Type-N female chassis-mount connector (UG-58 or equiv).
Q1, Q2—NEC NEL1320-81 microwave power transistor.
R1, R4—50-Ω, 10-W chip termination (Component General CBT-10 or equiv).
R2, R3—160-200-Ω, 2-W resistor (see text).
RFC1-RFC4—4t no. 28 wire, 0.1 inch ID, close wound.
W1, W2—Sage Wireline 90° hybrid (see text).

Using Sage Wireline®

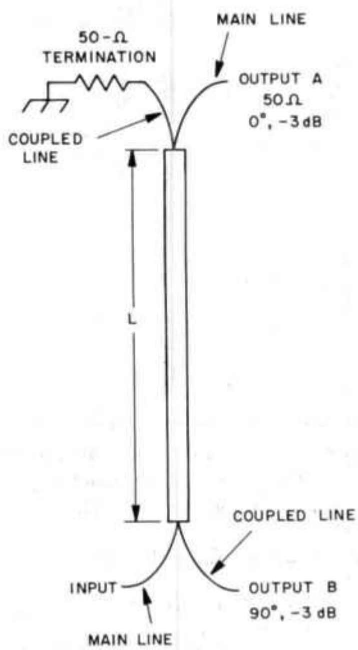
Sage Wireline is a convenient way to construct compact 3-dB hybrid couplers for combining amplifier stages in push-pull. The Wireline material is similar in construction to Teflon® -dielectric coaxial cable, but it has a twisted pair instead of a single center conductor.

Octave-bandwidth 3-dB couplers can be constructed by using an electrical ¼ wavelength of this material. The correct physical length of the line (L) can be determined from

$$L = \frac{1850}{F}$$

where F = the center frequency in MHz. For example, the line length for a coupler with a center frequency of 1200 MHz is 1850/1200, or 1.62 inches. This coupler would cover 800 to 1600 MHz—good enough for use at two amateur bands. Since the bandwidth is so great, minor measurement errors will have little effect on performance. The small size makes this type of combiner a natural for solid-state microwave circuits.

The inner conductors consist of a main line coated with an orange enamel and a coupled (bare) line. They are connected as shown in the accompanying figure. One end of the coupled line is terminated in a 50-ohm load. Assuming that the loads on the output ports are equal, any reflected power shows up at the termination port. This feature makes a nice flat coupler for combined amplifiers.



C10; C15 and C16 are used to tune the output.

A number of decoupling capacitors and chokes are used on the base and collector power leads. I have found the NEL1320 devices to be very stable, but it's good practice to include sufficient decoupling to prevent any chance of oscillation.

Construction Details

The amplifier is designed to fit inside a standard 4 x 2 x 1-inch diecast aluminum box (Hammond 1590B, Bud CU124 or equivalent). A heat sink is bolted to the bottom of the box, and connectors attach to the ends. The heat sink must be flat on the side that contacts the box bottom. See Fig 2. At this frequency, it's no surprise that the physical layout closely resembles the schematic.

Preparing the PC Boards

The first step is to prepare the two PC

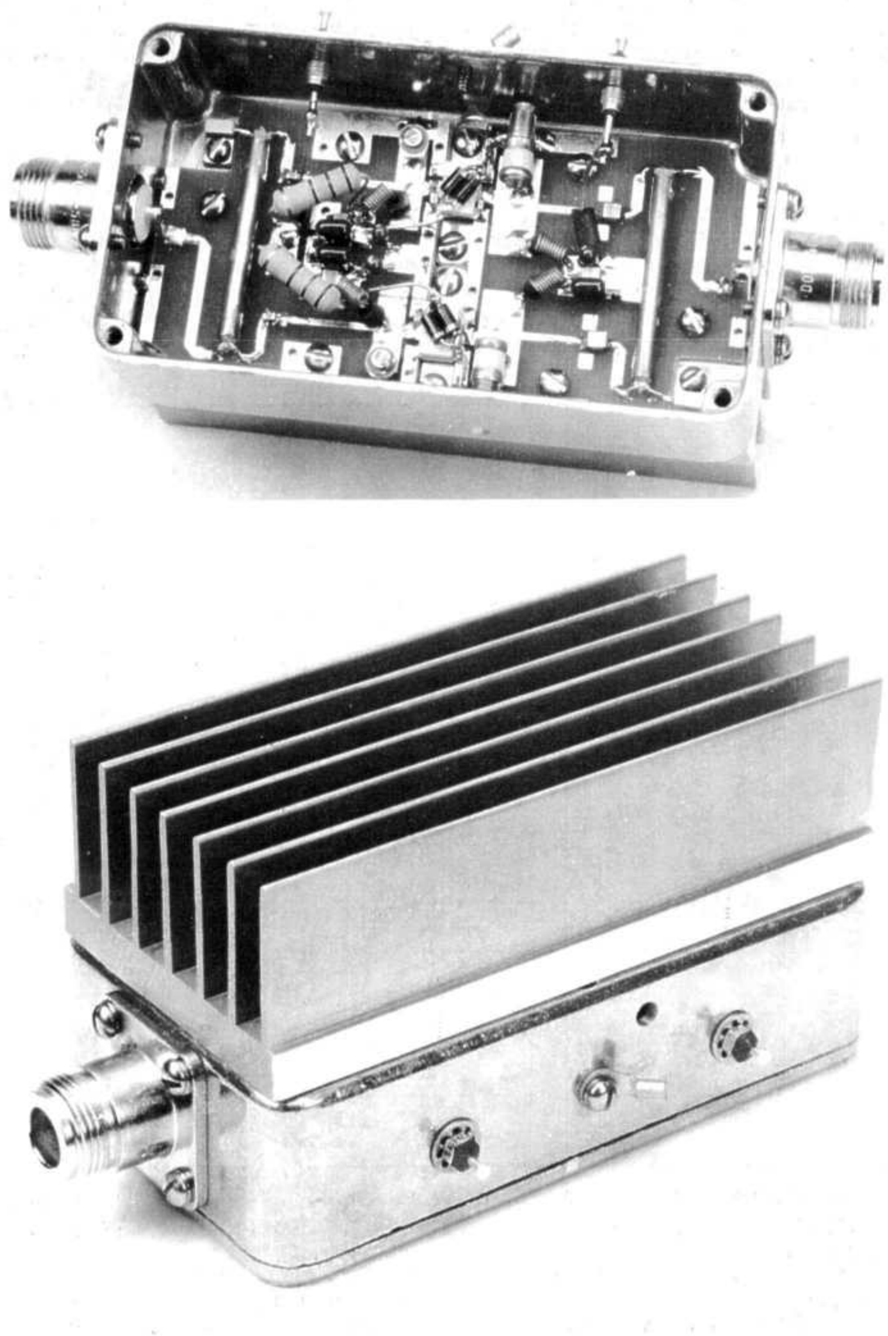


Fig 2—The 23-cm amplifier is built in a standard diecast aluminum box. Most of the parts are contained on a pair of PC boards. Q1 and Q2 mount in the center. The heat sink is flat on one side and is attached to the box with the screws that hold the PC boards in place.

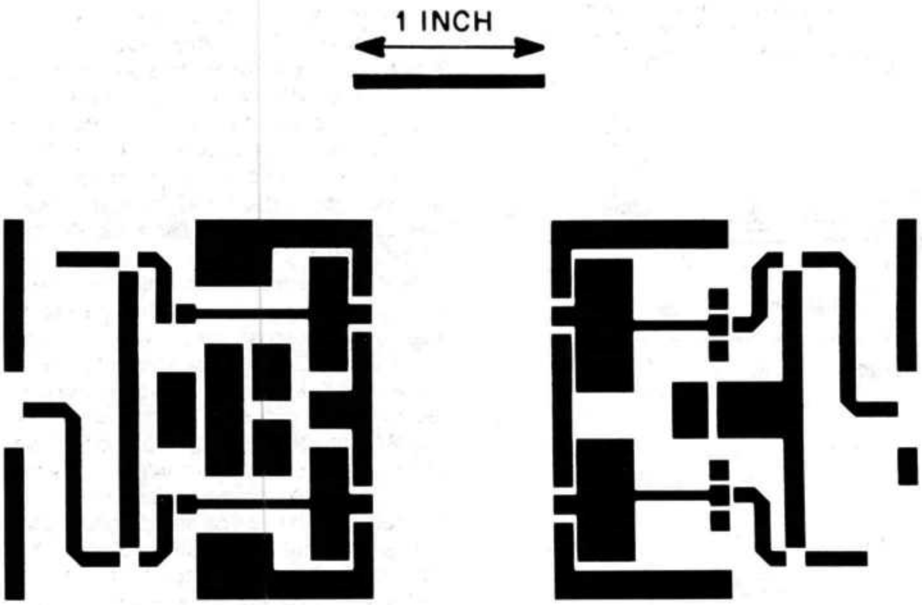


Fig 3—Etching pattern for the 23-cm amplifier PC boards. Black areas represent unetched copper. The back side is left unetched to act as a ground plane.

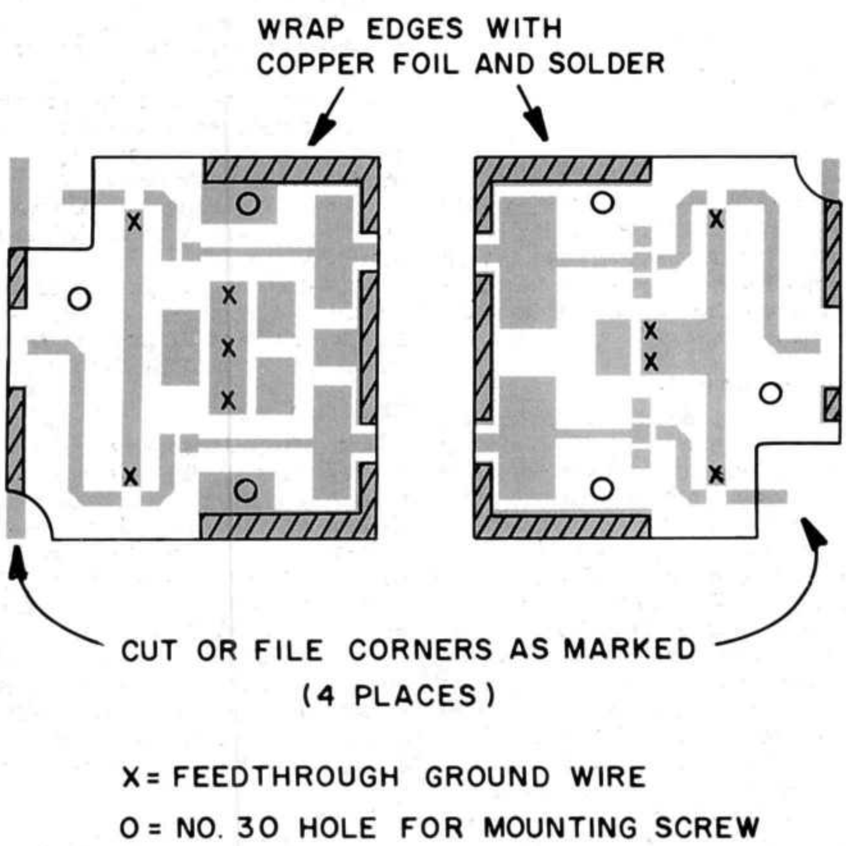


Fig 4—PC board preparation information. See text.

boards that hold most of the components. Fig 3 shows a full-sized etching pattern for these boards. The PC board material is standard 0.062-inch-thick, double-sided, glass-epoxy circuit board (G-10 or FR-4). Circuit elements are etched on one side, and the other side is left unetched to act as a ground plane.

After etching the boards, you must connect the ground areas on the top of the board to the ground plane. See Fig 4. First, wrap thin copper foil around the edges of the board where indicated and solder top and bottom. Then, drill small holes through the board at each spot marked with an X, pass a wire through each hole, and solder the wire top and bottom. Be sure to make all of the ground connections shown, or the amplifier may not work properly!

Next, drill three no. 30 holes in each board as indicated; these holes will clear the no. 4-40 screws that will be used to fasten the boards to the box and heat sink. Finally, cut or file the corners of the circuit boards as shown to fit the corners of the box and to make room for R1 and R4. This completes preparation of the PC boards.

Machining the Box

Fig 5 shows the mechanical details of the box and heat sink assembly. Be sure to prepare the PC boards first; they will be used as templates to mark and drill the box. As explained in an earlier >50 column, it is important that the transistor leads rest flush against the PC board traces. In many cases, the heat sink must be milled out to the right depth. For this project, however, all you need is a drill press and file! The NEL1320 flange height is almost exactly the same as the thickness of the PC boards plus the thickness of the bottom of the box. If you simply cut a ¼-inch-wide slot across the bottom of the box and bolt the transistors directly to the heat sink, the leads will rest properly on the traces.

First, we'll cut the slot to clear the transistor flanges. Draw a line across the center of the bottom of the box. This line will be 2.15 inches from either end. Center punch the line every ¼ inch and drill a series of ¼-inch holes along the line. Use a file to clean up the slot until the transistor flanges clear.

Now put the boards and transistors back into the box. Make sure everything fits well with the transistor flanges sitting in the slot. Again, butt the boards up against the transistors. Place R1 and R4 in their respective positions, butted up against the PC boards. Mark the locations of the three mounting screws for each board and the mounting screws for R1 and R4. Remove the components and drill no. 30 holes at each of the eight locations you just marked.

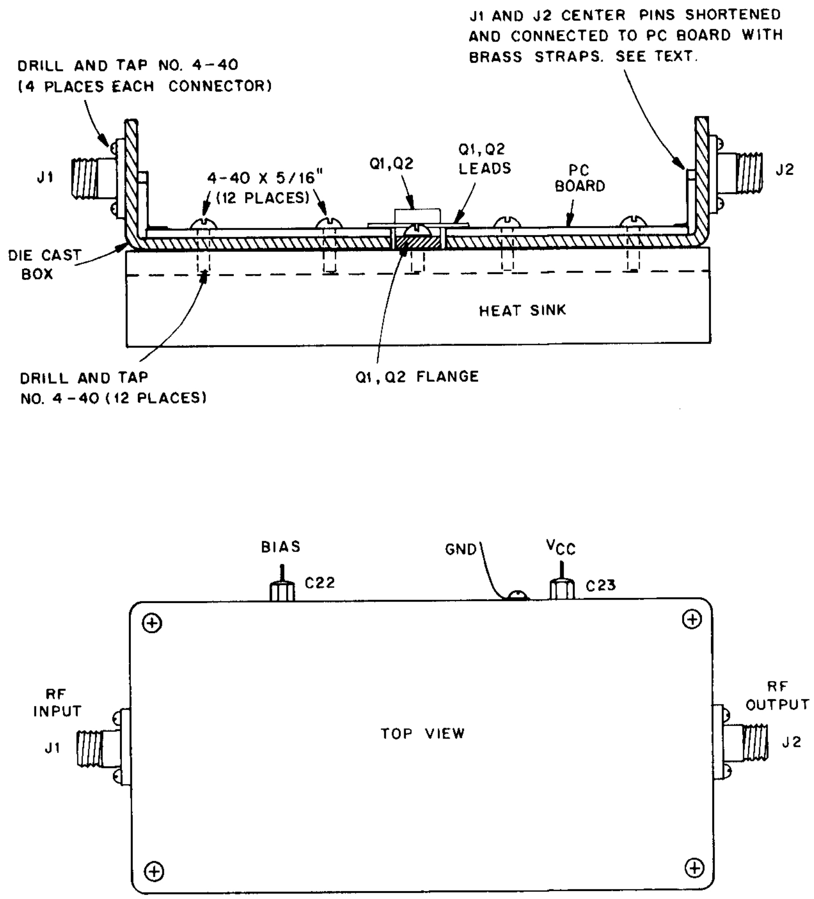


Fig 5—Mechanical layout of the 23-cm amplifier box.

J1 and J2 (Type-N female) are centered on the end walls of the box with the flanges on the outside. Locate and drill a hole in the center of each end wall and enlarge it to 5/8 inch to fit the connector. Next, drill and tap each end of the box for the connector mounting screws (no. 4-40 hardware).

Now, locate and drill holes in the side of the box for the feedthrough capacitors and ground lug. The exact hole sizes will depend on the parts you have available. Since C15 and C16 mount horizontally, you'll have to drill holes in the sides of the box to get at them with your favorite tuning tool. This completes machine work on the box.

Drilling the Heat Sink

Using the bottom of the box as a template, mark the locations of the mounting hardware for the PC boards and R1 and R4 on the heat sink. Position Q1 and Q2 in the slot exactly as they will be in finished product and use the mounting holes in the flanges to mark the heat sink. You should have marked the locations of a total of 12 holes. Now drill and tap each hole for no. 4-40 hardware. Put everything back in the box one last time and lightly screw down the PC boards, connectors, Q1, Q2, R1 and R4. Now is the time to make sure everything lines up. Congratulations! You've done the tedious part. Now it's time to warm up the soldering station.

Mounting the Parts

Put the PC boards in the box and tighten them down snug. Put in the transistors (be sure you have them in the right way) and tighten them down firmly. After the next step, it will be difficult to disassemble the amplifier. Solder the transistor leads to the PC board. Using Fig 6 as a guide, solder C11-C14 directly to the transistor leads. Solder in the rest of the chip capacitors. Next, solder in the four RF chokes and C3-C6 and C18 and C19. Now solder in the variable capacitors (C9, C10, C15, C16).

Hybrid combiners W1 and W2 are identical. To prepare them, you'll need to remove the outer copper jacket for ¼ inch from each end of the Sage Wireline. If you've ever worked with 0.141-inch semi-rigid cable, you know the drill. If not, you may want to practice on a scrap of 0.141—Sage Wireline is pretty expensive. Cut a 2-inch section of Wireline for each combiner. Mark the outer jacket ¼ inch from each end. Place the Wireline on a flat surface, hold a sharp X-acto® knife blade firmly against the outer jacket at the mark, and roll the Wireline under the blade to score the jacket all the way around. Hold the Wireline in one hand and use a pair of pliers to *gently* rock the scored section back and forth. It should separate cleanly after a few tries. Do this at each end.

Now take your X-acto knife and *very carefully* cut away the exposed dielectric material. *You must not score the center conductors!* Carefully separate the conductors and strip the ends of the main line (see Wireline sidebar). Place one of the Wireline sections on the input board as shown in Fig 6 and tack solder the shield to the grounded area. Solder one end of the coupled line (uninsulated conductor) to the pad that goes to R1. Solder the other end of this same conductor to the pad going to C2. Now connect the main line (insulated conductor) to the traces going to the input and C1. Solder the other Wireline section to the output board in a similar manner. The coupled line goes between R4 and C20; the main line goes between the output and C21.

Solder in R2 and R3. These resistors should be mounted 1/4 inch or so above the board to allow air to circulate on all sides. Install D1 and D2, making sure that the diodes physically contact the tops of the transistor packages. Bolt down R1 and R4 and solder the leads as shown.

Cut and file the center pins of the input and output connectors until they protrude about 1/8 inch inside the box. Connect the center pins to the PC board traces with short pieces of brass shim stock about 1/8 inch wide.

Install feedthrough capacitors C22 and C23 and the ground lug. Connect wires from the bias and V_{CC} pads on the PC boards to C22 and C23 and you're done.

Obtaining Components

Most of the parts needed for this project are available at flea markets. Chip capacitors and trimmer capacitors are available from Microwave Components of Michigan, 11216 Cape Cod, Taylor, MI 48180, tel 313-941-8469 (evenings). NEC transistors are available through California Eastern Labs, 3260 Jay St, Santa Clara, CA 95050. Sage Wireline and R1 and R4 may be tough to come by. I can provide those parts, as well as etched PC boards and NEC transistors, and any other parts you have a tough time finding.

Tune-up

Once again check to see that you've mounted all of the parts and look for any obvious shorts. Terminate the input and output with 50-ohm loads and apply 13.8 V through a milliammeter to the V_{CC} feedthrough capacitor. (Do not apply bias

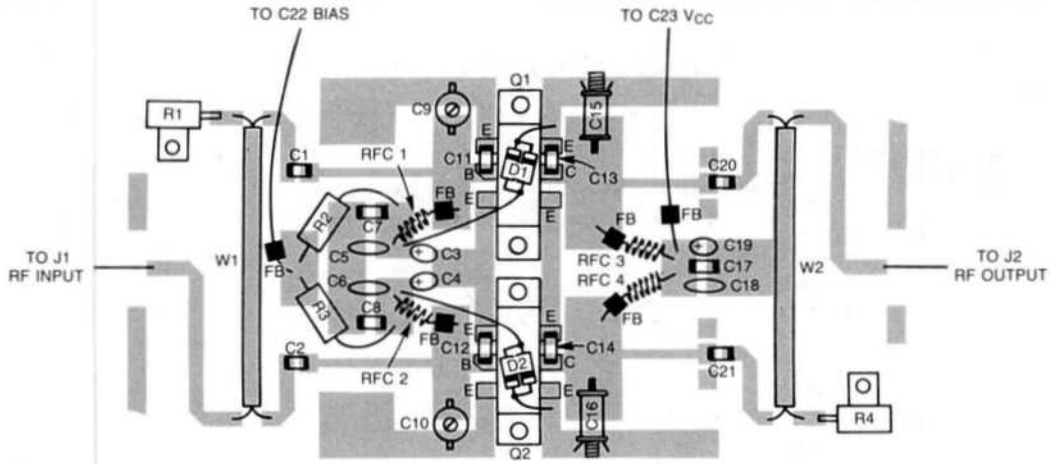


Fig 6—Parts placement diagram for the 23-cm amplifier. All components mount on the etched side of the board.

voltage yet.) The amplifier should draw no current whatsoever at this point. Remove the voltage.

If nothing smokes, the next step is to check and adjust the quiescent collector current of each transistor. We'll check Q1 first. Unsolder one end of R3 and apply collector and bias voltage. (Your milliammeter should be connected so that it reads *only* the current in the line to the V_{cc} feedthrough and not the current to the bias feedthrough.) Note the quiescent collector current. It should be between 120 and 150 mA. If it's more than 250 mA or so, you most likely have a major problem and should recheck your wiring. If necessary, change the value of R2 until the quiescent current comes into the specified range. Remove the voltages, reconnect R3 and lift one end of R2. Repeat the procedure to find the right value for R3. Remove power and reconnect R2. The quiescent current with both transistors biased on should be 240-300 mA.

Set C9 and C10 for minimum capacitance and set C15 and C16 at midrange. Connect your exciter to the input and connect the output to a dummy load through a good wattmeter. Apply V_{cc} and bias voltage, and drive the amplifier with a watt or two. Adjust C9 and C10 for maximum collector current and then adjust C15 and C16 for maximum power output. Amplifier gain should be 7 to 8 dB. Gradually increase the drive and readjust the tuning capacitors as you go. For best linearity, drive the amp with 7-8 W and peak the output for maximum. Power output should be 32 to 35 W. When everything is working properly, performance should be as specified in Table 1.

Table 1

Amplifier Performance at 1296 MHz

V_{cc}	13.8 V
I_{cq}	300 mA
P_{out} @ 1-dB compression	34 W
P_{gain} @ 1-dB compression	7 dB
I_c @ 1-dB compression	5.8 A
P_{out} @ 10-W drive	36 W

If the power output is low, there may be a problem with one side. Try removing V_{cc} from one side and then the other by lifting one end of the appropriate RF choke. The side with little or no output is probably the culprit. Inspect for cracked chip capacitors or improper Wireline installation. As a last resort, you can try firing up one side at a time by removing W1 and W2 from the circuit. Use a short length of foil or miniature coax to connect one side at a time to the input and output connectors.

When the amplifier is tuned at 1296 MHz, power output will be about the same at 1269 MHz, but the gain will be lower. When tuned at 1280 MHz, good performance can be obtained from 1260 to 1300 MHz.

That's it for this month. Enjoy your new amplifier, good DX, and look for me on 23 cm during the next band opening!

Bits

Shielded + Plus® Ribbon Cables For IDCs

W. L. Gore and Associates, Inc, manufacture a line of Insulation Displacement Connector-compatible ribbon cables. Important characteristics of these high-performance GORE-TEX® expanded PTFE-insulated cables include an extremely low effective dielectric constant, low crosstalk, low capacitance, faster signal speeds, a wide operating temperature range, a continuous flex life and they are chemically inert. Design variations such as color coding primaries for conductor identification, a variety of AWG sizes and additional drain wires, multiple shields or thinner jackets are available. For more information on Shielded + Plus Ribbon Cables, call W. L. Gore and Associates at 1-800-228-3024 for a distributor in your area.—*KA1DYZ*

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Zippertubing® is a versatile form of protection specially devised for wire, cable, tubing and other lines. Essentially a flexible jacket, it features a unique zipper closure to allow for fast, easy use on new or existing installations—without the need to thread through tubing or disconnect any lines. Why Zippertube? This product will bundle, insulate, resist chemicals, shield, prevent abrasion, identify and be waterproof. For a brochure, contact the Zippertubing Co, PO Box 61129, Los Angeles, CA 90061; tel 213-321-3901 or write to PO Box 1732, Wayne, NJ 07470; tel 201-256-4980.—*KA1DYZ*

Correspondence

Continued from page 3.

Tours of local surplus stores like Nortex and Collins Surplus will be offered on Thursday. VUCC managers will be present at the conference to handle applications and endorsements. A conference Proceedings will be made available to all attendees—bring your schematics, technical data or short topics. A women's program is scheduled; tours will visit both the Dallas and Fort Worth area. Complete information on the 21st Annual Conference is available from Al Ward, WB5LUA, Rt 9, Box 132, McKinney, TX 75069

EMP Literature Increasing in Popularity

The public is becoming more aware of how electronic life, as we know it, may cease to exist in the presence of a nuclear explosion. The result of this self awareness is a thirst for literature on how to protect our resources. Articles related to EMP protection and the vulnerability of electronic equipment are becoming increasingly available to those who desire it. Several new articles to look for are:

- Robert J. Antinone (BDM Corp), "How to Prevent Circuit Zapping," *IEEE Spectrum*, Apr 1987, pp 34-38.
- C. De Carlo, "Washington: The Zap Gap," *The Atlantic*, Vol 259, No. 3, Mar 1987, pp 24, 26 and 28.
- Theodore B. Taylor, "Third-Generation Nuclear Weapons," *Scientific American*, Vol 256, No. 4, Apr 1987, pp 30-39.

—Nick Leggett, N3NL, 1500 Massachusetts Ave, NW, Apt 610, Washington, DC 20005

Feedback

Several changes must be made to Fig 1 in the article, "Pocket-sized Audio Frequency Counter," (Apr 1987 *QEX*, p 9) for proper circuit operation. Place R11 between S1 and +5 V. The X10 DEC PT connection should be made to DS3, pin 7, not DS1. Then, connect the X1 DEC PT to DS4, pin 7.

It is important that the 74C925 multiplex driver use +5 V, while the others can use +V. This is not critical, but running the CMOS components at battery voltage will improve the circuit performance.

U5, the CD4098 dual one-shot, requires timing circuits. The correct circuit configuration is shown in Fig 5.*—Mark N. Richey, WA7UGB, PO Box 1082, Stanwood, WA 98292*

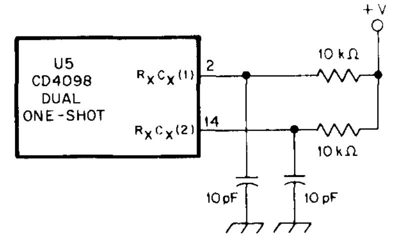

Fig 5

In Fig 1 of the Richey article, the MM5369EST 17-stage oscillator/divider chip with 100 Hz out may be a better choice for U1. If used in this circuit, the CD4040 (U2) could be eliminated.

Pin 8 V_{DD}, should be going to +5V and pin 2, V_{SS} is connected to ground. Also, the correct value of the ADJ trimmer is 3-8 pF.

I built an oscillator circuit using Fig 1, but had to make several minor revisions to the component layout at U1. Fig 6 shows the circuit I am using.

On page 5 of the Kumetz article, "The DTMF-64² Decoder," program line 1520 should read IF TI-T>3600 GOTO 1520.*—S. Premena, AJ0J, PO Box 1038, Boulder, CO 80306-1038*

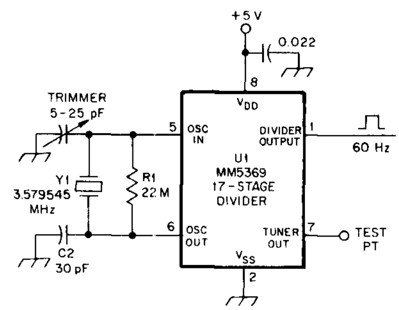

Fig 6

Bits

New Catalog Reflects Old Times

If you remember names like Hallicrafters, National Radio or James Millen, then you've been involved with electronics before transistors. Despite changes brought about by miniaturization or ICs, a large demand for Millen hardware components still exists. A new catalog, distributed by Electronic Instrument and Specialty Corp, describes Millen hardware along with a selection of specialty and custom items such as crystal and tube sockets, vernier counter dials and high voltage, multipole, multiposition switches. Electronic Instrument and Specialty Corp designs, manufactures and markets reed and solid-state relays, RF inductive components and custom-order hardware. For a copy of their catalog write to the company at 42 Pleasant St, Stoneham, MA 02180; tel 617-438-5300.*—KA1DYZ*

A Quick Guide To Paper And Film Capacitors

Sprague Electric Co has made available a *Quick Guide* to their paper and film capacitor products. The *Guide* provides easy reference to over 100 different commercial and military capacitor lines. Detailed tables cover performance characteristics and useful applications information. Graphs show operating characteristics for various dielectric materials. Custom capacitors are also available. Copies of the *Sprague Quick Guide to Paper and Film Capacitors*, ASP-420K, may be obtained by writing to Technical Literature Services, Sprague Electric Co, PO Box 9102, Mansfield, MA 02048-9102.*—KA1DYZ*