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No need to wait any longer – this is it! Whether you are already on 2-meter and want something better or you’re just thinking of getting into it, the VHF/ONE is the way to go.

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**Model 30 — Morse to Video Converter**
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More Details? CHECK-OFF Page 118

July 1976
The HAL ST-6000 demodulator/keyer and the DS-3000 and DS-4000
KSR/RO series of communications terminals are designed to give you
superlative TTY performance today—and in the future. DS series termi-
nals, for example, are re-program-

mable, assuring you freedom from
obsolescence. Sophisticated systems
all, these HAL products are attrac-

tively priced—for industry, govern-

ment and serious amateur radio
operators.

The HAL ST-6000 operates at
standard shifts of 850, 425, and
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controlled. Loop supply is internal.

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select AM or hard-limiting FM modes
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reliable, all-electronic TTY transmis-
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of codes, including Baudot, ASCII
and Morse. The powerful, program-
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mum flexibility for your present needs—and for the future. The KSR models
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video display is a convenient 16-line
format, of 72 characters per line.

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sheets available on request. Write for
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sophisticated TTY operation you can
have today...or in the future.

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editorial staff
James R. Fisk, W1DTY
editor-in-chief
Patricia A. Hawes, W1WHM
assistant editors
J. Jay O'Brien, W8GO
fm editor
Joseph J. Schroeder, W6JUV
associate editor
Wayne T. Pierce, K35UK
cover

publishing staff
T. H. Tenney, Jr., W1NILB
publisher
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associate publisher
Fred D. Moller, Jr., W7USO
advertising manager
Cynthia M. Schlosser
assistant advertising manager
Theresa R. Bourgeois
circulation manager

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Ontario, Canada, N7A 3V5
Ham Radio Europe
Box 444
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2 bis, Avenue des Clarins
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STE, Via Manzoni 15
1-20134 Milano, Italy
Ham Radio UK
Post Office Box 64, Harrow
Middlesex HA3 6H5, England
Holland Radio, 143 Greenway
Greenside, Johannesburg
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contents

10 frequency synthesizer design
Ulrich L. Rohde, DJ2LR

24 wind-generator characteristics
and installation
Edward M. Noll, W3FOJ

32 inverted-vee installation
Edward W. Sleight, K4DJC

36 five-frequency WWV receiver
Henry D. Olson, W6GZN

40 transistor tester
David C. Cheney, W0MAY

44 IC base-step generator
Henry Wurzburg, WB4YDZ

47 frequency display for digital synthesizers
Garry M. Poirier, WB4TZE

50 vhf/uhf antenna matching techniques
Joseph H. Resiert, W1JAA

57 carrier-operated relay
Robert C. Haepig, K3PHF
Robert D. Shriner, W9FZUO

62 microprocessors
David G. Larsen, WB4HYJ
Peter R. Rony
Jonathan A. Titus

4 a second look

118 advertisers index

95 fleamarket

110 ham mart

68 ham notebook

88 new products

40 novice reading

6 stop press

76 1976 sweepstakes winners

50 vhf/uhf techniques

40 weekender

july 1976
Although many of the great discoveries in the natural sciences occurred in the 18th century, when the Declaration of Independence was signed in Philadelphia 200 years ago, little was known about electricity — most of the great scientific minds of the day were focusing their attention in other areas. However, one of the signers of the document that proclaimed the independence of men as individuals, Ben Franklin, had flown his famous kite some twenty years earlier, thus proving the connection between lightning and electricity.

When Franklin first became interested in electricity in 1746, science — or natural philosophy, as it was then called — was practically nonexistent in America. Americans were forbidden by the British to engage in arts and crafts based on natural phenomena, the Puritan ethic persisted, and men were still cautious about new notions that ran counter to popular belief. Until Franklin’s time all that was known about electricity was that when certain substances — such as sulfur or glass — were rubbed, they attracted other light substances, such as bits of paper. No one knew why. Sparks could also be made to jump from the rubbed material to a finger tip, and experimenters noted that the accompanying smell and cracking noise were similar to that produced by lightning. In 1749 Franklin first suggested the "sameness of lightning with electricity," but it was two years later before his paper was published in Paris. The experiment was immediately carried out by two Frenchmen, carefully following Franklin’s instructions, one month before Franklin’s kite flying episode.

Although many others tried the same experiment, not all were as lucky as Franklin. George Richmann, a Swede working in Russia, failed to ground his apparatus as Franklin had suggested and paid the consequences: a foot-long spark jumped from the rod to Richmann’s head and made him the first martyr to the new science.

Although it was the lightning rod that made Franklin a demigod to his contemporaries (the French thought he was the reincarnation of Socrates and slept with his portrait under their pillows), his contributions were much more profound: he unified the disorderly body of existing knowledge that provided a basis for all subsequent advances. Lacking terminology, Franklin invented words as he went along, providing a lexicon of electricity that is still used today. His condenser (or “battery” as he called it) formed an evolutionary link between the short-time sparks of the Leyden jar and the continuous current of the later voltaic cell. He established the positive-negative nature of electricity, hinted at the existence of a basic charge and his single-fluid theory led directly to the concept of electrons moving through conductors. In barely ten years, by trial and error, using simple tools, he had moved a primitive science into the modern world of the 18th century.

After Franklin, the focus of electrical discovery shifted back to Europe, where it would remain for nearly 100 years; Americans were much too involved in the progress of their fast developing country to spend much time or money in nebulous scientific pursuits. It wasn’t until 1840, when Samuel B. Morse patented his telegraph, that attention again focused on America.

Morse, a successful portrait painter who knew next to nothing about the basic principles of electricity, had seen some experiments dealing with electromagnetism in Europe in the 1830s and wondered if the effect could be used to send messages over a wire. He made some sketches during his voyage back from Europe, and spent the next three years trying to build the device he had sketched, but nothing came of his work. Lack of knowledge didn’t stop him. When Congress offered a $30,000 prize for a 1000-mile system, Morse plunged headlong into the search for a practical telegraph. When one of his colleagues, Leonard Gale, saw one of Morse’s unsuccessful machines he pointed out the need for insulation on the windings of the electromagnets, and showed Morse how to arrange the battery circuit. A backer, Stephen Vail, agreed to put up $2000 if Morse would take on his son Alfred. Morse agreed, and it was Alfred Vail who worked out the final form of Morse’s code, introduced the key, and reduced the equipment to its final, compact form. It was also Vail who invented the printing telegraph that was patented in Morse’s name.

Before 1838, when the patent law was enacted by Congress, only about 500 patents had been granted, but within three years after the patent law more than 10,000 patents were issued. Soon to come were the telephone, the incandescent lamp, the electrical generator, the transatlantic cable and the wireless telegraph. Each of these would lead to thousands of by-products, to major new industries, and to the rapidly advancing electronic technology of the 20th century.
Now ICOM Introduces 15 Channels of FM to Go!

The New IC-215: the FM Grabber

This is ICOM's first FM portable, and it puts good times on the go. Change vehicles, walk through the park, climb a hill, and ICOM quality FM communications go right along with you. Long lasting internal batteries make portable FM really portable, while accessible features make conversion to external power and antenna fast and easy.

Grab for flexibility with the new IC-215 FM portable.

- Front mounted controls and top mounted antenna
- Narrow filter (15KHz — compatible spacing)
- 15 channels (12 on dial / 3 priority)
- Fully collapsible antenna
- Compatible mount feature for flexible antenna
- Dual power (3 watts high / 400 mw low, nominal)
- External power and antenna easily accessible
- Lighted dial and meter

Your new IC-215 comes supplied with: 5 popular channels; handheld mic, with protective case; shoulder strap; connectors for external power and speaker; 9 long-life C batteries.

VHF/UHF AMATEUR AND MARINE COMMUNICATION EQUIPMENT

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<td>Suite 307 3331 Towerwood Drive Dallas, Texas 75234 (214) 620-2700</td>
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More Details? CHECK-OFF Page 118
MOST NEW AMATEUR HF receivers and transceivers would have to be certified that they meet FCC Part 15 radiation limits under a Notice of Proposed Rule Making recently released by the Commission. Docket 20777 would limit conducted radiation (at the antenna terminals) of receivers capable of tuning in the 26- to 30-MHz region to 100 microvolts from 450 kHz through 25 MHz, with additional radiation limits extending to 3 GHz.

Receiver Radiation Problem came to a head when one popular synthesized CB receiver was found to be radiating sufficient RF in the 37-MHz area that it was interfering with mobile communications in the Power Radio Service.

FCC'S BANDWIDTH DOCKET, 20777, steps on a number of toes and their owners are not at all happy about it. Fast-scan TVers were quickest and most vehement in their reaction to their suggested exile to above 1215 MHz, but the many AM users on 160 meters are also starting to become aware of their jeopardy.

LESS Obvious Problems beginning to be discussed are potential conflicts between 850-Hz RTTY, facsimile, slow-scan TV and phone operators on all the present phone bands and the use of modulated CW in the CW segments.

FCC APPROVED ARRL'S TRAINING CONCEPT in mid May, to be tried as an experimental one-year program. The League has proposed a carefully monitored training course of 10 to 12 lessons to be conducted by qualified, certified instructors. Upon satisfactory completion of the course the student would be certified 'qualified for Novice license' to the FCC, which would then issue him a license without further exam. By the time you read this approximately 40 clubs and organizations will be teaching courses under this program on a trial basis.

Three Key Stipulations in the FCC's decision favoring the ARRL proposal are an insistence that the integrity of any examinations used in the course be absolute, the instructors must be adequately qualified, and administration of the program must not become a lucrative marketplace. Though the FCC is apparently willing to delegate responsibility for determining instructor qualifications to the League, it does not (and probably legally cannot) give the ARRL an exclusive claim on what will surely become a lucrative marketplace.

CHARLOTTE REID RESIGNED from the FCC and will be leaving the Commission on June 30. In her letter of resignation she submitted to President Ford, Commissioner Reid stated that she had just married H. Ashley Barber of Aurora, Illinois and would be returning to Illinois to live later this summer.

Commissioner Reid was also very active in matters affecting Amateur Radio and showed herself to be a real friend of the Amateur service on numerous occasions. She was also an honorary member of APAR, the Aurora (Illinois) repeater group. Her presence on the Commission will be missed by the Amateur Community.

220-MHz CLASS-E CB was dealt another blow by a submission filed with the Commission May 3 by the Association of Maximum Service Telecasters, a TV broadcasters' group. Heart of the submission was an April 20 report from A.D. Ring & Associates, a Washington consulting radio engineering firm, stating that severe interference could occur to channel 13 TV reception in an urban area from a 25-watt, 220-MHz mobile at a distance up to 300 feet. Other areas where channels 11 and 13 are both in use could experience similar problems out to 1000 feet.

AMATEUR AND CB RADIO RULES have finally been split into separate volumes by the Government Printing Office. First out is the CB volume — Part 95 — which is now available from the GPO or one of its stores in major cities for $1.50 (stock number 004-000-00326-8). Part 97, Rules for the Amateur Radio Service, will become available this summer and also costs $1.50 (stock number 004-000-00325-0). Part 99 for the Disaster Communications Service, stock number 004-000-00326-8, is due out momentarily and will cost 75c. Any or all can be ordered now from the Superintendent of Documents, GPO, Washington D.C. 20402 or the Public Documents Distribution Center, Pueblo, Colorado 81009.

NASA HAS APPROVED AMSAT'S request to "piggy back" OSCAR 8 into orbit on a launch sometime in 1977 or 1978. At this time mid 1977 looks likely, leaving the various contributors to the 444 Amateur satellite precious little preparation time. OSCAR 8 Frequencies were proposed at the command station operator's meeting. Tentative choices are: 435.15-435.29 in and 145.850-145.990 out for one mode; 145.850-145.990 in, 435.150-435.290 out for the alternate mode. Beacon frequencies proposed are 435.300, 435.145, 145.995 and 145.845. User comments on all these choices are solicited.

SOUTH AMERICA'S FIRST 432 MOONBOUNCE will be available this summer thanks to Mount Airy VHF Club (the Pack Rats) and the Colombian government. Three Pack Rats, W3HQT, K3BFP and W3HNU, will accompany a complete EME station to Barranquilla, Colombia in time for early August operation. They plan to be active for about two weeks on 432.040 MHz using high power and a portable 16 Yagi array.

Stateside Liaison will be handled through W3KKN and W3NTP at Callbook address or 215 659-3485; HK1BN will handle the Colombian end. The group plans to field test the complete setup in the June 15-16 VHF QSO party from a portable location.
If the amplifier you're thinking of buying doesn't deliver at least 1000 to 1200 watts output, to the antenna, you're buying the wrong amplifier.

Our New Super Amp is sweeping the country because hams have realized that the Dentron Amplifier will deliver to the antenna, (output power), what other manufacturers rate as input power.

The Super Amp runs a full 2000 watts P.E.P. input on SSB, and 1000 watts DC on CW, RTTY or SSTV 160 - 10 meters, the maximum legal power.

The Super Amp is compact, low profile, has a solid, one-piece cabinet assuring maximum TVI shielding.

The heart of our amplifier, the power supply, is a continuous duty, self-contained supply built for contest performance.

We mounted the 4 - 811 A's, industrial workhorse tubes, in a cooling chamber featuring the on demand variable cooling system.

The hams at Dentron pride themselves on quality work and we fight to keep prices down. That's why the dynamic Dentron Linear Amplifier beats them all at $499.50.

The No-nonsense Amplifier at a No-Nonsense Price $499.50.
either way is the right way

...they're both KENWOOD

the TR-2200A

Kenwood's high performance portable 2-meter FM transceiver...completely transistorized, rugged and compact.

12 channel capacity. Built in telescoping antenna can be easily replaced, or stored in carrying case. Connector for external antenna also. External 12 VDC or internal ni-cad batteries, complete with 120 VAC battery charger. 146-148 MHz frequency coverage. 12 channels, 6 supplied. Battery saving "light off" position. Hi-Lo power switch (2 watts - 400 mW). Sensitivity: 0.5 uV or less/26 dB S+N/N. Built-in speaker. Size: 5-3/8" x 2-5/16" x 7-1/8", 3-3/4 lbs. Complete with Dynamic mike, O-T-S carrying case, all cables, speaker/headphone plug and 10 Ni-Cad batteries. Amateur net...$229.00.

the TR-7200A

Kenwood's superb 2-meter FM mobile transceiver. Designed to withstand the most severe punishment while providing consistently excellent performance.

Packed with features like the PRIORITY function...Put your favorite crystals in channel 7, and the 7200A switches there with the push of a button...no matter what channel you are on. 146-148 MHz coverage, 22 channels, 6 supplied. Completely solid state. Voltage required: 13.8 VDC. Antenna impedance: 50 ohms. Frequency adjusting trimmers on every crystal. RF output power: 10 watts (or 1 watt at low power). Adjustable frequency deviation (factory set at ±5 kHz). Automatic VSWR protection. Receiver sensitivity less than .5 uV for 27 dB. Selectivity: 12 kHz/-6 dB and 24 kHz/-70 dB. Size: 7-1/16” W x 2-3/8” H x 9-7/16” D, 5-1/2 lbs.

Complete with dynamic mike, DC power cord, mobile mount, mike hanger, auxiliary connector and external speaker plug. Amateur net...$249.00.

The perfect companion to the TR-7200A is the PS-5 AC/DC power supply. Together they provide an efficient and handsome base station. The PS-5 is complete with a digital clock and automatic time control feature built in. Amateur net...$79.00.
When you get tired of compromises...

KENWOOD'S TS-700A finally fulfills the promise of 2-meters...more channels, more versatility, tunable VFO, SSB-CW and, best of all, the type of quality that has placed the Kenwood name out front.

- Operates all modes: SSB (upper & lower), FM, AM, and CW
- Completely solid state circuitry provides stable, long lasting, trouble-free operation
- AC and DC capability. Can operate from your car, boat, or as a base station through its built-in power supply
- 4 MHz band coverage (144 to 148 MHz) instead of the usual 2
- Automatically switches transmit frequency 600 KHz for repeater operation. Just dial in your receive frequency and the radio does the rest...Simplex repeater reverse
- Or do the same thing by plugging a single crystal into one of the 11 crystal positions for your favorite channel
- Outstanding frequency stability provided through the use of FET-VFO
- Zero center discriminator meter
- Transmit/Receive capability on 44 channels with 11 crystals
- Complete with microphone and built-in speaker
- The TS-700A has been thoroughly field-tested. Thousands of units are in operation throughout Japan and Europe

The TS-700A is available at select Kenwood dealers throughout the U.S. For the name of your nearest dealer, please write.

KENWOOD...pacesetter in amateur radio

TS-700A Specifications

TRANSMIT/RECEIVE FREQUENCY RANGE: 144-148 MHz
MODE: SSB, FM, CW, AM
RF OUTPUT: CW, FM more than 10W output, AM more than 3W output; SSB more than 20W DC input
ANTENNA IMPEDANCE: 50 ohms (unbalanced)
CARRIER SUPPRESSION: Better than 40 dB
SIDE BAND SUPPRESSION: Better than 40 dB SPURIOUS RADIATION: Less than -60 dB

KENWOOD'S TS-700A finally fulfills the promise of 2-meters...more channels, more versatility, tunable VFO, SSB-CW and, best of all, the type of quality that has placed the Kenwood name out front.

- Operates all modes: SSB (upper & lower), FM, AM, and CW
- Completely solid state circuitry provides stable, long lasting, trouble-free operation
- AC and DC capability. Can operate from your car, boat, or as a base station through its built-in power supply
- 4 MHz band coverage (144 to 148 MHz) instead of the usual 2
- Automatically switches transmit frequency 600 KHz for repeater operation. Just dial in your receive frequency and the radio does the rest...Simplex repeater reverse
- Or do the same thing by plugging a single crystal into one of the 11 crystal positions for your favorite channel
- Outstanding frequency stability provided through the use of FET-VFO
- Zero center discriminator meter
- Transmit/Receive capability on 44 channels with 11 crystals
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- The TS-700A has been thoroughly field-tested. Thousands of units are in operation throughout Japan and Europe

The TS-700A is available at select Kenwood dealers throughout the U.S. For the name of your nearest dealer, please write. 
modern design of frequency synthesizers

A design review of today's synthesizers including a practical circuit for 41-71 MHz that provides low-noise output in 1-kHz steps

All frequency synthesizers use one of two methods to generate output frequencies for use in communications equipment: direct frequency synthesis and synthesis using the phase-lock technique. Direct frequency synthesis has been extensively used in the past and has more or less been responsible for the word "synthesizer," which describes generators that provide accurate and stable frequencies derived from one frequency standard.

This article presents a survey of existing synthesizer technology. The major circuit elements comprising the frequency synthesizer are analyzed, with emphasis on recent design techniques of the phase-locked-loop method to achieve fast switching, low-noise, relatively spurious-free output at high frequencies. Special emphasis has been placed on the analysis of frequency dividers using TTL or CMOS logic devices as synchronous counters, as well as phase discriminators using CMOS logic. A practical synthesizer circuit for use in the 41 to 71 MHz range is also included, which employs most of the techniques described in the circuit analyses.

direct frequency synthesis

A typical arrangement of this method is shown in fig. 1, in which the desired output frequencies are created by mixing various individual frequencies. The output frequencies are not derived from one oscillator only but are obtained by mixing various frequency components, which are filtered out of a spectrum of frequencies.

Spectral purity. Spectral purity is a basic characteristic that defines synthesizer quality. It's important to distinguish between wide-band performance (that is, performance with sideband noise, which appears symmetrically about the carrier as modulation) and performance with spurious frequencies.

The selective filters used in the direct method determine the spurious-frequency response, and the sideband noise depends on the wideband-mixer power level and crystal-oscillator performance. The signal-to-noise performance of a direct synthesizer, up to 10 kHz off the carrier, is better than that of a free-running LC oscillator. Further off this carrier frequency, LC oscillators are better by definition because these oscillators can't produce wideband noise. Using direct synthesizers, 80 to 100 dB freedom from spurious response is obtainable, and the sideband noise is typically 130 dB/Hz at frequencies more than 20 kHz off the carrier.1,2

Switching Speed. Frequency change in direct synthesizers is achieved by switching filters. Switching times with only a few microseconds delay are obtainable; however, phase-coherent switching is not possible.

Disadvantages. The basic disadvantage of a system of this nature is the huge number of components and the requirement of expensive bandpass filters. It is hardly possible to build direct synthesizers above 1 GHz, because the intermediate frequencies will be so much higher that filters having the required performance are not feasible.

frequency analysis

Frequency analysis using phase-locked-loop techniques is a comparatively inexpensive method of obtaining multichannel frequency generators with high stability. For this method the following is important:

The output voltage is determined only from the voltage-controlled oscillator (one), and the exact frequency of this oscillator is determined by the loop. The low-pass filters used in this technique limit the bandwidth of the system where unwanted transients may cause frequency

By Ulrich L. Rohde, DJ2LR, 52 Hillcrest Drive, Upper Saddle River, New Jersey 07458
shift. To compare and synchronize the voltage-controlled oscillator, which is at a different frequency than that of the reference-frequency oscillator, a mixing and dividing scheme is used for frequencies above 500 MHz, while phase-locked loops using only synchronous counters as dividers are used up to this frequency. This cutoff frequency is determined by the availability of an integrated-circuit divider. Fig. 2 is a block diagram of such a synthesizer.

Spectral purity. An ideal phase-locked loop, which does not produce its own noise and spurious frequencies, will synchronize and transfer the performance of the crystal oscillator used as a reference to the voltage-controlled oscillator (vco). If the crystal oscillator noise performance is sufficient, the signal-to-noise performance of the vco can be improved, while a noisy reference can degrade the performance of the vco (i.e., an LC or voltage-controlled crystal oscillator). A typical application where the sideband noise and spurious frequencies of an oscillator can be reduced is in the synchronization of microwave oscillators (klystons, microwave tubes, microwave transistor oscillators). A phase-locked loop or synchronizing circuit can improve the performance dramatically. However, there is a limit to the possible improvement because the mixer and phase discriminator will produce noise or spikes.

In addition, the phase-locked-loop circuit acts as an integrating device, and good compensation is possible only when the loop gain is high enough. Because of the lowpass performance, close to the cutoff frequency, no noise or spurious frequency improvement can be achieved. Fig. 3 shows the sideband noise performance of an LC oscillator, a vco synchronized with low loop bandwidth, a vco synchronized with wide loop bandwidth, a standard-quality crystal oscillator, and a high-performance crystal oscillator.

With respect to spurious frequencies, the phase-locked-loop circuit in its pure form (no frequency conversion involved) performs better than direct synthesis because the oscillator does not create any spurious frequencies. Complete freedom from spurious frequencies is impossible, because the loop reference frequency cannot be suppressed to values significantly better than 100 dB.

It is important to understand the following fact: If a frequency is divided, its value is reduced by the factor of the division. At the same time, the amplitude of the fm spurious frequencies is reduced by the same amount; however, the value of the discrete frequency of the fm spectral line remains the same. For example, two discrete spurious sidebands are located ±100 kHz with respect to a 100-MHz carrier, and the carrier-frequency is divided by 100. The two sidebands are reduced by, say, 40 dB. The modulation index will be reduced by the division ratio, but the modulation frequency will remain constant.

The consequence of this action is that, in the case of a phase-locked-looped system with wide bandwidth, the sideband noise of the reference oscillator will be multiplied up; therefore, the crystal oscillator must be carefully designed in terms of noise performance. This disadvantage can be reduced by using filters of very narrow bandwidth. By doing so, it is possible to build an absolutely spurious-free generator that has the sideband noise response of the LC oscillator (vco). In a circuit such as

fig. 1. Direct synthesis method in which the output frequency, $f_{out}$, is equal to the crystal frequency, $f_o + f_0/n$ (division ratio), where $n$ may be changed by using a switch.

fig. 2. Phase-locked-loop arrangement with a reference frequency oscillator, $f_0$. The vco frequency is mixed down, using A's harmonics of $f_0$ as an auxiliary frequency to decrease the frequency to a value where integrated circuits are usable. If $f_{out}$ equals 2 GHz and $f_0$ equals 10 MHz, then A might be 180. The bandpass frequency would then be 200 MHz.
oscillator frequency, \( f_0 \) (MHz)

Fig. 3. Noise sideband performance of various oscillators. Curve A represents a high-Q LC oscillator; B and C a vco synchronized with narrow and wide loop bandwidth, respectively. D shows the performance of a standard-quality crystal oscillator; E represents a high-performance crystal oscillator.

In general, switching speed is almost 100 times slower than that of direct synthesizers. An advantage is that phase-coherent frequency switching is possible, which enables digital sweeping. This type of switching is much more accurate and is easily remotely controllable.

Advantages. Phase-locked loop synthesizers have the great advantage that very little filtering is required. In addition, most of the stages can be integrated and very little alignment is required. Including harmonic synchronization (sampling techniques), synthesizers up to 10 GHz can be built.

voltage-controlled oscillators

To build low-noise voltage-controlled oscillators, a few design techniques must be considered. Up to 500 MHz, field-effect transistor oscillators show very little noise due to the reduced load they present to the LC circuit. They are superior to bipolar transistors. Since agc is required in some cases, and agc introduces some noise into the system, the performance of some bipolar transistor circuits nearly equals the performance of fets. In some instances it is desirable to preset the vco to certain frequency bands; eg., 1 MHz wide. This is referred to as "coarse tuning" and is accomplished by using a digital-to-analog converter with sufficient filtering to avoid noise. This technique has the advantage that sample-hold discriminators, which are explained later, can be handled somewhat more easily.

Above 500 MHz only bipolar transistors or gallium-arsenide fets can be used. Fig. 4 shows a typical field-effect transistor vco, and Fig. 5 shows a typical bipolar vco. In some rare cases, voltage-controlled crystal oscillators are used; however, time constants of a few seconds will result, and circuits of this nature are used only where the lock time is of no concern. Fig. 6 shows such an oscillator.

Fig. 4. Field-effect transistor vco with coarse and fine tuning, using a digital-to-analog (D/A) converter for presetting.
frequency dividers

TTL or cmos integrated circuits can be used as synchronous counters. Typical ICs are 74192 (TTL), 74C192 and CD4018 (cmos). To extend the frequency range to 500 MHz, so-called "swallow counters" are being used. The most popular swallow counters are the 95H90 made by Fairchild* and the Plessey SP8640. The division ratio of a swallow counter is controlled by two inputs. The counter will divide by 10 when either input

is in the high state and by 11 when both inputs are in the low state.

This 10/11 division ratio enables you to build fully programmable dividers to 500 MHz. The switch counting principle means that high-frequency prescaling occurs without any reduction in comparison frequency. The disadvantage of this technique is that a fully program-

mable divider is required to control the 10/11 division ratio and that a minimum limit is set on the decision ratio possible — although this is not a serious problem in a practical loop. Fig. 7 uses a division ratio of \( P/P+1 \), which is set to 10/11. The A counter counts the units, and the B counter counts the 10s.

Consider the system shown in fig. 7. If the \( P/P+1 \) is a 10/11 divider, the A counter counts the units and the M counter counts the tens. The mode of operation depends

\[
(M-A) P+A (P+1) = MP + A
\]

*The Fairchild 95H90, which is recommended for operation up to 350 MHz, has recently been superseded by the 11C90 which has a top frequency rating of 520 MHz at room temperature.

fig. 5. Bipolar vco with fine and coarse tuning.

fig. 6. Vcxo circuit with a temperature-compensating network. Instead of using this circuit, a dc voltage may be applied to shift the frequency to desired values. Third- or fifth-overtone crystal oscillators are required for extremely low sideband noise.
FREOUENCY

fig. 7. Simplified block diagram of a synthesizer using a program-
mable prescaler.

therefore

\[ f_{\text{out}} = (MP + A) f_{\text{ref}} \] (2)

If A is incremented by one, the output frequency changes by \( f_{\text{ref}} \). In other words, the channel spacing is equal to \( f_{\text{ref}} \). This is the channel spacing that would be obtained with a fully programmable divider operating at the same frequency as the \( P/P+1 \) divider.

For this system to work, the A counter must fill before the M counter does, otherwise \( P/P+1 \) will remain permanently in the \( P+1 \) mode. There is therefore a minimum system division ratio, \( M_{\text{min}} \), below which the \( P/P+1 \) system will not function. To find that minimum ratio, consider the following:

The A counter must be capable of counting all numbers up to and including \( P-1 \) if every division ratio is to be possible, or:

\[ A_{\text{max}} = P - 1 \] (3)

\[ M_{\text{min}} = P, \text{ since } M > A \] (4)

The divider chain divides by \( MP+A \), therefore the minimum system division ratio is:

\[ M_{\text{min}} = M_{\text{min}} (P + A_{\text{min}}) = P (P + 0) = p^2 \] (5)

Using a 10/11 ratio, the minimum practical division ratio of this system is 100.

In the system shown in fig. 7, the fully programmable counter, A, must be quite fast. With a 350-MHz clock to the 10/11 divider, only about 23 ns are available for counter A to control the 10/11 divider. For cost reasons it would be desirable to use a TTL fully-programmable counter, but when the delays through the ECL-to-TTL translators have been taken into account, very little time remains for the fully-programmable counter. The 10/11 function can be extended easily, however, to give a \( +N/N+1 \) counter with a longer control time for a given input frequency, as shown in figs. 8 and 9. Using the 20/21 system shown in fig. 8, the time available to control 20/21 is typically 87 ns at 200 MHz and 44 ns at 350 MHz. The time available to control the 40/41 (fig. 9) is approximately 180 ns at 200 MHz and 95 ns at 350 MHz.

This frequency division technique can, of course, be extended to give 80/81, which would allow the control to be implemented with cmos, but which would increase the minimum division ratio to 6400 (80^2). This ratio is too large for many synthesizer applications, but it can be reduced to 3200 by making the counter a 80/81/81. Similarly, a 40/41 can be extended to 40/41/42, as shown in fig. 10, to reduce the minimum division ratio from 1600 to 800. The time available to control the 40/41/42 is a full 40 clock pulses; i.e., 200 ns with a 200-MHz input clock or 110 ns at 350 MHz. The principle of operation is:

Minimum division ratio

\[ 800 = (20 \times 40) + (0 \times 41) + (0 \times 42) \]
\[ 801 = (19 \times 40) + (1 \times 41) \]
\[ 802 = (19 \times 40) + (2 \times 42) \]

More information can be found in reference 5.

In most cases the oscillator must drive an ECL divider. Fig. 11 shows a simple method using two transistors in a differential amplifier to achieve the nonsaturated voltage swing.

In dealing with counters it must be remembered that, because of the switching action, the counter input represents a high and a low impedance as a function of the status. This means loading the oscillator output stage. Especially when using swallow counters, or so-called variable-modulus counters where unsymmetrical loading occurs, the input signal will show phase modulation. This phase modulation will appear at the counter chain output as excessive sideband noise much larger in magnitude than that contributed by the vco.

To avoid this problem, a low-impedance stage should
be used between the buffer amplifier and the prescaler input; A suitable buffer amplifier is the SN72733, made by Texas Instruments, which has a cutoff frequency of 200 MHz. A common-emitter stage with a 50-ohm load resistor following is a suitable decoupling scheme. Fig 12 shows such an arrangement. Slightly better noise performance is obtained by using the Plessey SP8690 prescaler. This device has a substantially higher input impedance and needs less surrounding circuitry.

A lowpass filter is required. Suitable formulas for designing these filters can be found in reference 6. To the best of my knowledge, that book is the best collection of filter tables on the market.

**phase discriminators**

Various forms of phase discriminators are available. The simplest uses a double-balanced mixer in which two identical frequencies applied to the rf port and local-

![fig. 10. A 40/41 prescaler extended to a 40/41/42 system to reduce the minimum division ratio.](image)

In cases where the synthesizer must be modulated, mixing schemes are used, and the frequency that represents the auxiliary frequency is modulated. Careful selection of the proper mixer and filtering techniques is required to avoid spurious frequencies in the synthesizer. In addition, well-shielded cabinets are required to avoid radiation problems. Fig 13 shows a typical mixing arrangement with adequate filtering. The harmonics of the oscillator frequency to be converted down may produce spurious frequencies, which means that an expensive oscillator port result in a dc output voltage, which must be filtered. Flip-flop discriminators have recently become very popular. The Motorola phase-locked-loop handbook refers to this type of discriminator only because of the ease of its design. However, conventional flip-flop discriminators have significant disadvantages because of the permanent ripple at the output. Therefore, the loop filter cutoff frequency has a tendency of being only 1% or less of the reference frequency so this technique, in practice, does not take advantage of the

![fig. 11. Oscillator circuit with a buffer stage and an ECL voltage translator, using two transistors as a differential amplifier.](image)
possibilities of improving VCO noise performance.

Because of the additional introduction of a bipolar transistor as a current charge pump, the sideband noise performance is almost degraded, so the flip-flop technique is seldom used in high-performance synthesizers. Complete information on flip-flop discriminators is given in the Motorola handbook previously mentioned.7

The introduction of the RCA CD4046A integrated circuit containing a new type of phase comparator represents a big step forward. Fig. 14 shows a schematic of this cos/mos phase comparator, which is an edge-controlled digital memory network. It consists of four flip-flop stages, control gating, and a three-stage output circuit comprising p- and n-type field-effect transistors. When the p-mos and n-mos drivers are on, they pull the output up to \( V_{DD} \) or down to \( V_{SS} \), respectively. This type of phase comparator acts only on the positive edges of the signal and comparator-input signals.

The duty cycles of the signal and comparator inputs are not important, since positive transitions control the PLL system. If the signal-input frequency is higher than that of the comparator input, the p-mos output driver will be on continuously. If the signal-input frequency is lower than that of the comparator input, the n-mos output driver will be on continuously. If the signal and comparator-input frequencies are the same, but the signal input lags the comparator input in phase, the n-mos output driver will be on for a time corresponding to the phase difference.

If the signal- and comparator-input frequencies are and will hold the voltage constant on the capacitor of the lowpass filter.

Moreover, the signal at the “phase pulses” output will be at a high level and can be used for indicating a locked condition. Thus, for phase comparator II, no phase difference will exist between signal and comparator input over the full VCO frequency range. In addition, the power dissipation due to the lowpass filter will be reduced when this type of phase comparator is used, because both the p- and n-mos output drivers will be off for most of the signal-input cycle. It should be noted that the PLL lock range for this type of phase comparator will be equal to the capture range, independent of the lowpass filter. With no signal present at the signal input, the VCO is adjusted to its lowest frequency for phase comparator II. Fig. 15 shows typical waveforms for a cos/mos phase-locked loop employing phase comparator II in a locked condition.

Fig. 16 shows the state diagram for phase comparator II; each circle represents a state of the comparator. The number at the top of each circle represents the state of
the comparator, while the logic state of signal and comparator inputs, represented by a 0 or a 1, are given by the left- and right-hand numbers, respectively, at the bottom of each circle.

The transitions from one state to another result from either a logic change on the signal input (1) or the comparator input (C). A positive transition and a negative transition are shown by an arrow pointing up or down, respectively. In the state diagram, it is assumed that only one transition on either the signal input or the comparator input occurs at any instant. States 3, 5, 9, and 11 represent the condition at the output of phase comparator II when the p-mos driver is on, while states 2, 4, 10, and 12 determine the condition when the n-mos driver is on. States 1, 6, 7, and 8 represent the condition when the output of phase comparator II is in its high-impedance state; i.e., both p- and n-devices are off, and the phase-pulses output (terminal 1) is high. The condition at the phase-pulses output for all other states is low.

As an example of how you can use the state diagram shown in fig. 16, consider the operation of phase comparator II in the locked condition as shown in fig. 15. The waveforms in fig. 15 are shown in three parts. Part I corresponds to the condition in which the signal input leads the comparator input in phase, while part II corresponds to a finite phase difference. Part III depicts the condition when the comparator input leads the signal input in phase. These three parts correspond to a locked condition for the cos/mos phase-locked loop; i.e., both signal- and comparator-input signals are of the same frequency but differ slightly in phase.

Assume that both the signal inputs begin in the 0 state, and that phase comparator II is initially in its high-impedance output condition (state 1), as shown in figs. 16 and 15, respectively. The signal input makes a positive transition first, which brings phase comparator II to state 3. State 3 corresponds to the condition of the comparator in which the signal input is a 1, the comparator input is a 0, and the output p-device is on. The comparator input goes high next while the signal input is high, bringing the comparator to state 6, a high-impedance output condition. The signal input goes to zero next while the comparator input is high, which corresponds to state 7. The comparator input then goes low, bringing phase comparator II back to state 1.

As shown for part I of fig. 15, the p-device stays on for a time corresponding to the phase difference between the signal input and the comparator input. Starting in state 1 at the beginning of part III, the comparator input goes high first while the signal input is low, bringing the comparator to state 2. Following the example given for part I, the comparator proceeds from state 2 to states 6 and 8, then back to 1. The output of phase comparator II for part II corresponds to the n-device being on for a time equal to the phase difference
devices, will contain much more energy than that from mos devices. In addition, using cmos, the power supply is much simpler. Therefore, it is strongly recommended that cmos be used where possible to take advantage of the inherent good properties of the RCA CD4046 discriminator. This type of circuit comes very close to the sample-hold discriminator, which has been known for quite some time. The sample-hold discriminator requires somewhat more circuitry; however, it offers the best possible reference noise suppression.

The divider-chain output (square wave) is converted into a sawtooth voltage, which is sampled using a switch between the signal and comparator inputs. The state diagram of phase comparator II completely describes all modes of operation of the comparator for any input condition in a phase-locked loop.6

As can be seen from fig. 15, the phase comparator II output voltage is a dc voltage, a big advantage over the discriminators used by Motorola. The other important feature is that it uses low-current cmos devices. Building very clean synthesizers can become difficult and expensive because of the shielding involved. Radio-frequency noise created from switching, using TTL

example of a 145-MHz carrier signal. The reference line is 70 dB down; frequency markers are spaced 10 kHz. Excessive noise starts about 60 dB down, which does not fall off completely.
fig. 18. Balanced modulator circuit in a switching arrangement for superior sideband noise performance as a phase comparator.

(sample-hold discriminator). This output voltage is used to charge a capacitor, and the discriminator holds the charge as long as phase and frequency remain the same. If the phase changes, this switch will charge or discharge the capacitor, so that the dc control voltage will also change. Crosstalk or feedthrough is extremely small; the reference noise can be suppressed by 60 dB. However, the fast switching creates spikes, which will produce spurious output.

To reduce spurious output, two sample-hold discriminators are cascaded as in fig. 17, which shows a typical arrangement including the waveform-changing stages. The input from the reference divider, which in our arbitrary case is 10 kHz, is used to trigger gate CD4009, and the arrangement with the diode and the RC combination produces a sawtooth waveform (fast charge-slow discharge). The cmos CD4016 receives its input from the reference divider. This input frequency is exactly 10 kHz.

Since the input signal pulse may be a bit too narrow, a one-shot with two gates is used, and the signal now is 2 microseconds wide. The input of the first switch charges a 1000 pF capacitor, and the following Intersil 8007 mos operational amplifier is the low-impedance source for the second CD4016 switch. The input signal to this switch, which is derived from a second one-shot, is delayed; therefore unwanted spikes are suppressed.

The second 8007 operational amplifier drives a T-notch filter. One leg has a 10-kHz resonant frequency; the other 20 kHz. A notch depth of 60 dB can be achieved. The BCY59 transistor is an emitter follower, which drives the vco.

fig. 19. Frequency response filter for synthesizers using a lag filter, two LC tuned circuits as notch filters, and diodes for automatic selection of wider search bandwidth.
Phase-locked loop with a very noisy vco. Loop bandwidth is about 15 kHz within which the sideband noise is improved, as described in the text. Outside the loop bandwidth, noise increases then decreases; however, sideband noise remains at about 90 dB/Hz. Reference line is 40 dB; frequency markers are spaced 10 kHz.

For synthesizers with extremely low sideband noise, an improved version of a circuit similar to a balanced mixer is used. This circuit avoids spikes (in the order of 1 mV in magnitude) which are found in cascaded sample-hold discriminators. To minimize the influence of these spikes, a coarse presetting of the vco is often used, which results in a 20 dB improvement. However, if sideband noise suppression greater than 130 dB/Hz is required, this circuit is still not sufficient.

Fig. 18 shows an arrangement that requires a substantially larger number of components but which provides superior performance. The programmable-divider output (using 100-kHz channel spacing) is differentiated and amplified in transistor Q1. Diode CR2 across the unbalanced-to-balanced transformer provides a voltage similar to a sawtooth waveform. The RC combination R6, C7 and R7, C8 permits the dc voltage to rise to 30 volts maximum. The 100-kHz TTL reference triggers the one-shot formed by transistors Q4, Q5, and Q6.

The output of this circuit is fed into the center of the bridge of the "balanced mixer," represented by transformer T2. Voltage divider R18, R19 supplies a starting dc voltage, which is brought into the center of this bridge circuit. Transistor Q2 acts as a high-impedance source follower, and transistor Q3 acts as a low-impedance driver for the lag filter. The two back-to-back diodes, CR10 and CR11, are speed-up diodes; their function has been explained earlier. The dc output voltage for the vco contains substantially fewer spikes, and
The overall loop bandwidth can be made roughly 50% of the reference frequency and still support reference noise suppression. Most high-performance synthesizers on the market use a similar circuit.

**Response filters**

Lowpass filters are required in phase-locked-loop circuits to limit system bandwidth for stable operation. A mathematical treatment of loop stability, as it can be done with the Nyquist diagram, is found in reference 9.

Lag filters are required to set the frequency performance. These lag filters depend upon the type of discriminator used. The Motorola handbook refers to active filter designs where the cutoff frequency is about 1% of the reference frequency. Let's assume that the reference frequency is 10 kHz. The flip-flop discriminator would require a bandwidth of 1% (100 Hz) for 3-dB cutoff. This means that the noise performance of the oscillator can be improved at best between 0 and 10 Hz. All microphonic effects, or sideband noise of the oscillator as such, will remain. In mobile equipment this is most undesirable, because all mechanical resonances will not be compensated.

When analyzing the circuits described in the Motorola handbook, it can be seen that not only are cutoff frequencies down to a few Hz used, but also that the additional transistors used as charge pumps will add noise to the system. Especially the so-called “flicker noise,” which appears below 1 kHz, is a very unpleasant effect.

A sample-hold discriminator and the RCA edge-controlled digital memory do not give an output ripple when locked and no shift occurs; therefore, the loop bandwidth can be 20 times wider. In this case, compensation of microphonic effects up to several kHz is available.

As mentioned earlier, in some cases for signal generators, it is only required to synchronize them rather than improve them. The switching speed will then be very slow: e.g., 100 milliseconds. In some cases, as with digital sweeping, this is much too slow. To increase the speed, the filter bandwidth can be increased until the loop has settled. An easy way of doing this is to use two back-to-back diodes across the lag filter. This technique was suggested by Rohde & Schwarz many years ago, however, it is rarely found in the literature.
If the phase/frequency comparator is in the search mode, the output is a dc voltage with an ac component. This ac component opens both diodes and short circuits resistor R1, which determines the low-frequency time constant. After the loop has settled, the diodes will no longer conduct.

An additional means of suppressing the undesirable reference noise is by using notch filters. Fig. 19 shows a notch filter with two back-to-back diodes with a series resistor for automatic change of time constants.

A modified Wien-bridge arrangement acting as a T-notch filter can be used to suppress the reference frequency. Together with the RCA integrated circuit or with the sample-hold discriminator, the T-notch filter provides an additional 40 dB suppression. It is highly recommended that two T-notch filters be used, one for the fundamental frequency and one for the first harmonic (10+20 kHz). Fig. 20 shows such an arrangement. It is also possible to use an LC notch filter for selective suppression, as shown in fig. 19.

practical circuit

Figs. 21 through 23 show a complete 41-71 MHz synthesizer that produces steps of 1 kHz. (Using a D/A converter, or better yet, a simple microprocessor, linear resolution can be gained, e.g., the reference frequency can be pulled in such a way that additional resolution, such as 100 Hz, 10 Hz, or 1 Hz, can be achieved.)

Fig. 21 shows the reference oscillator and phase detector. A 1024-kHz series-resonant crystal is used, which can be set right on frequency with the variable capacitor. The gate circuit acts as an amplifier to produce an oscillator circuit that is decoupled from the reference divider, CD4020, by a gate. The MV1404 diode can be used for additional crystal-oscillator frequency pulling.

The RCA CD4020 IC divides the crystal frequency to 1 kHz, and the input is fed to the CD4046 phase comparator, which was described earlier. In addition, sidetone output is provided and a lock-condition indication is available. The phase-comparator output, which drives the vcos (fig. 22), uses a lag filter with back-to-back diodes, as discussed earlier. The 1-kHz signal from the programmable counter is decoupled by a gate and fed to the phase comparator.

Fig. 22 shows the three independent, low-noise vcos.
whose outputs are selected by setting appropriate digits on a selector switch. The Texas Instruments SN72733 wideband amplifier is used for decoupling, and a cascade arrangement is used to provide two independent outputs at low impedance.

Fig. 23 shows the programmable counter. The 5 volts required for operation is derived from a simple regulator circuit. The input prescaler uses either the Plessey SP8640 or the Fairchild 95H90, which are pin compatible. The 2N2907 transistor is the ECL-to-TTL converter. The gate between the 74LS196 and the 95H90, together with the 74C00 at the lower right-hand corner of the schematic, determine the count rate. All other integrated circuits are cmos to keep the power consumption low.

This synthesizer uses most of the techniques described earlier. Because of the back-to-back diodes, the lockup time is 6 milliseconds, and the loop bandwidth after the loop has settled is about 10 Hz. The 1-KHz reference noise is suppressed more than 80 dB and is therefore hardly detectable. This loop bandwidth cannot counteract any microphonics; however, because of its extremely good noise performance and fast switching time this synthesizer is ideally suited for use in a receiver with a first i-f at 41 MHz. Because it’s a so-called one-loop synthesizer, it’s basically spurious free and the reference noise as mentioned earlier, is almost totally suppressed.

The total power consumption is in the order of 100 mA at 12 volts dc, and the synthesizer can be built on one PC board, requiring less space than half the size of a

Comparison of two phase-locked-loop synthesizers with the same reference frequency. Output from balanced-mixer phase detector is shown at left, while the signal at right is from a loop using the technique suggested in the Motorola Phase-Locked-Loop Handbook. All other circuit details are the same. Reference is 0 dB, marker-frequency spacing is 10 kHz, and the carrier is about 150 MHz. Instrumentation used for all photos was the Rohde & Schwarz model EZF/EZFU spectrum analyzer.

normal picture postcard. A very simple circuit, requiring only a few gates, can be built to subtract 41 MHz from the reading; the thumbwheel switches can then be directly calibrated to the receiver input frequency (see fig. 24). In this circuit the upper 74C83 receives the 10-MHz input which must be connected to pins 21 and 23 of the synthesizer input command. The lower 74C38 receives the 1-MHz steps and is connected to pins 24, 25, 26, and 28 of the synthesizer input command.

It has been shown that today’s technology permits building fast-switching synthesizers with low-noise and essentially spurious-free output at high frequencies. With new techniques and integrated circuits, these synthesizers consume little power, are physically small, and have high reliability. Especially, if cmos ICS are used, rf noise will be very low and almost no shielding will be required. A shortwave transceiver using a synthesizer based on these techniques will be described in a future article.

references
Windblades and rotors are reviewed and an example is given of an amateur 200-watt electrical generating system.

Many experiments have been made over the years with windmills and wind-rotating mechanisms. Several have been adapted as electrical-power generators. The theoretical maximum efficiency in converting wind power to torque at the rotor of a windmill is 59.3 per cent. Many rotating blades and other wind-driven configurations come rather close to this theoretical limit: within 5 to 8 per cent. The present direction of development involves economy in the support structure, gearing, generator, and other accessories. The objective has been to develop a strong, reliable, safe, lightweight, and economical support. Types of blades and rotors are significant in attaining these goals for a specific application.

Air is composed of gas molecules that have mass. Motion of these molecules is called wind. Upon striking a windblade, sail, or similar device, the wind imparts energy of motion. The efficiency of conversion depends on the design of the wind device. The force of such mechanical motion or torque made available at the rotor of a windmill depends on wind velocity, blade size and blade aerodynamics. Power made available varies as the square of the blade radius and the cube of the wind speed. For example, to quadruple the power output, it's necessary to double the blade radius. Doubling the wind speed results in an eight-fold power increase.

The equation that determines wind force in watts that impinges on a slim two-blade propeller is given by*:

\[ P = 0.005AV^3 \text{ watts} \]

*When the blade rotational area, \( A \), is in square meters, and wind velocity, \( V \), is in kilometers per hour, the correct formula is:

\[ P = 0.0129AV^3 \text{ watts} \]

By Ed Noll, W3FQJ, Box 75, Chalfont, Pennsylvania 18914
where:

\[ A = \text{Area covered by the blade as it rotates (equivalent to m}^2\text{), square feet} \]

\[ V = \text{Wind velocity, mph} \]

\[ P = \text{Power, watts} \]

Table 1 presents as approximation of the useful power that can be derived from an efficient two-blade windmill in terms of wind velocity in mph (km/hr) and blade diameter in feet (m). An approximate overall efficiency of 30 per cent has been assumed, which includes gearing and generator. Not considered are additional losses in parts of the electrical system such as the charger, battery, distribution system, and inverter (if used). Shown is the relationship between power increases and blade diameter and wind speed.

## Windmill Characteristics

Several characteristics describe the performance of windmills; here they are discussed in terms of two- and three-blade propellers. A simple two-blade arrangement, fig. 1, consists of blades, hub, and vane. Two blades are attached to a hub, which is fastened to the windmill rotor. The vane assembly keeps the blades pointed into the wind. To derive maximum benefit from wind power, the deviation from true orientation into the wind should not exceed \( \pm 12 \) degrees.

Another important factor is the blade pitch angle (fig. 2A), which refers to the angle of the blade relative to the wind direction. When the relative wind velocity is in line with the blade element, no transfer of wind energy to torque occurs at the axle. For low-speed rotation of a multi-blade windmill, pitch angles of 30° and higher are used. For high-speed rotation, angles are substantially smaller. Small angles are required because the airfoils of many high-speed blades stall in the range of 12° to 14°. However, optimum pitch angle depends on application, desired operating conditions, type of blade, preferred angle of attack for blade airfoils, and the use of the wind-rotating system based on wind-speed limits at the site.

Windmills are sometimes classed as either low or high speed. In general a multiblade windmill rotates at low speed and is usually a heavy affair that develops high torque even in a light wind. It is widely used to convert wind energy to some sort of mechanical action such as running a water pump. The high-speed windmill employs as few as two blades. It is lightweight and more adaptable to converting wind energy to electricity. Its high rotation speed is adaptable to low-ratio gearing of electrical generators.

Another factor of concern is tip-speed ratio. The tip-speed ratio, fig. 2B, is the ratio of wind velocity to tip rotational velocity. It is, in a practical sense, the ratio of wind speed to the speed of motion of the very tip of the blade. Tip speed is often stated as a whole number that compares the blade-tip velocity with the wind.

\[ \text{Tip speed ratio} = \frac{V}{\omega} \]

\[ \omega = \frac{2 \pi N}{60} \]

\[ V = \text{Wind velocity} \]

\[ N = \text{Rotation speed} \]

\[ \text{Tip speed ratio} = \frac{V}{\frac{2 \pi N}{60}} \]
speed. A ratio of 4 indicates the propeller tip has a velocity four times faster than the wind speed. For electrical power generation, tip speed ratios under 4 are not recommended.

Lift-to-drag \((L/D)\) ratio, another characteristic of concern, is an indication of how well the blade is turned by the wind relative to the torque or opposition offered by the propeller to being set into motion by a light wind. This ratio is related to blade construction, size and airfoil. Airfoil refers to the geometric shape of the blade. As in aircraft design, airfoil has a great influence on how well the blade can be turned by the impinging wind. A high-lift airfoil can increase the power output but also increases drag. Nonetheless, a high \(L/D\) ratio does permit higher output at a lower wind speed. Compromises must be made in establishing the preferred \(L/D\) ratio in terms of desired power output, weight, and wind-speed range over which the assembly is to operate at high efficiency.

For many low-powered applications a two-blade propeller is effective and efficient. However, in terms of weight and blade diameter, there is a practical limit to the size of a two-blade propeller. A three-blade propeller, fig. 3, provides additional power output as compared with a two-blade propeller and reduces periods of vibration with changes in wind direction as well. When the windmill orientation follows the tail vane, the resistance to orientation shift made by a two-blade propeller is in accordance with its position. When in a horizontal position this resistance is maximum. The net result is a jerking movement of the windmill as it follows a wind direction change. This action produces an undesirable stress when the blade is heavy or too large in diameter. Three- and four-blade arrangements present a steady resistance as the tail vane responds to a wind-direction change.

### Two lightweight rotators

The Chalk rotator, fig. 4, is unique, effective, lightweight, and starts easily in a light breeze. Early measurements indicate that it can reach an efficiency in the 50 per cent region (recall that theoretical maximum is 59.3 per cent). The Chalk rotator consists of a spoked wheel. The structure supports lightweight sheet-aluminum blades shaped in an appropriate airfoil section. The spoked wheel construction provides great strength despite its low weight. For example, a 15-foot \((4.6m)\) diameter wheel weighs about 70 pounds \((32kg)\).

An important advantage of the Chalk construction is that it simplifies gearing to a generator. As an option, it’s possible to extract power at the rim. Since the wheel rim speed (comparable with the tip speed of a conventional blade) is high, it may be used to drive a generator directly or may use a very simple gearing system. In fact,
it's conceivable that the generator field poles themselves can be made part of the rim assembly. Table 2 shows power output for spoked-wheel wind turbines at various wind speeds. Note that for a small (less than 8 feet, or 2.4m) diameter wheel, 77 watts are generated at a 10 mph (16 km/hr) wind velocity.

An advanced sail wing developed by Princeton University was conceived initially for boat application and eventually as an aircraft wing. Its structure is simple, lightweight, and efficient. Materials are inexpensive and permit a more simplified support structure than conventional blades. A sailwing consists of a rigid leading edge, fig. 5. The root section is attached to the rotor hub. Both tip and root are connected by a trailing-edge wire cable, which is fastened to a wraparound sail. The sail is cut in such a manner that its trailing-edge shape is set by the tension of the trailing-edge cable. A taut wing results, with a simple structure. However, the wing deforms and responds to loads in accordance with the wind velocity and angle, developing an effective aerodynamic characteristic. Of importance is its high lift-to-drag ratio. A lift coefficient and gentle stall characteristic compare favorably with the conventional hard wing and blade; it has the same load carrying capability. Furthermore it has the high efficiency of a sophisticated hard blade despite the favorable economics of its structure and support tower. In fact, its weight is such that a two-blade, 25-foot (7.6m) diameter blade is possible before dynamic effects become troublesome. For windmills larger than this diameter, three or more blades are advisable.

A study of wind conditions in the contiguous United States indicates that the maximum ratio between maximum and average wind is approximately 6. Since dynamic pressure increases as the square of the velocity (factor of 36), it's understandable that a windmill must be designed to withstand pressures many times greater that that exerted by the average wind at a given site. The effect of strong winds is reduced by braking the windmill or by using a pitch-control system. The fact that the sail blade of the Princeton design is readily deformable results in a twisting component in high wind, which holds the rpm to a safe value.

![Sailwing generator developed by Princeton University.](image1)

![fig. 5. Sailwing generator developed by Princeton University.](image2)

fig. 5. Sailwing generator developed by Princeton University.

![fig. 6. Savonius vertical S-rotor.](image3)

The windmills described previously employ structures that rotate about a horizontal axis. Two plans that involve rotation about a vertical axis, although developed many years ago by Savonius and Darrieus (fig. 6 and 7), are being studied and experimented with today. Such rotors respond to wind pressure regardless of wind direction. No vane assembly is needed to orient them into the wind. In general complexity and maintenance are reduced using such a structure. Efficiency is good, and in an area subject to gusting and changing wind direction, output is steadier compared with the horizontal-axis rotor, which encounters loss time during intervals when it's being reoriented by the vane system to accommodate change in wind direction.

The Savonius or S-rotor is a drum-like configuration.* Air striking one of the concave sides of a two-blade arrangement is pressed through the rotor center vent to the back of the convex side, setting up the rotational

---

* A modified version of the Savonius rotator is sometimes seen on top of buildings where it's used as a ventilator. Editor.
pattern. It is a successful wind rotor but much is still to be learned about its characteristics. What is the most efficient and/or effective aspect ratio (ratio of height to diameter)? How does the shape, number of blades, and venting system affect operation?

Every indication shows that the Savonius has a high starting torque, which means that for a general applica-

[Diagram of Catenary vertical rotator by Darrieus.]

output increased to 8 kilowatts. As an aid during manufacture the blades were made of consecutive straight sections. Fastened together, a reasonable catenary shape can be synthesized. The catenary vertical axis rotor is not self starting. A starting vane or other arrangement starts the initial rotation of the catenary blades.

The vertical-axis wind generator, developed by Sandia Laboratory, combines the Savonius and Darrieus concepts to obtain self starting using a catenary vertical. Two three-bladed Savonius cups (starter buckets) at top and bottom of the power-generating catenary section, fig. 8, provide the high torque needed to start the rotating system in a light wind.

wind-generator installation

A 200-watt Winco* wind generator was installed at W3FQJ, fig. 9. The specifications of table 3 indicate that in an area with a yearly average wind speed of 10 mph (16 km/hr) you can expect an average output from the generator of about 20 kilowatt-hours per month. This figure can be somewhat more or less depending on the season. Ten-year average monthly wind speed figures in mph (km/hr) for Philadelphia, Pennsylvania are:

<table>
<thead>
<tr>
<th>Month</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>10.3 (16.6)</td>
<td>10.8 (17.4)</td>
<td>11.8 (19.0)</td>
<td>11.1 (17.9)</td>
<td>9.6 (15.5)</td>
<td>9.0 (14.5)</td>
</tr>
</tbody>
</table>

In this area active winds occur in late fall, winter and early spring. Summer wind speeds are lower. Solar panel augmentation is advisable in planning a self-sufficient system. For most amateurs on-the-air activities are limited during the summer months. A 20-kWh-per-month rating at an average wind speed of 10 mph (16 km/hr) provides about 650 watts per day. Not too much power, but enough to run a 100-watt PEP solid-state transceiver almost continuously. Presently amateur radio station self-sufficiency in terms of power is no financial bargain, but it’s a pioneering effort and encourages individualism.

As indicated in the specifications, the propeller is a wooden two-blade type, 6 feet (1.8m) in diameter. The propeller hub drives the generator directly; no belts or gear train are used. Generator rpm falls between 270-900 over a wind speed range of 7-23 mph (11-37 km/h).

The site for the wind generator at W3FQJ is on a small rise, reasonably in the clear, at the back of the house. The first step in the installation was the erection of the bottom section of the two-section 15-foot (4.6m) tower. Each leg is supported by a concrete base constructed by pouring concrete into a 2-foot (0.6m) hole dug with a posthole digger. Sixteen 2-foot-long (0.6m) threaded rods, 5/16-inch (8mm) in diameter, support the four base brackets of the tower.

The next step was to attach the wind generator to the top mast section. The top mast section houses a slip-ring

*Winco, Box 3263, Sioux City, Iowa 51102.
assembly that mounts on a platform, fig. 10. Hence the slip-ring and generator assembly rotate as the vane keeps moving the propeller into the wind. Slip-ring and contacts can be seen by opening the slip-ring case, fig. 11.

The generator bracket is between two small knobs on the top of the collector-ring cover. This entire assembly was placed atop the lower mast section. Blade and brake drum were then attached to the generator hub and the vane bolted to the rear generator bracket, fig. 12.

A mechanical governor controls rpm when the wind speed is greater than 28 mph (45 km/h), fig. 12. In normal winds the governor end plates follow a nonresistive circular path as the blades rotate in the wind. At high rpm the centrifugal force opens the end plates, and the resultant resistance holds down blade rotational speed.

A brake rod extends down through the slip-ring assembly, and an extension of this rod can be used to brake the generator when desired. Pulling down on the rod causes the brake shoe to engage the brake drum. Braking is recommended when there is a possibility of winds higher than 75 mph (120 km/h). However, to minimize wear, the wind generator can be shut down when it's not being used to charge batteries. In fact, the wind generator should never be operated into an open

<table>
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<tr>
<th>Table 3. Specifications for the 200-watt Winco wind generator.</th>
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<tbody>
<tr>
<td>Tower height</td>
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<tr>
<td>Propeller type</td>
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<tr>
<td>size</td>
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<td>material</td>
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<td>Gear ratio</td>
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<td>Generator</td>
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<td>Capacity</td>
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<td>Approximate maximum volts</td>
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<td>Generator</td>
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<tr>
<td>Governor type</td>
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<td>Propeller speed range</td>
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<tr>
<td>Wind speed range</td>
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<tr>
<td>Average usable kwh per month</td>
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<tr>
<td>Charge rates</td>
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fig. 8. Vertical-axis rotator developed by Sandia Laboratories.

fig. 9. Winco generator and Solarex panel installation at W3FQJ.
circuit. A properly placed short circuit at the control box, fig. 13, can eliminate this possibility.

The generator can be used to charge lead-acid batteries, and with suitable circuitry, other types of batteries. One technique is to keep a high-capacity lead-acid battery under full charge and use it, in turn, to charge batteries of lower ratings. The manufacturer of the Winco generator recommends using a 230-ampere-hour battery, which can take good advantage of a sustained high-wind period to accumulate a full charge. If lower-rating batteries are used, care must be taken not to overcharge and you must be ready to change over among batteries.

In my installation, the generator is about 500 feet (152m) from the area where the batteries are located and my operating position. I use a small coaster wagon to carry batteries between generator and operating position. From the battery operating location a heavy-duty line runs into my office and electronics bench.

The new 6-volt Gel/Cel 20-ampere-hour batteries are ideal for operating small transceivers such as the Ten-Tec, fig. 14. These batteries are lightweight and can be right in the operating room or can be transported easily when portable operation is desired.

circuit description

The generator- and control-box schematic is shown in fig. 15. The generator is a brush type with a fixed field winding and a rotating armature. When the armature is turning, current flows from brush I through field coils D and C and back to brush H. Current is removed by the pair of collector rings. Wires connect between the generator and the two terminals of the collector ring cover. These terminals can be seen in fig. 10. Internal connections are made between the collector rings and the two terminals fastened to the top of the tower. From these two terminals, wires are run to the control box. Two no. 10 AWG (2.6mm) wires are used for this connection because, in my case, the control box was attached to the
mast. If the control box is well separated from the mast, no. 6 AWG (4.1 mm) wire is recommended for distances up to 50 feet (15 m) and no. 4 AWG (5.2 mm) wire for distances between 50-100 feet (15-30.5 m). Longer distances require larger-diameter wire. You’re working with low voltage and high current; therefore, wire resistance is a very important factor.

The control box houses a charge-discharge ammeter, diode and terminals. The diode prevents the battery from discharging through the generator. However, its polarization is such that charge current from the generator passes with no significant attenuation. The generator is, of course, a dc machine using rectification by brush and commutator. A scheduled-maintenance inspection of the brushes is recommended. Brushes should be replaced when worn.

Note from fig. 15 that the plus side of the generator output connects to the A-Gen terminal of the control box. From here the path is through the diode and the ammeter to the control box +Bat terminal. The generator negative terminal connects to the control box F-Gen terminal. This is the negative side of the battery-charging circuit.

When checking out the wind generator a discharged battery should be connected between the -Bat and +Bat terminals. The brake can be released and the blade allowed to rotate in the wind. The charging current will be indicated on the meter. In no wind, the circuit can be checked by “monitoring” the generator. In this operation the battery is connected and a short circuit is connected between points B and G (across the diode). This allows the battery current to flow in the generator, which operates as a motor and rotates the blade. In this case the ammeter will read on the discharge side.

If the blade is to be rotated without any battery load, a short circuit must be connected between the control box F-Gen and A-Gen terminals. An open circuit is to be avoided because it results in high voltages appearing in the generator and arcing among commutators and brushes. The generator produces a charging current at 7 mph (11 km/h), reaching a maximum in a wind speed of 23 mph (37 km/h). Governing action begins at 28 mph (45 km/h).

Charging current varies with the wind, so it’s difficult to keep a charge record unless an ampere-hour meter is inserted in the charging circuit. Therefore a hydrometer is essential in determining when a given battery is fully charged.

As shown in fig. 9 a Solarex* solar panel has been attached to the south side of the tower. This is a 6-watt unit that provides a ½-ampere trickle-charge current. Thus during periods of daylight no-wind conditions a trickle charge can be maintained. A separate control box is being constructed for this panel.

A “much obliged” is extended to Richy Atkinson WA3KHM, Bob Bucher WA3KMW, (now deceased), Heinz Frey, WA3DNZ, Harry Mullen, WA3RLI and Dick Wagner, who aided in the wind generator project.

* Solarex, Corporation, 1335 Piccard Drive, Rockville, Maryland 20850.
how to add an inverted V or delta loop to your tower

An easy way to obtain low-angle coverage for 40, 80 or 160 meters using a simple mast extension on your high-frequency beam antenna installation.

Over the past few years, and especially since the introduction of the 5BDXCC and 5BWAS awards, numerous articles on antenna systems for 80 and 40 meters have appeared in the amateur magazines. These systems were basically trying to accomplish one purpose: a lower radiation angle on these bands. All too often, however, impractical heights or a considerable amount of real estate were involved.

Presented here is an inexpensive means of extending the height of your tower so you can mount one of the popular inverted-vee or "drooping dipole" antennas for the lower frequencies. The only requirement is a tower of some height with the antenna rotor installed inside the tower.

description

The basic idea is a mast extension at the top of your tower. To this extension a swivel joint is affixed. Above the swivel joint, another 6 to 12 inch (15-30 cm) length of identical mast is mounted, which acts as a mounting base for a low-frequency antenna. A typical setup is shown in fig. 1. When erected as shown, everything below the swivel rotates when you rotate your beam. Antennas for 80 and 40 meters, or for that matter, any bands you wish, then serve to guy the installation and keep the short section of mast above the swivel from rotating. Simple? You bet! The cost for the entire assembly, not including antennas, will be less than $20.

design considerations

The upper mast extension is needed so your beam element ends will clear the low-frequency antenna (or antennas) as the beam antenna is rotated. The mast extension length depends on the size of your beam antenna. A typical tribander, such as the Classic 36 or TH6DXX, will require a minimum extension of about 22 feet (6.6m) above the plane of the elements. This is the minimum extension. In practice, about a foot (30cm) should be added to allow for ample clearance. Dimension X in fig. 2 is the minimum value that will allow the beam antenna to turn freely under a low-frequency wire antenna drooped 45 degrees from the horizontal. Dimension X is determined by simple geometry:

\[ X = \sqrt{Y^2 + Z^2} \]  

where X is the clearance height, Y is the distance from the rotator mast midpoint to the end of the boom, and Z is the distance from the boom end to the end of the longest element. Remember that dimension X is the

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By Ed Sleight, K4DJC, 4165 Williamsburg Drive, College Park, Georgia 30337
minimum value needed to clear your beam antenna; it's not the maximum value for the mast extension.

construction

The mast extension was made of ordinary heavy-duty TV mast, available in 5- and 10-foot (1.5 and 3m) sections. The longer sections are easier to work with and are recommended for the main part of the extension. A 5-foot (1.5m) mast section is best for building the swivel-joint portion. If three 10-foot (3m) sections and one 5-foot (1.5m) section are used, the extension gained will be about 30 feet (9m) above the plane of the beam elements. This will allow about 5 feet (1.5m) of the extension to be enclosed by the rotator mast. While probably feasible, extensions longer than 35 feet (10.6m) have not been tried here.

The swivel joint is the key to the whole system. It may be as simple or as elaborate as you wish. My first one was made with parts from an old tricycle. The latest model was made from a 0.75-inch (19mm) water pipe union joint (Sears part no. 42G 12673) and two short pieces of water pipe screwed into the union joint. The union was tightened snugly, while allowing it to still rotate, then it was secured with a sheetmetal screw to prevent further movement. The water pipe sections, each about 1 foot (30cm) long, were then built up with pieces of aluminum scrap tubing until a force fit was obtained inside the 5-foot (1.5m) mast section.

installation

My low-frequency antennas are fed with baluns. I believe in feeding a balanced antenna with a balanced feed system. The baluns are easily attached to the short section of the swivel and serve nicely as attachment points for the antenna wires. They will also keep the low-frequency antennas separated at the top of the extension. Tape the feedline securely to the sides of the mast extension. This will keep the weight of the feedline more along the centerline axis of the mast and prevent excessive bowing as the mast is raised.

The assembly is easiest to erect if all masting is placed inside the tower, then joined in proper order and fed out the top of the rotator masting. This will usually require removing the rotator. Since the swivel joint will most likely not pass through the rotator mast, it should be fitted in place (with all antennas attached) as the next lower section of masting is pushed upward. Continue feeding the mast extension out the top. When fully extended, secure the base of the extension. I do this by just slipping the rotator back into place. Tie off the ends of the antennas to obtain the best vertical positioning of the extension mast. Don't worry if the mast leans or bends over slightly while it's being extended. When fully erected, the wire antennas do double duty as guys.

performance

If your tower is in the 50 to 60 foot (15-18m) range, you'll probably have a couple of inverted-vee antennas tied off below the top. With this mast extension, the high-current portion of your antennas will be about 80 to 90 feet above ground (24-27m). On 40 meters, this will lower your radiation angle from about 35 to around 20 degrees.

If your present system is in the 50 to 60 foot (15-18m) range, most of your 80-meter signal will radiate straight up. The system described here will lower that radiation angle to around 45 degrees.
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five-frequency receiver for WWV

Design and construction of a frequency-standard receiver using a modified transistor broadcast set and an fet converter

For those amateurs whose receivers lack WWV reception, a separate frequency-standard receiver is a useful addition. The special-purpose receiver described here receives WWV on 2.5, 5, 10, 15, and 20 MHz which covers all WWV transmissions except 25 MHz. The receiver gets all of WWVH's transmissions, since WWVH doesn't transmit on 25 MHz.

A block diagram of the receiver is shown in fig. 1. The system consists of a modified transistor broadcast receiver and a converter. The transistor radio operates “straight through” for 2.5-MHz reception and serves as an i-f amplifier for the converter, which tunes the higher WWV frequencies. Two crystal oscillators are required, one at 7.5 and one at 17.5 MHz. Each local-oscillator frequency allows dual-frequency reception of WWV, because 10 MHz and 20 MHz are the respective image frequencies when receiving 5 and 15 MHz.

broadcast receiver

The 2.5-MHz section, consisting of a transistor broadcast radio, requires a slight modification to the antenna tuned circuit to make it a fixed-tuned 2.5-MHz amplifier. The modification is simple, because almost all transistor broadcast sets use high-side mixing; i.e., the local oscillator is 455 kHz higher than the received frequency. This means that when the radio is tuned to 1590 kHz, its local oscillator is at 2045 kHz, and the image frequency is 2.5 MHz. Thus 2.5 MHz is easily received by retuning the broadcast radio's antenna tuned circuits to 2.5 MHz.

I didn't want the loopstick to function as a 2.5-MHz antenna when receiving other frequencies, so the loopstick was replaced with a small slug-tuned coil. Modification of the broadcast transistor radio is the first step, so it will be treated first.

The broadcast set I used was sold by Magnavox, uses six npn germanium transistors, and was apparently made in Japan. Newer sets may use npn silicon transistors, and some older GE sets may use npn germanium transistors; however, the conversion will be similar. A typical six-transistor receiver is shown in fig. 2.

Tune the receiver to 1590 kHz, remove power, then replace the loopstick antenna (L7 in fig. 2) with a slug-tuned coil (L6 in fig. 3). Note that the new coil has both primary and secondary windings, so problems of dc isolation are simplified between the broadcast receiver and the rest of the system.

receiver front end

The WWV receiver front end is shown in fig 3. Note the use of field-effect transistors. Dual-gate mosfets are used in the rf and mixer stages, while a jfet is used for the crystal-controlled local oscillator. Using dual-gate mosfets as rf and mixer stages simplifies matters, because in each case one gate can be used as a signal-input port and the other for gain control or local oscillator input.

The jfet makes a simpler crystal oscillator than a mosfet because it has a built-in gate-to-source diode, which rectifies oscillator rf voltage and acts much the same as the grid-cathode diode in a vacuum-tube oscillator in establishing grid-leak bias.

The band switch is a five-pole, five-position wafer switch. In the 2.5-MHz position, S1 disables the crystal oscillator and mixer so that only the rf amplifier and the transistor radio are used. Note that L6 is part of a 2.5-MHz parallel-tuned circuit, which is the load for the drain of the mixer fet when the receiver is tuned to 5, 10, 15, or 20 MHz. When the receiver is on 2.5 MHz, L6 becomes the load for the amplifier drain (by means of S1D and S1E). It is for this reason that L18 does not exist.

Rf gain may be adjusted by a 10k pot that varies the voltage on gate 2 of Q1 from zero to +3 volts through a

By Hank Olson, W6GXN, Stanford Research Institute, Menlo Park, California 94025
100k resistor. If agc is desired (not included here because it's not known what transistor radio the reader may start with), it would be fed into gate 2 of Q1 through the 100k resistor. The agc would vary this voltage from zero (minimum gain) to about +3 volts (maximum gain), with variations in signal level.

power supply

A regulated power supply for the WWV receiver is shown in fig 4. A three-terminal IC regulator provides +12 volts for the front-end section, and a simple emitter-follower regulator provides +9 volts for the converted broadcast receiver. Some transistor broadcast radios operate on 4 volts (a mercury battery) or even on 6 volts (four penlight cells); it's possible to accommodate these by using a different voltage-breakdown zener in place of CR3. The zener voltage should be close to 0.6 volt more than the desired output voltage of the emitter-follower regulator. A 4.7-volt (HEP Z0405) zener for 4-volt output and a 6.8-volt (HEP Z0409) zener for 6-volt output would be appropriate.

construction

The receiver was built in an LMB W1A box. Looking at the front panel, the power transformer and modified broadcast radio are on the top side of the subchassis at the left. The transformer is the only part of the power supply on top of the subchassis; the rectifier and regulator are on the underside of this subchassis. The broadcast radio (actually its PC board without plastic case) is mounted on the top side of the subchassis. Three or four 1/8-inch (6.4mm) fiber or plastic spacers were used in mounting to avoid shorting out PC-board traces. The speaker was remounted on the W1A box front panel (using an appropriate hole size and a piece of perforated metal grille material). Also mounted on this front panel is a volume-control of the same value as that contained in the transistor radio. This control was wired into the radio in place of the original, which was left undis-
Converter for the WWV receiver. Dual-gate mosfets are used for the rf and mixer stages; the local oscillator uses a jfet, which has a built-in gate-to-source diode that rectifies rf voltage.

The three +12 volt lines (one each for rf, mixer, and crystal oscillator) emerge through the copper laminate through small 1000 pF feedthrough capacitors, with the 0.22 µF bypass capacitors on the top side. The 100-ohm decoupling resistors are located on the bottom. I strongly recommend that all bypass and coupling capacitors (1000 pF, 0.1 µF, and 0.22 µF) be ceramic disc or Erie Redcap types. These have both high capacitance and low inductance for broadband rf use. The smaller capacitors (10 pF - 100 pF) should be silver-mica.

If the older types of dual-gate mosfets such as 3N140 or MFE3006 are used (which have no gate-protection diodes), the transistors must be handled with the usual precautions. That is, a small No. 32 AWG (0.2mm) bare wire must short all four leads until they are soldered into the circuit. The 470k resistor from each drain of Q1 and Q2 ensures that, during band switching, some dc resistance is always between all elements of each mosfet.

Tuning the receiver is simple, especially if you have a good signal generator. With the broadcast radio tuned to 1590 kHz, inject a 2.5-MHz signal into the WWV receiver (bandswitch on 2.5 MHz) and maximize the broadcast receiver output near 1590 kHz. Then adjust L1A and L6 for maximum output. Next switch to 5 MHz and peak L2A and L2B; in a similar manner, maximize L3A and L3B on 10 MHz, L4A and L4B on 15 MHz, and L5A and L5B on 20 MHz.

The receiver is designed to use a short piece of wire as an antenna. With a standard 50-ohm generator connected (mismatched) to this antenna, signals of 1 microvolt (1000 Hz, 50% modulated) could be easily detected on all five bands.

Regulated power supply for the WWV receiver, which provides +12 volts for the converter and +9 volts for the converted broadcast radio. Other transistor radios can be accommodated by using a different zener in place of CR1. The MC7812 voltage regulator IC is heatsinked directly to the chassis. Transistor Q4 is mounted on chassis with mica washer and silicone grease.

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More Details? CHECK—OFF Page 118
The transistor tester described here is useful when troubleshooting circuits. It's also great to take along while shopping the surplus stores for checking unknown devices. Large quantities of older transistors are available at low cost in surplus outlets, many of which are entirely suitable for many projects.

This tester will allow you to grade devices into npn/pnp and good/bad categories. It will also give you a pretty good idea as to whether the transistor is germanium or silicon. The best way to illustrate what the tester can do is to go through a typical test routine. The following procedure is based on the fact that the loaded terminal voltage of the battery in the tester is at least 7.5 volts.

**using the tester**

Suppose you wish to test a small-signal transistor that has no recognizable markings. Before plugging it into the tester, make sure the function switch is at the short position. This test must always be made first. Since nothing is known about the device, either npn or pnp can be chosen on the toggle switch. If the meter shows any reading at all, you'd normally reject the transistor without making any further tests. In this case however, if the toggle switch were set to npn and the device under test was a pnp (or vice versa), the meter would indicate a short circuit. (More about this later.)

Move the toggle switch to its other position and check for a meter reading. If the meter still deflects, we no longer care what the device is because it's definitely bad. Do not attempt to make any other tests on a bad device; it's bad for the meter! If the meter reads zero, then we've determined the device type and the fact that it's probably usable. The second step is to determine the quality of the device.

Turn the knob to test for $I_{cbo}$ (collector-to-base current, emitter open). Most modern small-signal transistors exhibit nanoamperes of $I_{cbo}$. Many older types have microamperes of $I_{cbo}$. The former will give little or no reading on this meter, while the latter will produce small to moderate readings. We'd normally relegate a transistor with a high $I_{cbo}$ reading to the trash can or give it to some curious youngster, so further testing at this point is really academic. In any case, a transistor that produces a moderate-to-high meter reading is probably a germanium device. Germanium devices typically have $I_{cbo}$ values 10 to 100 times that of silicon devices, which is one reason why most transistors made today are silicon. Since $I_{cbo}$ will increase with temperature and effectively increase the forward bias on the device in a circuit, a condition known as thermal runaway ensues. And if the $I_{cbo}$ reading is moderate to high, be prepared for a high $I_{ceo}$ (collector-to-emitter current, base open) reading on the next test. $I_{ceo}$ always will be greater than $I_{cbo}$ by a factor approximately equal to the current gain (beta) of the device. The modern silicon devices may not show an indication on the meter on this test either.

The final test is for beta. The switch selects a high beta range of 500 and a low range of 100. You won't find transistors with a beta of 500 very often, but they do exist. A transistor I like to use is a 2N3391, which typically gives beta readings between 300 and 400. The more usual case for the older types is a beta of 100 or less, and many of the types made for switching applications read quite low.

Having finished this test sequence, we've obtained some pretty useful information about the device under test. The transistor tester is packaged in small instrument box only 2½" (66mm) wide and 4" (85mm) high.

* A complete parts kit for this transistor tester is being made available in conjunction with this article. For ordering information and prices, write to G.R. Whitehouse & Co., 10 Newbury Drive, Amherst, New Hampshire 03031.

By Dave Cheney, WØMAY, 4808 N. Monroe, Loveland, Colorado 80537
test. Of course, the most important aspect of these tests is to determine if the device is suitable for our needs. Admittedly the tests don't tell us anything about frequency response, but this requires an entirely different tester. If you really must know whether a device is germanium or silicon, an additional test can be made. Set a volt-ohmmeter or vacuum-tube voltmeter to the one-volt range, and connect the meter test probes between base and emitter with the device plugged into the tester. Select npn or pnp, depending on the device type, and set the function switch to the B500 position. A germanium device will read 0.2 to 0.3 volt while a silicon will read 0.6 to 0.7 volt.

The short test is really an \( I_{ces} \) test, as shown in fig. 1A. In this test the full-scale meter reading is 5 mA. Resistor R1 limits the current to about 6 mA, depending on battery condition. This resistor provides some meter protection and limits battery current drain during short tests. A meter reading will be obtained if the device has a collector-to-base or a collector-to-emitter short. To see why an npn device will show a short when the toggle switch is set to pnp (or vice versa), visualize the collector-base junction as a reversed-biased diode in normal operation. If the battery polarity is reversed, the collector-base junction becomes forward biased, which is the case when the toggle switch is in the wrong position.

The complete test circuit is shown in fig. 2. Note that collector resistor R1 is connected at all times. Its purpose has already been explained. Note, however, that this scheme does not adversely affect the test readings. The diode across the meter is for over-current protection. Any small-signal germanium unit is suitable. The meter tracking accuracy doesn't compare with that of more costly units but is entirely satisfactory for this use.

The \( I_{cb} \) test circuit is shown in fig. 1B. The meter reads 50 \( \mu \)A full-scale, as no meter shunt is used. This value of current seems to be a good compromise for checking the collector-to-base leakage of most transistors. The same current range was used for the \( I_{ceo} \) test. Some transistors, especially germanium types with high \( I_{ceo} \) and beta, will pin the meter. Fortunately, this...
The meter that maintains its zero position while in use has good damping. At the present price of about $7.95 it's a good choice for this kind of project. The meter isn't supplied with electrical data on either meter resistance or full-scale terminal voltage. Information such as this seems to be missing from many of Radio Shack's products. I suspect that the low price and lack of information means that the specifications aren't held to close tolerances.

The shunt resistors can't be calculated without having one or the other of the above specifications, so I measured mine. I applied current until the meter read full scale then measured the terminal voltage, which was 80 mV. (I didn't carry the test to its conclusion to see if the full-scale current was truly 50 μA.) Assuming the proper current value, an Ohms law calculation shows that my meter should have an armature resistance of 1600 ohms. If you're so inclined, you can measure your meter terminal voltage and recalculate the shunt resistor values for R3 and R4 using

\[
R_s = \frac{I_m}{I_s} \times R_m
\]

where: 
- \(R_s\) = shunt resistance
- \(R_m\) = meter resistance
- \(I_m\) = meter current
- \(I_s\) = shunt current

Note that \(I_s\) = circuit current minus meter current \((I_m)\).

**construction notes**

The transistor tester is very compact and the battery is a tight fit. My original intention was to use an 8.4 volt mercury battery (E-146X), which is almost the same size as the common carbon-zinc 9-volt transistor radio battery. The problem is that the two batteries are not exactly the same size. The mercury battery is just slightly thicker and will not allow the front panel to fully close. I mention this because the mercury battery is the most suitable for this application. The mercury battery has a relatively flat discharge characteristic, so that the terminal voltage remains fairly constant until the end of its life. Such a battery will improve the long-term accuracy of the tester. I didn't realize the physical differences between the two batteries until it was too late, and the carbon-zinc cell is used at present. The battery is positioned between the bottom of the case and the back of the meter. The rotary switch in my tester was a junk box item and it's not as suitable as the one in the parts list. The recommended switch uses only two wafers, which provide more room inside.

Those who wish to use my layout may refer to fig. 3 for the front panel dimensions. Note that this is the rear view of the panel, and that the meter-mounting screws are not symmetrically displaced from the center of the meter cutout.

**alignment and test**

No alignment is needed other than adjusting the meter mechanical zero. The battery should be replaced when its loaded terminal voltage reaches 7.5 V. If the voltage falls below that value, the B500 test will read low. A simple battery check may be performed as follows:

1. Set the function switch to short.
2. Set the toggle switch to either position.
3. Insert a small bare wire in the test socket between the collector and emitter pins.
4. If the meter reads less than 50, replace the battery.

There you have it: a handy-dandy transistor tester you can take to the surplus store in your pocket. If you've read this far, you probably need one too.

---

Transistor tester parts layout. A slightly larger case than used here (see fig. 3) may be used to accommodate a type E-146X 8.4-volt mercury battery, which will improve the long-term accuracy of the tester.

---

fig. 3. Front-panel layout viewed from the rear. The two 5/32-inch (3.9mm) holes at bottom are located 0.156 inch (3.9mm) in from each side and are for panel-to-case mounting screws.

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A straightforward circuit which may be used in building a curve tracer

Several articles have appeared recently describing curve tracer adapters for oscilloscopes. These adapters provide a means of measuring and displaying the current-versus-voltage characteristics of two- and three-terminal semiconductors on an oscilloscope. All of these adapters have two basic sections: a collector sweep circuit, and a base-step generator.

The collector sweep circuit generates a sweep voltage which is applied to the collector of the device under test. This voltage is usually derived from stepped-down line voltage which has been halfwave (60 Hz) or full-wave (120 Hz) rectified. The magnitude of the waveform is controlled by either an adjustable resistive divider or by a variable autotransformer. The circuit also usually contains a resistor for sensing collector current, and/or current-limiting load resistors. The design of this portion of the curve tracer adapter is straightforward and has been adequately discussed in previous articles.¹,²

base-step generator

To generate a family of curves for three-terminal devices, the adapter must include a base-step generator in addition to the collector sweep circuit. This circuit generates a series of voltage or current steps which are synchronized with the beginning of each collector voltage sweep. These steps are then applied to the base or gate of the three-terminal device under test. The accuracy of this portion of the adaptor is a major factor in the overall accuracy of the curve tracer adapter.

To achieve good accuracy and low parts count, the base-step generator circuit of fig. 1 was designed using a digital-to-analog, integrated circuit approach.

The resulting circuit has the following features:

1. Calibration of the circuit involves only one adjustment.
2. Accuracy of the circuit is determined only by the accuracy of resistor ratios, not absolute resistor values.
3. A true current source supplies base current.
4. The number of current or voltage steps is selectable.
5. Parts count is low and therefore construction is easy.
6. It is easily adapted to the builder's individual requirements.

circuit

The heart of the circuit is Motorola's MC1406L, a six-bit, digital-to-analog (D/A) converter. Before introduction of this device, most D/A converters were too expensive to be used by amateurs in their projects. Now, a D/A converter is available that is within most amateurs' budgets.* The basic configuration of the MC1406L is shown in fig. 2.

A reference current, $I_{ref}$, is established and flows into pin 12. $I_{ref}$ is given by

$$I_{ref} = \frac{V_{ref}}{R_{12}}$$

The output current, $I_0$, which flows into pin 4, is an accurate fraction of $I_{ref}$. This fraction is determined by the digital word present at the inputs of the MC1406L, pins 5 through 10. The output current is given by:

$$I_0 = I_{ref} \left( \frac{A_1}{2} + \frac{A_2}{4} + \frac{A_3}{8} + \frac{A_4}{16} + \frac{A_5}{32} + \frac{A_6}{64} \right)$$

For example, if the digital inputs ($A_1 - A_6$) are of the

*Single quantities of MC1406L are available at the price of approximately $5.90.

By Henry Wurzburg, WB4YDZ/7, Motorola Semiconductor Products, Inc., Phoenix, Arizona 85008
form 101100, then $A_7$ through $A_0$ would be 010011, and the output current, $I_o$, would be

$$I_o = \frac{I_{ref}}{2^7 + 1 + 0 + 0 + 0 + 1 + 1} = \frac{I_{ref}}{64}$$

The output current can range from 0/64 to 63/64 of $I_{ref}$ in increments as small as 1/64, depending on the state of the digital inputs. A set of guidelines is given in Appendix 1 on the proper operating conditions for the MC1406L IC.

If the output of a digital counter is connected to the inputs of the MC1406L, a series of current steps result on its output. This is the technique that is used in the base-step generator of fig. 1. Referring to the circuit, a train of clock pulses is derived from rectified line voltage. My curve tracer adapter used full-wave rectification of the line voltage for the collector sweep. Therefore, the ac voltage from which the clock pulses are derived is likewise full-wave rectified. This voltage is applied to Q1 at point A. The pulses from Q1 are inverted by U1A, and its output is applied to the clock inputs of U2 and U3. These J-K flip-flops, along with U1B and U1C, form a synchronous divide-by-eight counter.

The outputs of this counter are then applied to the $A_1 - A_3$ inputs of the D/A converter, U5. $I_{ref}$ is adjusted by potentiometer R1 to be 400 μA and the inputs $A_4$ through $A_6$ are tied to +5 volts. With this configuration, the output current into pin 4 is incremented 1/8 $I_{ref}$ or 50 μA, each time the counter is incremented. Note that the minimum increment of current that can be obtained with this configuration is 1/8 $I_{ref}$, or 50 μA. If current increments other than 50 μA are desired, they can be obtained by appropriate adjustment of R1 and by using inputs $A_2 - A_4$, $A_3 - A_5$, etc. The guidelines for proper MC1406L operation, as set forth in Appendix 1, should always be followed when such a modification is done.

The output of U5 is then fed into a current amplifier composed of U6, Q2, and their associated resistors.

The basic configuration of the current amplifier is shown in fig. 3. The relationship between the input current $I_I$ and the output current $I_2$ is given by

$$I_2 = I_I \left(1 + \frac{R_1}{R_2}\right)$$

An important feature of this configuration is that the output current is constant if the input current is constant, independent of the voltage between the output terminals. Note that the accuracy of the current gain is dependent only upon the ratio of R1 and R2, not on their absolute values. This affords the builder the opportunity of obtaining highly accurate current gains without the use of expensive precision resistors.

This current amplifier configuration is used in the circuit of fig. 1. Transistor Q2 reduces the amount of current U6 must supply by a factor of Q2's beta. Resistor R9 converts the current steps into voltage steps for fet measurements. This resistor is the only precision part necessary in the circuit. U4 and S1 select the number of steps generated by resetting the counter section at the appropriate point in the count sequence. The circuit power supply is shown in fig. 4. At this point two words of caution are in order:
1. Be extremely careful not to apply voltage steps to the base of bipolar transistors, or excessive base current will result.

2. The ground for the step generator circuit must be isolated from the collector sweep circuit and chassis grounds for proper operation.

construction

Normal construction practices are applicable. However, it is important that the power supply leads be properly bypassed. For the digital portions, a 0.01 \( \mu F \) disc capacitor for every five IC packages is satisfactory. All linear device supply voltages should be bypassed as close to the device as is possible with 0.1 \( \mu F \) disc capacitors.

table 1. Values for R3 through R8 are shown in last column as a ratio of R2 for various gains and voltage- and current-step ratios.

<table>
<thead>
<tr>
<th>Current step</th>
<th>Voltage step</th>
<th>Gain</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 ( \mu A )</td>
<td>5 mV</td>
<td>1</td>
<td>( \infty )</td>
</tr>
<tr>
<td>100 ( \mu A )</td>
<td>10 mV</td>
<td>2</td>
<td>R2</td>
</tr>
<tr>
<td>250 ( \mu A )</td>
<td>25 mV</td>
<td>5</td>
<td>R2/9</td>
</tr>
<tr>
<td>1 mA</td>
<td>100 mV</td>
<td>10</td>
<td>R2/19</td>
</tr>
<tr>
<td>5 mA</td>
<td>500 mV</td>
<td>20</td>
<td>R2/199</td>
</tr>
<tr>
<td>10 mA</td>
<td>1000 mV</td>
<td>200</td>
<td>R2/199</td>
</tr>
</tbody>
</table>

With the exception of the current amplifier’s gain determining resistors, circuit components are noncritical and appropriate substitutions can be made. The accuracy of the circuit is directly dependent upon the selection of resistors R2 through R9.

As was previously mentioned, the gain of the current amplifier is determined by the ratio of two resistors. If an accurate digital ohmmeter or resistance bridge is available, it is a simple matter to “bridge” the resistors necessary to obtain the desired gain. For example, if it is desired to obtain a gain of 100, then R2/R1 = 99. Since R2 equals approximately 10k, R should be approximately 110 ohms. R2 would be accurately measured and its value noted. Then resistors of 100 ohm nominal value would be measured and a resistor selected whose measured value is closest to being 1/99 of R2’s measured value. Highly accurate resistor ratios, and therefore gains, can be obtained in this manner.

Of course, this method can not be used if a digital ohmmeter or resistance bridge is not available, or if you don’t have a healthy stock of resistors on hand. In this case, precision (1%) resistors must be obtained and used in combinations to obtain the appropriate resistor values.

To calibrate the circuit, set switch S1 to step position 7, switch S3 to the VOLTS position, and switch S4 to a midrange position. Connect an oscilloscope to the B and E output terminals and adjust R1 to obtain the correct voltage steps. The circuit is now ready for use.

Conclusion

This circuit offers versatility and adaptability. In addition, its accuracy is limited only by the accuracy of the instruments that are used to select the components and to calibrate the circuit. The inclusion of this base-step generator circuit in a curve tracer adapter provides a highly accurate and extremely useful accessory for an oscilloscope.

Appendix

The following are some guidelines for proper circuit operation of the MC1406L six-bit, digital-to-analog converter. They are by no means maximum limits, nor are they intended to define all the possible regions of operation. Instead, they are given as an aid for individual design and are appropriate for most circuit configurations. For more detailed information on the MC1406L's capabilities and applications, see the manufacturer's data sheet.

1. Normal operating voltages:
   \[ V_{CC} = +5 \text{ volts}, \quad V_{EE} = -15 \text{ volts} \]
2. \( I_{ref} \) should be equal to 500 \( \mu A \) to 4 mA
3. \( V_{ref} \) should be equal or less than +5 volts and well regulated.
4. If \( V_{ref} \) is obtained from a logic supply, it should be heavily bypassed close to R12 (fig. 2).
5. R13 should be approximately equal to R12.
6. Voltage on pin 4 (output pin) should never exceed plus or minus 0.4 volt. This may be accomplished by the use of op amp buffering.

References

readout display

for two-meter
digital synthesizers

Dress up your transceiver with a 7-segment display for easy-to-read switch settings

The readout display described here is a great convenience when setting up the channel switches on your two-meter transceiver in the dark or while operating mobile. The display shows the decoded BCD count that controls the synthesizer. If the BCD input to your synthesizer is through front-panel switches, the display makes a nice remote switch-position indicator.

My setup consists of a Heathkit HW-202 and a GLB synthesizer built from a kit. The display is intended for use with the GLB; however, it will work with all the homebrew synthesizers I’ve seen, of which there are many in this area. I built a three-digit display for $13.00; a two-digit display would be about $8.00. The three-digit display covers all six switches, while a two-digit display would cover the 100- and 10-kHz positions. Since the decoded BCD count that’s loaded into the synthesizer is taken from the switches, no mods are required to the synthesizer.

description

The front-panel switches used for frequency selection on the GLB are ten-position rotary switches; i.e., each switch has ten positions with binary-decimal-coded outputs that represent the decimal numbers 0-9. Six identical switches are used; three represent the received frequency (RX), and three represent the transmit frequency (TX). The switches are marked 0 through 9.

The three numbers in a three-digit format represent respectively MHz, 100 kHz, and 10 kHz. Thus if the RX switches are set to 694, for example, and the TX switches are set to 634, you’d be receiving on 146.94 MHz and transmitting on 146.34 MHz. A two-digit format would display the 94 only, for 146.94 MHz. Most homebrew synthesizers have ten-position thumbwheel switches (BCD) that are mechanically different but electrically the same as in the GLB synthesizer.

Since the RX/TX count is loaded into the synthesizer at the same point, the display will normally read out the numbers set up on the RX-selected switches. When you activate the PTT line the readout will automatically display the numbers from the TX-selected switches; this allows three digits to read out all six switches, displaying only those in use.

construction

Fig. 1 is the basic circuit and can be used for all three digits. The transistors aren’t critical; most any type of npn device will work. The diodes should be silicon switching types. Substitutes for the readouts are MAN-4 or DL-4. You’ll need two identical circuits as in fig. 1, each of which will be used for the 100-kHz and 10 kHz readouts. The 7404 IC module has six separate inverters. If you build a three-digit display, sections 5 and 6 from the 100- and 10-kHz 7404 modules provide the four inverter for the MHz readout, using pins 10, 11, 12, and 13.

On some synthesizer models the MHz switch is locked from going below 4 and above 7. If you have this type,

By Garry M. Poirier, WB4TZE, P.O. Box 3871, Gastonia, North Carolina 28052
build the MHz display as shown in fig. 2 using the two unused inverters from the 100-kHz 7404. For the 5 volt supply I used a LM309K regulator (fig. 3). Component layout isn't critical. I mounted everything on perfboard except the diodes, which I mounted inside the synthesizer. If you plan to have your display located remotely from the synthesizer, such as dash mounted, small coax should be used for interconnecting wires and you still may have an erratic display while transmitting (this problem is discussed under troubleshooting).

I built my readout into a Minibox, bolted it to the top of the synthesizer, drilled a hole through both, and used standard hookup wire. I cut out the front of the Minibox just enough to view the LEDs, then put a polaroid filter over the cutout.

No modification to your synthesizer should be required to connect the display. However, you must connect the readouts to the proper point for a 1-2-4-8 BCD decoding with automatic switching (see fig. 4). Remove the cover from the synthesizer. At the back of the 10-kHz switch you'll see four diodes connected to it, and they in turn connect to four diodes from the lower points (watch the polarity). Repeat this operation for the 100 kHz and the MHz readouts. If you have only two diodes on the MHz switch, see fig. 2.

**Test and troubleshooting**

When all connections have been made, position the RX switch to use the lower set of switches and turn power on. The display should represent the output from the lower switches. Move the RX switch to the upper switches and the display should change to represent the

---

**fig. 1. Basic circuit of the synthesizer display. Two identical circuits are needed; one for the 100-kHz and one for the 10-kHz readouts. Two sections of the 7404 are used for the MHz readout.**

**fig. 2. Circuit for limited-range MHz switch. Connect the 2-display diode to the point that measures +4V for both 6 and 7 positions (see text for measurement). The 1-display diode is connected to the other MHz-diode point.**
upper switches. With the RX switch on the upper set of switches and the TX on the lower set, ground the PTT line and the display should change from upper to lower switches.

If a readout is in error from a switch setting and the rig is on the right frequency, then you have made a wiring error, most likely at the diode 1-2-4-8 connections, or you have used a bad component. If the readout is correct or erratic and the rig is on the wrong frequency, check for a diode connected backward or a shorted diode. If the reading is correct in RX but in error in TX, you have rf leakage from your rig. Check the reading with the rig terminated into a good dummy load. The diodes isolate the readout from the synthesizer, the transistors bring the signal to a TTL level, the 7404 inverts the signal to the correct polarity, and the 7448 decodes the signal to drive the DL704.

If trouble still persists, such as an erratic readout on transmit, check for rf leakage in and around your set. The shields of all leads from the synthesizer to the transceiver should be grounded at the point of entry into the transceiver. Check for poor antenna connections, high vswr, loose hardware in both rigs, a poor microphone connection, or an oscillating power supply. The readout should be correct and steady, even with a 50-watt amplifier sitting on top of it.

The reason for two types of MHz switch hookups is that the GLB has a MHz switch that will not go below 4 (144.00 MHz) or above 7 (147.99 MHz). This prevents out-of-band operation. However, some amateurs wish to use their synthesizer on MARS frequency so they order a band-extended version, which allows the MHz switch to go from zero to 9 (144 to 149 MHz). All homebrew rigs (to my knowledge) will go from 140.00 to 149.99 MHz, or at least the switch is not locked out to prevent it.

ham radio

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matching techniques for vhf/uhf antennas

In my last column, in the May issue1, I discussed feed systems, feedlines, baluns, matching networks and matching techniques. This month I will concentrate not only on matching techniques but also on easily-built test equipment which can be used to assist in matching and evaluating antenna performance.

More often than not, the station transmitter is used as a signal source to check vhf and uhf antenna performance. This is easy to understand since most stations are equipped with an in-line vswr indicator. However, using the station transmitter for antenna evaluation has several drawbacks. The most obvious problem is that adjustments cannot be readily made with power applied. Another problem which has only recently been mentioned is the possible hazard due to exposure to high-intensity rf fields.*

A better technique for measuring and matching vhf and uhf antennas uses a low-power (1 to 100 mW) amplitude-modulated (usually 1-kHz square wave) signal generator. This generator can be either a standard commercial signal generator (such as the Hewlett-Packard 608) or a small solid-state signal source such as that described later in this column. Low power testing eliminates most of the problems associated with using the station transmitter. It is also much less time consuming because adjustments can be made with rf power applied. Furthermore, construction of such an rf generator is simple and straightforward.

Most in-line vswr meters (such as the Monimatch) use a microammeter or milliammeter as an indicator. This requires moderate power (more than 1 watt) to drive the meter. Dc amplifiers can be used to increase sensitivity, but they tend to drift and can be quite complex. If a modulated rf source is used, the detected rf signal is ac (rather than dc) so it can be easily amplified to a suitable level to drive a vswr indicator. A typical test set-up is shown in fig. 1.

A suitable low-power 144-MHz (10-milliwatt) signal source for antenna measurements is shown in fig. 2. It consists of a 72-MHz crystal oscillator followed by a times-2 multiplier. This design follows the general guidelines of reference 3. Experimental tests have shown that overtone crystal oscillators can be balky starters. Therefore, I recommend that the oscillator be run continuously while keying the doubler. Simple, off-on (square-wave) keying is preferred. I have also used this technique on a 432-MHz signal source which uses a 108-MHz oscillator followed by two-keyed doublers. Over five years of rough treatment have not caused any problems.

There are several requirements for a suitable rf source. Output power should be constant. This can best be controlled by using a regulated power supply. Battery operation is recommended for field use, but the batteries should be checked periodically for signs of discharge. For best performance in the field, a simple 3-terminal, 12-volt, IC voltage regulator following a 16- to 20-volt battery supply is recommended.

Another rf generator requirement is freedom from load variations (such as the antenna, etc.). This can be satisfied by a 3 to 6 dB attenuator between the generator output and the load. All spurious or harmonic outputs should be at least 30 to 40 dB below the output signal. A double-tuned output filter is usually sufficient (see fig. 2). Finally, a shielded box around the generator prevents excessive radiation or signal pickup.

Construction is straightforward. My units are built on a 2- by 4-inch (5x10 cm) piece of double-sided epoxy fiberglass PC board which is attached to the inside of the top lid of a Pomona 2901 shielded box. All grounded components are soldered to the copper ground plane. Be sure to remove the paint and protective coating where the box and lid make contact. This insures a well-shielded generator — a must for good measurement.

The 144-MHz rf generator has a CW output of 10 milliwatts and a modulated output of 5 milliwatts. All spurious and harmonic frequencies are 35 to 40 dB below the output. These characteristics are near optimum for the low-power antenna tests to be described in this article.

You may ask if a separate generator is needed for each band you're interested in. The answer is no. With the exception of 50 and 220 MHz, all major amateur vhf/uhf bands are harmonically related to 144 MHz so it's only necessary to build a 144-MHz generator and
add on amplifiers and multipliers for other bands. Keying the multipliers is not necessary because the 144-MHz source will supply sufficient modulation. Such a scheme is shown in fig. 3. It will be left to the user to provide the circuitry necessary to implement this system.

For several years I have been using a simple multivibrator and series pass transistor as the modulator for my rf generators. At the insistence of K1LOG, I finally updated my circuit to use an NE555 IC. One NE555 timer replaces the multivibrator and its 15 plus components and is easily adjustable from 750 to 1500 Hz. A series pass transistor, while not absolutely necessary, was added since it increased the output by about 2 dB. A complete schematic of the modulator is shown in fig. 4.

This unit is built in a small chassis box with two or more 3- or 4-pin Jones connectors on the output. The output connectors provide ground, +12 volts and keyed 12 volts, thus allowing quick changes or additional units to be plugged in (see fig. 3).

vswr measuring gear

In the May column I mentioned some recommended vswr measuring gear. In this column, I will describe simple homemade equipment that can be used instead of slotted lines, network analyzers and reflectometers. The vswr bridge is a very versatile unit since it can be used to measure various impedances, depending on the reference. Suitable bridges are commercially available from a number of firms including Texscan, Anzac, Telonic and Wiltron. Sometimes these units can be found on the surplus market.

A vswr bridge can be built to work through several GHz, but this requires careful attention to size components, and layout. However, with some care a simple homebrew bridge can be made to work well through 450 MHz. Such a unit is shown in fig. 5. Operation of this bridge is easily understood. If identical loads are placed at J2 and J3, the signals at opposite ends of R3 are equal and in phase, and there will be no output at J4. However, if the impedance of the unit under test at J3 is different from that of the reference load, an output proportional to this difference will be present at J4. The reference load and unit under test can be any convenient impedance value from 25 to 100 ohms. However, the bridge circuit in fig. 4 is designed for optimum performance at 50 ohms.

The values of R1 and R2 are not critical, but both should be the same type and well-matched for best accuracy. This can be easily accomplished by comparing 6 to 10 similar resistors on an ohmmeter and choosing
the two which are closest in value. R3 can be one of the rejects since its value is not critical. I would suggest the use of 51-ohm, ½-watt, carbon-composition resistors. If the bridge is primarily for use at 70 or 75 ohms, R1, R2, and R3 should be changed accordingly for best match to the device under test, but this is a fine point. Capacitors C1 and C2 are small copper tabs that can be added close to J2 and J3 if the ultimate in balance is desired (more about this later).

When building such a bridge, short leads and symmetry are the prime considerations because any long leads or stray capacitance will cause imbalance. A recommended layout is shown in fig. 6. I use a Pomona 2417 shielded box for the enclosure. It is a good choice for the components and type-N connectors.

To test the bridge a modulated rf signal is connected to J1 and an audio detector (described later) is connected to J4. Two identical loads are placed on J2 and J3. The detector output should be extremely low. If not, C1 or C2 can be added to balance out any residual signal. Removing either the load or reference will cause the detected output to rise from 20 to 40 dB or more, indicating proper performance. If two identical loads are swapped from J2 to J3 and vice versa, the detected output should not change.

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Hybrid couplers are also a good choice for vswr measurements and are preferred for operation above 500 MHz where bridges are less accurate. Hybrids are also quite suitable for lower frequencies. Usually quite expensive, recently a low-cost, broad-band, 500 kHz to 400 MHz hybrid coupler became available from Anzac Electronics.* It is mounted in a half-size relay can and is easily adaptable to microstrip circuitry. A schematic and microstrip circuit-board layout for the Anzac hybrid coupler is shown in fig. 7.

If all inputs and outputs of the hybrid coupler are properly terminated, and an rf signal is present at input 1, the same signal will be present at output 1 (less the coupling power) and no signal will be present at output 2. The signal level at input 2 will be below the level at input 1 by the coupling factor (19.5 dB in this case). However, if the vswr at output 1 is not 1:1, a signal will

*Cancion model CH137 available from Anzac Electronics, 39 Green Street, Waltham, Massachusetts 02154. Price is $13.00 plus tax and shipping.
be present at output 2 which is proportional to the vswr at output 1. The level at input 2 remains essentially the same.

To perform a vswr test, the signal generator is connected to input 1; output 1 and output 2 are terminated in good, nonreactive 50-ohm loads. A 50-ohm detector is connected to input 2 and the level on the detector indicator is noted for reference. The 50-ohm load at output 2 is now interchanged with the detector on input 1 and the detected output should drop considerably (at least 20 dB). Next the load on output 1 is removed and the device under test is connected. All that is necessary to complete a match is to adjust for minimum detected signal at output 2.

This coupler works well through 250 MHz. At 432 MHz there is some imbalance so if it is used at 432 MHz it is necessary to interchange the inputs and outputs, respectively (they are symmetrical, so operation should be identical), to determine which combination gives the best null when properly terminated. In my case input 2 and output 2 are better at 144 and 432 MHz.

A narrower-bandwidth stripline coupler with a bandwidth of 10% is shown in fig. 8. I have used this type of coupler through 2304 MHz with excellent results. Operation is identical to that of the Anzac unit. When building the stripline coupler be sure to keep any air gaps between the printed circuit boards to a minimum. Placing 1/8 inch (3mm) thick aluminum plates on top and bottom and bolting them together will keep the air gap to a minimum.

loads

Suitable 50- and 70- to 75-ohm loads are commercially available from a number of sources and can sometimes be found on the surplus market. A suitable homebrew load is shown in fig. 9. I have found that ordinary 1/4-watt, carbon-composition resistors to be the least reactive and therefore the most suitable for this application. Half-watt and especially 1-watt units are definitely inferior in this respect. A symmetrical four-resistor load (as shown in fig. 9) has been the best performer—tests have shown this arrangement to work well through 2304 MHz. If a 75-ohm load is desired, the individual resistor values can be changed to 300 ohms.

It is often desirable to have known mismatches to aid in determining the true antenna vswr. A 75-ohm load makes an excellent 1.5:1 vswr reference on a 50 ohm system. Four 100-ohm resistors will make a good 25-ohm load which can be used for 2:1 vswr tests at 50 ohms. In all cases the coaxial connector chosen should be of suitable quality (type-UHF connectors are not recommended above 30 MHz).

Infinite vswr can be tested with a short circuit. Open circuits are not recommended since fringing capacitance will alter the results. A suitable infinite vswr load is also shown in fig. 9.
A detector is built into the vswr bridge. If a hybrid coupler is used, you must build or purchase your own detector. It should be sensitive and well matched. Point-contact or zero-bias Schottky diodes are preferred because normal Schottky diodes are insensitive at low signal levels unless forward bias is applied. Since the cost of zero-bias Schottky diodes is presently quite high ($25 or more), low-cost point-contact diodes are preferred.

A schematic for a suitable detector using point-contact diodes is shown in fig. 10. The input is a 50-ohm termination and should be similar to the loads in fig. 9. It provides a dc return for the diode as well as providing a load for the hybrid coupler. Typical output is only 50 microvolts at -40 dBm, 5 millivolts at -20 dBm and 30 millivolts at zero dBm. The output is square law (output voltage doubles each time the input doubles) below -20 dBm and linear above -10 dBm. An amplifier is required at low levels.

The detector should have short leads on R1, CR1 and C1. I built mine in a Pomona 2417 box with the input connector on one end, a shield diagonally across the box for the ground return of the feedthrough capacitor, C1, and the output connector on the opposite end. This type of detector is suitable for use to 1000 MHz or so and can be used in many other applications.

The output of an rf detector is very low at small signal levels. Therefore, an amplifier is needed to drive an indicator such as a meter, and it should be tuned to 1 kHz to work best with modulated signal sources.

Recently many Hewlett-Packard 415 type square law meters have become available on the surplus market at reasonable prices ($25 to $40). This is an excellent meter to use since it has high gain and is calibrated to match typical detectors. It also has many other uses. A suitable homebrew model has also been described in ham radio.4

Recently I designed and built a simple, uncalibrated vswr meter that is easily transported and uses a minimum number of components. The circuit, which is shown in fig. 11, consists of a high-gain amplifier, a narrow-bandwidth (100 Hz) selective amplifier tuned to 1000 Hz, and a variable-gain output amplifier which drives a low-cost VU meter. This instrument is ideal for nulling-type vswr measurements, and uses only a single supply voltage. At 9 to 12 volts (not critical) the circuit draws only 5 to 6 mA so an inexpensive 9-volt transistor battery can be used.

Before making any vswr measurements, it pays to set up your vhf or uhf antenna in a clear area, on a tower, or on a wooden ladder pointing toward the sky. The length of the driven element should be set approximately as follows:

\[ L = \frac{5500}{f} \quad \text{(inches)} \]  
\[ L = \frac{13970}{f} \quad \text{(cm)} \]

where \( L \) is the driven element length and \( f \) is the frequency in MHz. If the driven element passes through a metal boom it should be lengthened by adding approximately 75% of the boom diameter to compensate for the shortening effect. The length of the driven element is
not critical for gain purposes and should be tuned for best VSWR in conjunction with the matching system.

I have received several inquiries regarding the actual length of a free-space wavelength at VHF and UHF. At the present time, authorities are in general agreement that light (and hence radio waves) travels at the rate of 299,792,456 meters per second. Therefore, the correct VHF and UHF formulas for wavelength are as follows:

$$\lambda = \frac{11803}{f} \quad \text{(inches)} \quad (3)$$

$$\lambda = \frac{29980}{f} \quad \text{(cm)} \quad (4)$$

where $f$ is in MHz. These formulas should clear up any questions on the subject.

table 1. Return loss, dB, vs voltage standing-wave ratio.

<table>
<thead>
<tr>
<th>Return loss</th>
<th>VSWR</th>
<th>Return loss</th>
<th>VSWR</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 dB</td>
<td>1.02</td>
<td>8 dB</td>
<td>2.32</td>
</tr>
<tr>
<td>35 dB</td>
<td>1.04</td>
<td>6 dB</td>
<td>3.01</td>
</tr>
<tr>
<td>30 dB</td>
<td>1.07</td>
<td>4 dB</td>
<td>4.42</td>
</tr>
<tr>
<td>25 dB</td>
<td>1.12</td>
<td>3 dB</td>
<td>5.85</td>
</tr>
<tr>
<td>20 dB</td>
<td>1.22</td>
<td>2 dB</td>
<td>8.72</td>
</tr>
<tr>
<td>15 dB</td>
<td>1.43</td>
<td>1 dB</td>
<td>17.39</td>
</tr>
<tr>
<td>10 dB</td>
<td>1.93</td>
<td>0 dB</td>
<td>∞</td>
</tr>
</tbody>
</table>

Now let’s assume we want to match an antenna. If the feed system is similar to the ones mentioned in the last column (delta match, gamma match, etc.), it is only necessary to set up the low-power test setup shown in fig. 1 using an appropriate VSWR bridge or hybrid coupler. Initially, a 50-ohm load (or appropriate impedance) can be used to test the matching gear for a null. Then the antenna under test can be substituted and adjusted for minimum VSWR. If a complete null cannot be obtained, a mismatch reference can be substituted to determine the actual VSWR and to see if any further improvement is required.

If a true square-law detector and indicator are used, the VSWR can be determined fairly accurately by measuring the return loss or change between an infinite VSWR and the unit under test. Typical values are shown in

![Fig. 12. If it is inconvenient to place a balun right at the antenna feedpoint, tuned lines can be used as shown here. If the line is one-half wavelength long (or a multiple) the impedance of this extension is not important (250 to 400 ohms is recommended).](image)

should strive for 1.5:1 VSWR as a goal (approximately 14 dB return loss). This is most easily tested by substituting a 75-ohm load in a 50-ohm system. If the return loss of the antenna under test is better than the 75-ohm load (greater than 14 dB) you can stop making adjustments. If return loss is less than 14 dB, more work is required.

Sometimes it is inconvenient to place a balun right at the antenna feedpoint, especially when using stubs. If this happens, you can use tuned lines between the antenna feedpoint and the balun as shown in fig. 12. The transmission line impedance of this extension is not important (250 to 400 ohms is recommended) if the line length is a one-half wavelength or a multiple thereof, using equations 3 or 4. If open-wire line with only a few insulators is used, a physical length of 95 to 98 per cent of the electrical free-space wavelength is recommended.
This technique should not be stretched beyond one or two wavelengths because errors are additive, so length becomes more critical.

Although many amateurs are somewhat afraid of matching stubs, they are quite versatile and really not that mysterious. Usually a 1.1:1 match can be easily obtained if the right procedures are followed. First, a matching stub should be at least one-half wavelength long. However, if the shorting bar does not fall exactly at the lower end, a match may not be possible. Therefore, a full wavelength is recommended. If this is not possible, an appropriate length of line can be placed between the stub and the device to be matched to place the shorting bar at a convenient place on the stub. This is a handy technique for tight spots (such as those suggested to me by John W1VSV, W21MU, W2DU, W1JAA, W1TMJ, and W21MU).

1. Remove the shorting bar.
2. Attach the feedline to the bottom of the stub (see fig. 13).
3. Feed rf power to the stub from a modulated signal source.

4. Using a voltage probe, find the minimum point (current maximum) which is nearest to the antenna. If this point is too close to the antenna end, either shorten the feedline to the antenna or move further down the line to the next current maximum point.

5. Place the shorting bar at the current maximum point.

Next, reconnect the feedline approximately 0.05 wavelength above the shorting bar and move the feedline up or down for the lowest VSWR. Then move the shorting bar slightly to enhance the VSWR null. Repeat these steps until a suitable match is obtained. The entire procedure is quite simple and takes longer to explain than it does to accomplish!

A simple voltage probe is shown in fig. 14. It can be easily built into a Pomona 2417 or equivalent shielded box. In this circuit L1-C2 are tuned to the frequency of operation. When used with the low-power test set-up and a sensitive VSWR indicator, this provides a very sensitive voltage sensor. When using the device make sure that the hot end of the probe does not touch the feedline. The groove in the Teflon insulator maintains the spacing between the probe and the line and facilitates moving the probe along the line.

gain measurements

By now you have probably guessed that the equipment described here can also be used to measure antenna gain. However, that subject is beyond the scope of this month’s column, so will have to wait until another time.

In the meantime, if you want to read about antenna gain measurements that can be done with the simple test equipment I have described, I recommend that you read references 6 and 7.

summary

It is hoped that this two-part series on VHF/UHF antenna matching techniques will tempt you to do more work on your antennas. The test equipment described here is a must for serious-minded VHF and UHF operators — it will more than pay for itself after a few antenna-matching sessions. And, if you use these techniques, you will no longer have to worry about RF burns or the hazards of RF radiation.

references


ham radio
carrier-operated relay

for repeater linking

An improved COR using ICs with dual-channel options for linking two repeaters

New concepts and new devices have been developed since the original carrier-operated relay article appeared in these pages.1 The FCC has approved linking of repeaters, so we've included an addition to the COR that will link repeaters or that can be used for other applications as well.

The basic purpose of a COR is to operate a repeater, so the COR must be as simple and reliable as possible. Other uses for the COR are in a guard receiver for repeater input channels and for speaker muting.

The basic COR circuit (fig. 1A) will handle most repeater requirements. The link, or two-channel COR, shown in fig. 1B can be used for linking two repeaters, for a remote base, or for a guard channel for your repeater. Both circuits have a common front end. Circuit boards are available, including a fully adjustable time-out timer and input-sensitivity control.*

circuit description

Referring to fig. 1, transistors Q1, Q2 are connected as a darlington amplifier for negative-going control signals, as found in a vacuum-tube receiver. The high impedance of the darlington amplifier closely matches the impedance of most tube receivers. For positive-going control signals, normally found in transistorized receivers, make the following changes: R1 to 27k, R2 to 100k, and R3 to 47k. Connect R3 to ground, Q1 emitter to ground, and Q2 base to Q1 collector. The circuit will then respond to positive-going control signals.

U1 is a dual Schmitt trigger that provides positive on-off action. When a control signal is received, ST1 will receive a high from Q2 and a low will appear on its output; this action will set the trigger of timer U2. The low from ST1 is passed to the input of ST2, causing a high to appear on its output, which enables the timer. Time-out is controlled by the setting of R8 and the value of C3.

When the timer starts, its output, pin 3, goes high and energizes the relay. If the input is held long enough, the timer will time-out and pin 3 will go low. However, if the input is released before time-out occurs, the timer output is again driven low and the relay will open. Each time the relay is energized, the timer will have been reset through the action of ST1.

applications

Fig. 2A shows how easy it is to connect this circuit into a receiver and transmitter to control a repeater. Fig. 2B illustrates another use for this circuit. Say you'd like to monitor a repeater or simplex channel for any calls, but you don't want to listen to all the yack-yack going on while you're watching your favorite TV show. Set the timer for about five seconds and when a call comes in, the first few words will be at normal volume. Then, in five seconds, the volume will drop to a low level (determined by the setting of the variable resistor). If the call is for you, simply disable the circuit for normal listening level.

If you wish to control two channels, such as a link repeater or a guard receiver for your repeater, merely add the circuitry shown in fig. 1B. In this configuration we will use the same basic carrier-operated relay shown

By Robert C. Heptig, KØPHF, and Robert D. Shriner, WA0UZO, Box 969, Pueblo, Colorado 81002
in fig. 1A and add a simple search-lock feature constructed from a single SN7400 and a few other components. Note that R4 (fig. 1A) is changed to 100 ohms, 1 watt for this application.

Gates 1 and 2 of the SN7400 are connected as a simple oscillator, and the output is fed through C9, C10 to gates 3 and 4, which are set up as a dual D flip-flop. Transistor Q3 acts as the lock to stop the oscillator. When no signal is applied to the system, ST1 output is low and Q3 is turned off. This action allows the oscillator to operate and causes transistors Q4, Q5 to conduct and switch on channels A and B respectively.

If a signal is presented to the receiver, the relay will close, causing the repeater transmitter to come up. The oscillator will stop on the channel that was received. As an example, let's say you desire to link a 34/94 repeater into a 28/88 repeater. For simplicity we'll call the two channels of the link repeater A and B (fig. 2C). Channel A will be set up to receive 94 and transmit on 28. Channel B will receive on 88 and transmit on 34.

When a signal out of the 34/94 machine is received by the link, the signal will be retransmitted automatically on 28 into the other repeater and will come out on 88. As soon as the signal drops out, the search feature will start up again, and if an answer comes back from the 28/88 machine, this signal will be retransmitted through

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fig. 1. Basic circuit of the COR (A) and simple search-lock feature (B) to control two channels such as a link repeater or guard receiver.

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the 34/94 machine. The action of the basic COR and time-out timer will remain the same as previously described.

How about a guard receiver for your repeater? Refer to fig. 2D. Let's say you have a 34/94 repeater and desire to install a receiver on 94 that won't allow the repeater to come up if the output frequency (94) is in use. Install a second oscillator in your repeater receiver
Basic COR component layout. Circuit will handle most repeater requirements. A fully adjustable time-out timer and input-sensitivity adjustment are included.

(channel B) and connect your relay as shown. Diode separation is used to prevent interaction between oscillator and COR. If a signal is not present on 94, the repeater will operate in a normal manner; but if a signal is present then the COR will lock on to channel B and the repeater can’t be brought up, simply because the input-channel oscillator (34) is disconnected.

trouble shooting

In the event of trouble use a dc scope or a vtvm to check for the following voltages. (All voltages are given assuming a negative-going signal into the system). First check the supply voltage (+12V) and the voltage to the ICs (+5V). Check Q2 output. It should be close to zero volts with the input open and should rise to near +5 volts with the input grounded and R2 at maximum sensitivity. If not, and Q1 and Q2 are both good, replace Q1, as any slight leakage here will affect the circuit.

To check U1: pins 1, 2, 4, 5 and 8 should be near zero volts with the input open, and pins 6, 9, 10, 11 and 12 should be near +5 volts. These readings should reverse when the input is grounded; if not replace U1.

To check U2: pin 3 should be near zero volts with the input open. Ground the input, and pin 3 should go high (12V); pin 4 will be high (5V). Connect the scope or vtvm to pins 6 and 7. The voltage should rise slowly to about 8 volts, the timer will fire, and pin 3 will go low. If not, replace U2, R7, R8 or C3 in that order.

To check U3: pins 1, 2, 3, 4, 5 and 6 should show a clock pulse of about 2 pulses per second. If not, replace U3, Q3, C8 or R10 in that order. To check U3: pins 3, 4, 5 should go high (12V); pin 4 will be high (5V). Connect the scope or vtvm to pins 6 and 7. The voltage should rise slowly to about 8 volts, the timer will fire, and pin 3 will go low. If not, replace U2, R7, R8 or C3 in that order.

By making simple modifications the circuit can be easily tailored to your own requirements. For instance, by increasing the value of C1, a delay activating the system will be noted. Increase the value of C5 to delay the dropout. Decrease the value of C8 to speed up the clock or search rate.

Several of these carrier-operated relays have been constructed and are in use in our area. We’ve found that others are amazed at the simplicity of the circuit and how well it works for them in their particular application. This circuit is just another example of putting those little plastic centipedes to work for amateur applications.

reference

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microcomputer interfacing: substitution of software for hardware

A reader who has followed the current literature on microcomputers will frequently encounter phrases such as "hardware/software tradeoffs" or "substitutions of software for hardware." These phrases are strongly indicative of anticipated applications for microcomputers in the near future and do much to explain why industry is so excited about them. In this month's column we discuss how to substitute microcomputer software for hardware.

**Hardware**
- Mechanical, magnetic, electronic, electromechanical, and electrical devices from which a system is fabricated.

**Software**
- Totality of programs and routines used to extend the capabilities of computers, such as compilers, assemblers, narrators, routines, and subroutines.

In our specific case, software represents the machine-language program stored within the memory of a microcomputer. Hardware represents the specific devices that store, manipulate, receive, or transmit digital information. The microcomputer itself is included in our definition of hardware. The basic point of this month's column can be simply stated:

*Through skillful programming, it is possible to substitute machine-level routines and subroutines for specific hardware devices that store, manipulate, transmit, or receive digital information. This activity is called the substitution of software for hardware.*

Typical replaced hardware includes knobs, buttons, pulsers, switches, logic switches, clocks, and small memories as well as TTL integrated circuit chips that perform digital functions such as debouncing, sequencing, shifting, adding subtracting, comparing, and logic operations on multibit digital words. Hardware not usually replaced includes simple TTL chips such as inverters, flip-flops, gates, latches, three-state buffers, and counters.

Fig. 1 illustrates the basic tools you would employ in the substitution of software for hardware:

1. Programming.
2. The use of synchronized data appearing on the bi-directional 8-bit data bus, D0 through D7.
3. Input and output synchronization pulses called device-select pulses.
4. Interrupts to the microcomputer.

In an 8080-based microcomputer, you can generate 256 different input and 256 different output synchronizing pulses. If you need more pulses, you can always employ memory I/O techniques as discussed in last month's column. You therefore have an unlimited number of synchronizing pulses with which to coordinate the behavior of almost any type of digital electronic circuit. As you substitute software for hardware, your main tradeoff will be speed of operation. It is useful to remember the following rule:

*In the substitution of software for hardware, the key tradeoff is speed of operation. The execution of any computer instruction takes time; the more instructions used, the longer it will take to execute them.*

This tradeoff is not as serious as it may seem. Present 8-bit microcomputers are very fast, and future microcomputers will be at least ten times faster. The majority of existing electromechanical machines are slow by digital electronic standards. The human senses cannot participate in activities that require millisecond time resolutions; i.e., in an input/output sense, we are very slow machines.

Table 1 summarizes some of the more commonly replaced hardware

---

**Table 1**

By Peter R. Rony, Jonathan Titus, and David G. Larsen, WB4HYJ

Mr. Larsen, Department of Chemistry, and Dr. Rony, Department of Chemical Engineering, are with the Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Mr. Jonathan Titus is President of Tychon Inc., Blacksburg, Virginia.
encountered situations where hardware such as debounced pulsers, switches, logic switches, and clocks are replaced by simple wire connections, latches, flip-flops, and inverters. We have provided abbreviated versions of the required software. (See reference 2 or previous columns in *ham radio* for details on the generation of the *out n* pulses, where *n* is an octal number between 000*₂* and 377*₂*).

A timing loop is a short subroutine that generates a precise time delay, typically greater than 100 microseconds. As the table shows, the replacement can be made in most cases by the use of one or two different device-select pulses. A pair of *out n* instructions that bracket a timing loop are sufficient, when applied to an SN7474 flip-flop, to produce a monostable pulse of precise time duration. The addition of a second timing loop and a *jump instruction*, JMP, changes the flip-flop output to that of a variable duty-cycle clock, the duty cycle being controlled by the relative time delays of the two timing loops.

Of particular interest is entry 6 in the table, in which an eight-position mechanical switch or eight individual mechanical switches are replaced by an 8-bit control word strobed into an 8212 chip from the accumulator with the aid of a device-select pulse. This control word is latched by such an action and can subsequently influence the behavior of a rather sophisticated digital circuit. The 8212 chip therefore functions as a control register for the circuit. We have directed your attention to this principle because it is now being widely used in an exciting new generation of interface chips that reduce the number of wire connections needed between a microcomputer and an external device. The 8255 programmable peripheral interface chip described in last month's column is included in this category.

Table 1 provides only a few examples of how hardware can be replaced by simple software with the aid of device-select pulses. Omitted from the table are the more obvious hardware substitutions: arithmetic logic units (SN74181), digital comparators (SN7485), and shift registers (SN74194, SN74198, SN74199). Such chips are replaced by microcomputer instructions that add, subtract, compare, and shift the 8-bit contents of the accumulator register.

Although the microcomputer is the most revolutionary electronic device since the invention of the transistor, it is not always obvious how a microcomputer can be used in an amateur radio station. To help lead the way we would like to encourage those that are using microcomputers in amateur stations to drop us a note on how they are being used with the idea of writing a guest column in this section of *ham radio*. Alternatively, you may want to submit a full construction article or even a short note that could be included in one of our regular columns.

### References

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Table 1. Some uses for device select pulses in the substitution of hardware by software

<table>
<thead>
<tr>
<th>Substituted Hardware Function</th>
<th>New Hardware Circuit</th>
<th>Software Employed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. PULSER, 500 AS MONOSTABLE.</td>
<td>DS 0</td>
<td>OUT 0</td>
</tr>
<tr>
<td>2. LOW DUTY-CYCLE CLOCK (500 MS PULSES).</td>
<td>DS 1</td>
<td>OUT 1</td>
</tr>
<tr>
<td>3. DEBOUNCED PULSER, MONOSTABLE, LOGIC SWITCH.</td>
<td>DS 2</td>
<td>DS 2, JMP</td>
</tr>
<tr>
<td>4. VARIABLE DUTY-CYCLE CLOCK.</td>
<td>DS 3</td>
<td>DS 3, OUT 3</td>
</tr>
<tr>
<td>5. ONE BIT OF CONTROL INFORMATION FROM A MECHANICAL SWITCH.</td>
<td>DS 4</td>
<td>DS 4, JMP, A CTRL, OUT 6</td>
</tr>
<tr>
<td>6. EIGHT BITS OF CONTROL INFORMATION FROM A SET OF EIGHT MECHANICAL SWITCHES.</td>
<td>DS 5</td>
<td>DS 5, A CTRL, OUT 7</td>
</tr>
</tbody>
</table>

---

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The schematic of fig. 1 shows a simplified and improved version of this popular keyer. The three transistors that made up the pulse generator were replaced with an NE555V (U1). Normally a free-running oscillator, the NE555V becomes a switchable dot generator by adding CR1, providing an accurate 1:1 ratio.

The sidetone generator was replaced by another NE555V (U4), which has a tone range of about three octaves. The output easily drives a 3-watt, 4-ohm speaker (no extra speaker is used for the keyer). Still another NE555V (U5) was added to U4 to provide a two-tone oscillator for ssb tuning. A 16-pin IC socket will simplify construction.

The output section consists of Q1 and Q2. The keying bias of my transmitter (an FL-DX500) is -26 volts at 5 mA, easily handled by Q2. Q1 is an inverter for Q2. The resistor across Q1's emitter-collector junction and the capacitor in the base circuit provide a good-sounding on-the-air signal.

The rotary multiswitch connects the receiver output to a speaker or headset. In either position, sidetone can be added by adjusting the volume control while listening to a desired signal. Keying speed and ratio are quickly adjusted, the volume control is turned to zero (no tone), and the transmitter is ready for keying.

The keyer circuit is mounted on a 3-3/16 by 1½ inch (80 by 40mm) perf

---

A variable dash circuit was added using an SN7473 (U2). When U1-12 is high, forming dashes, U2-13 is low, providing a load for U1-7. Voltage then decreases at U1-2, 6, 7, consequently dash length will be extended and may be controlled by the potentiometer shown. In the dot position, CR2 prevents feedback so that dot-space ratio is always 1:1.

External components of U5 may be chosen for a suitable fixed frequency, while U4's tone control may be varied to obtain a suitable second frequency and marked for presetting. If you wish to omit the pushbutton switch and U5, connect the 1N914 directly to U4, pins 2 and 6.

The output section consists of Q1 and Q2. The keying bias of my transmitter (an FL-DX500) is -26 volts at 5 mA, easily handled by Q2. Q1 is an inverter for Q2. The resistor across Q1's emitter-collector junction and the capacitor in the base circuit provide a good-sounding on-the-air signal.

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The keyer circuit is mounted on a 3-3/16 by 1½ inch (80 by 40mm) perf
board, with space remaining for more components. The transformer is mounted at the inside rear of the box near its jack.

Herbert Seeger, DJ9RP

stabilization of the Ten-Tec KR20 keyer

A nagging problem with the Ten-Tec model KR20 keyer during four years of use has been an intermittent dit when the keyed character was a dah. Persistent checking showed no component failure. Finally, by monitoring the output of the power supply, a 0.5-volt shift was discovered in the output voltage while keying. This annoying problem vanished and the shift was eliminated when the 270-ohm resistor between the base and ground of Q6 was replaced with a 5.6 volt zener (fig. 2).

Don Peck, W3CRG

AFSK generator

I recently built the excellent crystal-controlled AFSK generator described in Ham Radio* but since I didn’t have a +15 volt power supply available, I used the TTL oscillator circuit shown in fig. 3. The crystal is an FT243 that I hand ground to 4589.5 kHz. The 50-pF series capacitor allows the frequency to be trimmed to exactly 4590 kHz.

The output of the TTL oscillator was connected to a divide-by-10 7490 IC and then to pin 1 of U1A in the AFSK circuit.

The output oscillator was connected to a divide-by-10 7490 IC and then to pin 1 of U1A in the AFSK circuit. I installed two miniature transistor

Don Peck, W3CRG


fig. 3. Simple TTL oscillator uses 7400 IC.

transformers at the output of U4B, using the two high-impedance windings connected in series, tuned to 2210 Hz. The output was then connected to the microphone input to my KWM2 through a 22k/100 ohm divider. The output wave-form is very satisfactory and on the air tests were excellent.

Jean Nugues, F8KI

vlf converter

An interesting article appeared in the November, 1974 issue of Ham Radio† describing a very-low-frequency converter with a tuned circuit using magnets and a toroid. The converter shown in fig. 4 uses a lowpass filter instead of the usual tuned circuit so that the only tuning required is with the receiver.

Jean Nugues, F8KI

fig. 4. Vlf converter using untuned input.

Despite its simplicity the converter has a measured threshold sensitivity of about 20 microvolts, which is ample for these frequencies. The dual-gate mosfet and fet used in the mixer and oscillator aren’t critical. Any crystal having a frequency compatible with the receiver tuning range may be used. For example, I use a 3500 kHz crystal; hence 3500 kHz on the receiver dial corresponds to zero kHz; 3600 to 100 kHz, 3700 to 200 kHz, etc. At 3500 kHz on the receiver all you can hear is the converter oscillator, and vlf signals start to come in about 20 kHz higher.

R. N. Coan, W3CPU

tube shields

Many older pieces of gear, such as my 75A4 receiver, use tube shields to isolate various stages. These shields can cause instability if they no longer make good contact with the tube socket.

While this is easily cured by cleaning and by deforming the shield slightly to insure a tight mechanical connection to the socket, a far better course is to replace the shields with one of the more modern tube shield designs.

The old style shields were ineffective at best in helping cool the tubes and often actually caused envelope temperature to rise in local areas, leading to reduced performance and shortened tube life.

The modern shields are easily identified — they are generally black on the outside and feature fluted spring-metal fingers of one sort or another on the

Jean Nugues, F8KI


The 280 series.  
No-nonsense, no-corrosion 10-80 meter mobile antennas from Hy-Gain.

Now from Hy-Gain, a new concept in tip-changing Ham antennas. The 280 series is designed with no-nonsense, one piece fiberglass masts and tough, one piece baked fiberglass coils. You get maximum power handling capability, minimum heat drift, and no loss to corrosion. Yet it's lighter than aluminum and just as strong.

All five coils are mandrel wound for absolutely consistent performance, imbedded in fiberglass, then baked to make them impervious to weather. Tough ABS end caps and solid brass coil fittings keep performance in, corrosion out.

Whips are 17-7 ph stainless, the finest antenna steel, and are literally indestructible in normal use.

Nominal 52 ohm impedance on all bands. Any coax length will work. Heavy duty, chrome plated mast and whip fittings. 3/8" x 24 base stud fits all standard mounts.

(A) 60" bumper mount mast Model 276  
(B) 36" cowl or deck mount mast Model 277  
(C) 10 meter coil/antenna Model 280  
(D) 15 meter coil/antenna Model 281  
(E) 20 meter coil/antenna Model 282  
(F) 40 meter coil/antenna Model 283  
(G) 75/80 meter coil/antenna Model 284  

Quick disconnect unit Model 531  
Fold over adaptor Model 409  
Standard stainless spring Model 492  
Heavy duty bumper mount Model 415  
Flush body mount Model 499  
Extra heavy duty stainless spring Model 511  

Hy-Gain Electronics Corporation; 8631 Northeast Highway Six; Lincoln, NE 68505; 402/464-9151; Telex 48-6424

Manufacturers and distributors of more than 300 fine broadcast communications products.
With Hy-Gain's 273 2-meter J-pole all you pay for is performance.

The 273 is a high performance, all driven, stacked dipole array, vertically polarized. It has everything you need for maximum efficiency 2-meter broadcast or repeater use. Everything but a mast.

Because many 2-meter arrays are mounted on existing structures, we've left out the mast and passed the savings on to you.

The 273 mounts easily on 1 1/4" to 2" conductive/non-conductive masts or tower legs for directional or omnidirectional use. Unique center fed phasing and matching harness for perfectly parallel phase relationship and low angle of radiation. Moisture, condensation and corrosion protected.

The entire antenna is at DC ground for static elimination and lightning protection. Perfect 50 ohm coaxial feedpoint. Heavy duty worm gear mounting clamps and high impact styron insulators included.

Power 1 KW P.E.P., 250 watts AM
VSWR at resonance 1.2:1
Impedance 50 ohms
Produces gain over 1/2 wave dipole

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MEASURE FREQUENCIES TO 50 MHz
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HIGH SENSITIVITY 50 mV RMS
INTERNAL CRYSTAL REFERENCE
POWER 12 V D.C.
SIZE 1¼" x 2½" x 4½" PLUS CONNECTORS

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500 MHz ÷ 10 PRESCALER MMd500P
EXTEND YOUR FREQUENCY METER TO 500 MHz MAX.
SENSITIVITY 200 mV RMS
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OUTPUT TTL COMPATIBLE
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SUMMER SPECIAL  
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10 Day Money Back Guarantee  

FEATURES
1. 24 Channel Operation  
2. One priority Channel  
3. Selectable 1 or 10 Watts Out  
4. 10.7 Monolithic Filter installed  
5. 455 KHz Ceramic Filter  
6. 3 Microvolt Sensitivity for 20 dB Quieting  
7. Numerical Read-out on each Channel  
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9. Front Panel "Tone Burst" Control  
10. Accepts Wilson 1402 & 1405SM Kits  
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12. Mosfet Front End  
13. Helical Resonator  
14. High VSWR Protection Circuit  
15. Reverse Polarity Protection Circuit  
16. NBFM - 15 KHz Channel Separation  
17. Built-in Speaker  
18. External Speaker Jack  
19. Dynamic Microphone included  
20. Mobile Mounting Bracket Included  
21. Quick Disconnect Power Cable  
22. Frequency Range 144-148 MHz  
23. 0.5% "BW x 2%" x 90°  
24. Weight: 5 lbs.  
25. Power Requirements:  
Source: 13.5 VDC ± 10%  
Receive: 45A  
Transmit: 2.6A (10W), 7A (1W)

SPECIAL INCLUDES:  
A. WILSON "WE-224"  
B. MOBILE MIKE  
C. MOUNTING BRACKET  
D. 146.52/52 SIMPLEX CRYSTALS

SUMMER SPECIAL on Wilson Hand Held 220 and 450

2202 SM  
FREQUENCY RANGE 220 - 225 MHz  

- 6 Channel Operation  
- Individual Trimmers on all TX/RX Crystals  
- All Crystals Plug In  
- 12 KHz Ceramic Filter  
- 10.7 and 455 KHz IF  
- 3 Microvolt Sensitivity for 20 dB Quieting  
- Weight: 1 lb. 14 oz. less Battery  
- Battery Indicator  
- Size: 7 1/2 x 1 1/2 x 3/4  
- Switchable 1 & 2.5 Watts Output  
- 12 VDC  
- Current Drain: RX 14 MA, TX 500 MA  
- Microswitch Mike Button  
- Unbreakable Lexan Case

USES SAME ACCESSORIES AS 1405  
SUMMER SPECIAL  
$239.95

INCLUDES  
1. 2202 SM  
2. Flex Antenna  
3. 223.50 Simplex Installed

4502 SM  
FREQUENCY RANGE 420 - 450 MHz  

- 6 Channel Operation  
- Individual Trimmers on all TX/RX Crystals  
- All Crystals Plug In  
- 12 KHz Ceramic Filter  
- 21.4 and 455 KHz IF  
- 3 Microvolt Sensitivity for 20 dB Quieting  
- Weight: 1 lb. 14 oz. less Battery  
- Battery Indicator  
- Size: 7 1/2 x 1 1/2 x 3/4  
- Switchable 1 & 1.8 Watts Output  
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BT1 EXTRA BATTERY  6.00
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LC2 LEATHER CASE  1402  11.95
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TP1 TOUCH-TONE PAD  49.95
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CRYSTALS  
- TX or RX  
(For your Frequency Only)  3.75

BC-1 BATTERY CHARGER

More Details? CHECK-OFF Page 118
Wilson Electronics Corp.

FACTORY DIRECT ONLY

SUMMER SPECIAL

FEATURES

1402 SM
- 6 Channel Operation
- Individual Trimmers on all TX/RX Crystals
- All Crystals Plug In
- 12 KHz Ceramic Filter
- 10.7 IF and 455 KC IF
- 0.3 Microvolt Sensitivity for 20 dB Quieting
- Weight: 1 lb. 14 oz. less Battery
- S-Meter/Battery Indicator
- Size: 8 7/8 x 1 7/8 x 2 7/8
- 2.5 Watts Minimum Output @ 12 VDC
- Current Drain RX 14 MA TX 500 MA
- Microswitch Mike Button
- High Impact Plastic Case

1405 SM
- 6 Channel Operation
- Individual Trimmers on all TX/RX Crystals
- All Crystals Plug In
- 12 KHz Ceramic Filter
- 10.7 and 455 KC IF
- 0.3 Microvolt Sensitivity for 20 dB Quieting
- Weight: 1 lb. 14 oz. less Battery
- Battery Indicator
- Size: 8 7/8 x 1 3/4 x 2 7/8
- Switchable 1 & 5 Watts Minimum Output @ 12 VDC
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TO MORE DETAILS? CHECK-OFF PAGE 118

July 1976 75
1976 ham radio sweepstakes winners

WAØQZW is the grand prize winner — eight others win either Atlas transceivers or Icom IC-230s

Ham Radio's seventh annual Sweepstakes was by far the biggest ever with nine very happy winners and a very tired staff, both here, and at our local Post Office.

Well over 30,000 entries were received this year, along with many questions about the new Signal/One CX-11, the Icom IC-230 and the Atlas 210X transceivers.

Certainly the greatest interest was focused on the grand prize of the new Signal/One transceiver. Just what is there in that magic box to make it cost $4000? When Don Roehrs, President of Signal/One, personally delivered this prize we were almost as eager as its winner to see what it was all about. We certainly were not disappointed, to say the least.

The CX-11 represents a complete redesign of the earlier models, from a new front-end design in the receiver to a brand new, solid-state final amplifier. Virtually every stage of this intricate radio is either completely new or extensively revised. When you look inside you find almost nothing that looks familiar. The painstaking care that was put into this package should really pay off in both performance and reliability.

We've talked with Randy Powell, WAØQZW, the winner of the Signal/One after he received it and he could hardly believe what an exciting and complete package he had won.

Next on the winners list were the four lucky recipients of the Icom IC-230 synthesized two-meter transceivers including Glen Galati, WBØAXK; Dave Mitchell, WA3CPC; Bob McCarthy, WA1UVX; and Helen Haynes, WBØHOX.

The IC-230 has really made quite a name for itself in the past couple of years. Using a phase-locked-loop synthesizer it covers all the standard 30-kHz repeater pairs and is easily adapted to the 15-kHz "split" channels.

Perhaps the most exciting part of this radio is its very sensitive receiver which includes a five-section helical resonator type front-end filter to insure an absolute minimum of intermod problems. When all of this is put into a package no larger than most crystal-type rigs you end up with one of the most popular 2-meter fm rigs on the market today.

The final group of winners received Atlas 210X transceivers. Included on this list were Chester Koziol, WA2BGS; Robert Trotter, K7VOG; Harry Newport, WØJDP; and Herb Frostell, K21B.

The versatile Atlas features 200 watts dc input to an all solid-state, broadband, no tune-up final. It operates on 80 through 10 meters and offers one of the best receivers available. Extremely small in size and running on 12 Vdc the Atlas is one of the best mobile rigs around today; with an ac supply it is easily adapted to home-station use.

This year's contest was certainly the most work yet (and the most fun yet) for all of us here at ham radio, and we certainly want to thank all of you who gave the time and effort to enter. We'll look for your entry next year when we draw the grand prize.

ham radio
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The "W-67 for 76" will carry you to new heights. A crank-up tower that you can rely on.
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Four sections.
No guys or house brackets needed.
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Included is a free rigid base mount. And the top plate is pre-drilled for a TB-2 thrust bearing.
Start the next 200 years right—start with a Tri-Ex W-67 for 76. Write today or see your nearest dealer.

More than 20 years of reliable service to amateur operators.
**Ham it up for $3.95.**

Amateur crystals 144.0-148.00 only for this trim price, plus 25c per crystal for handling and postage. Florida residents add 4% sales tax. Send frequencies, make and model when ordering. Our price includes most gear on our free Parts List. For equipment not listed, we'll provide prices on request and slice up something special. Master Charge and Bankamerica telephone orders accepted. No C.O.D.s.

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Please send me the booklet and Application Blank for the 1976 Glade Valley School Radio Session.

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MODEL 12751-5 KIT

Special Introductory Offer, $4995* (Reg. $599.95) Offer ends Oct. 31, 1976

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- Solid state reliability.
- Automatic timer can be set from 1 min. to 10 min.
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- Special code design circuitry assures correct and full ID. every time.
- Operates in automatic or manual modes.
- Ideal for base, mobile, or repeater operation.

**KIT INCLUDES:**
- Quality 5 x 7 printed circuit board, components, and 20 page instruction and assembly manual.
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All equipment listed is operational and unconditionally guaranteed. Money back if not satisfied—equipment being returned must be shipped prepaid. Include check or money order with order. Prices include UPS or motor freight charges.

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**BECKMAN 7570A Counter Freq conv** $10,100mHz
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**BOONTON 262B AM/FM sig gen** $54,216mHz
**DEI TDU 2.8mHz video display** $55
**GR546C Audio microvolter** $65
**GR61A Twin Tune bridge to 40mHz** $165
**GR1302A Audio Osc. 01-100kHz** $75
**HP160B (USM05) 15mHz scope w/ norm horiz, dual trace vert plugs** $375
**HP166B (M11) Delay sweep for above** $130
**HP185A Sampling Scope 1GHz 186B xtal rise plug** $335
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**HP571B 561B Digital clock/rdr** $245
**HP616 Sig Gen 1GHz-4GHz FM CW** $385
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**TEK 181 Time mark scope calib** $45
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For complete list of all test equipment send stamped, self addressed envelope.

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Unplated hardware. We use a nickel-chrome plating that defies corrosion.

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ULTRA LOW CURRENT CROS CIRCUIT
BUFFERED OUTPUT
* WORKS DIRECTLY WITH 50252, 5314, 5316, 5375 ETC.
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BULLET WAS THE FIRST ON THE MARKET WITH A 60HZ TIMEBASE FOR LESS THAN $10.00 (TB-02). THE TB-02 WAS A NER MODEL THAT HAD A SMALLER CRYSTAL, AND LOWER CURRENT DRAW. NOW WE ANNOUNCE THE TB-03, AVAILABLE IN 50 OR 60HZ OUTPUT MODELS. PLEASE SPECIFY OUTPUT FREQUENCY DESIRED.

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MOBILE CLOCK KIT
DRILLED AND PLATED BOARDS .01% LOW CURRENT TIMEBASE
ADJUSTABLE BRIGHTNESS
EVERYTHING YOU NEED BUT THE CASE
3 3/4" Wide (5/" FOR READING)
SPECIAL NOISE SUPPRESSION CIRCUITRY
FULL 24 HOUR ALARM CAPABILITY FOR CAMPER, TRUCKS AND VANS
SORRY: 12 HOUR FORMAT ONLY

THIS PRICE GOOD TILL JULY 31, 1976 ONLY

MOCKUP $17.76
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A single 5 pin IC chip that locks onto a VARIOUS telephones and produces the various tone pairs that will work on all brand name touchtone systems. Can be acoustically coupled.

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NEED TO KNOW REAL TIME AND ELAPSED TIME FROM ONE COMPACT INSTRUMENT? THIS KIT USES TWO MOS CLOCK CHIPS A SPECIAL SWITCHING CIRCUIT TO GIVE YOU 12 HOUR ONLY TIME AND A REGULATED ELAPSED TIME INDICATOR FOR CHECKPOINTS AND INSTRUMENT APPROACHES. THE TIMEBASE MAKES IT WORKABLE FROM 3 TO 15 VOLTS. THE WHOLE THING WILL MOUNT UP IN A STANDARD PANEL INSTRUMENT CASE. YOU WILL HAVE TO FURNISH THE SWITCHES AND CASE BUT WE GIVE YOU THE KIT REELED.

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PSB-04 LOWER CURRENT POWER SUPPLY KIT, GIVES YOU THE TRANSISTOR MOUNTING KIT, CURRENT LIMITING, SHORT PROOF SUPPLY THAT WILL HANDLE UP TO SAMS.
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COMPLETE INSTRUCTIONS
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ALL THE COMPONENTS YOU NEED TO BUILD IN THE MORNING THE TUBE MAKE: ALARM BUT THEN TAKE COMPLETE WITH PC BOARD

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JULY 31, 1976
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SUMMER SPECIALS

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For tuning from 30-42 MHz, add $25.00

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Power/Control cable for above unit $25.00

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Phone: (201) 469-9000

More Details? CHECK-OFF Page 118
A single tuned circuit intended for signal conversion in the 30 to 170 MHz range. Harmonics of the OX or OF-1 oscillator are used for injection in the 60 to 179 MHz range. 3 to 20 MHz, Lo Kit, Cat. No. 035105. 20 to 170 MHz, Hi Kit, Cat. No. 035106. Specify when ordering. $4.50 ea.

OX OSCILLATOR
Crystal controlled transistor type. 3 to 20 MHz, OX-Lo, Cat. No. 035100. 20 to 60 MHz, OX-Hi, Cat. No. 035101. Specify when ordering. $3.95 ea.

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THE SOLID STATE CIRCUITRY of our transceivers is based on designs by Les Ernshaw formerly ZL1AA, widely recognized as one of the foremost solid state radio engineers in the world, and founder of Southcom International located in Southern California. Southcom is one of the leading manufacturers of commercial and military radio equipment sold throughout the world. Atlas transceivers’ immunity to overload and cross modulation from strong signals is nothing short of fantastic, and is a result of the advanced state-of-the-art designs by Les, and licensed to Atlas by Southcom.

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Continental Specialties Corporation has developed three new test instruments to aid the professional engineer, student, or hobbyist in solving electronic design problems. Called Design Mates, these instruments are not kits but are completely wired, fully tested, and ready to use. They are available for immediate delivery from local distributors or from the manufacturer.

Design Mate 1 allows you to build any circuit using no. 22 AWG (0.6mm) solid hookup wire for connecting discrete components, including transistors and ICs in TO-5 or dual in-line packages from 8-40 pins or more. No solder is needed for connections because components fit into an appropriate socket and bus strips. Easy in, easy out for circuit testing. Also included is a regulated power supply (5-15 volts dc up to 600 mA). You can monitor supply voltage with a built-in voltmeter or use the meter to monitor voltage on the circuit under test. Design Mate 1, wired, tested, and ready to use sells for $49.95.

Design Mate 2 is a full function generator designed for troubleshooting and circuit-design testing. It features three waveforms and a short-proof output amplifier, which provides variable signal amplitudes and constant output impedance. It can be used to test audio amplifiers, operational amplifiers, and prototype circuit designs. It's versatile enough to handle complex industrial electronic design problems. Complete with instruction and operating manual, Design Mate 2 is priced at $64.95.

Third in Continental's new instrumentation series is Design Mate 3, a low-cost R/C bridge. Takes the guesswork out of deciphering component values with unreadable markings. You can measure component values to an accuracy of better than 5 per cent using only two controls and a unique solid-state null detector. Null-detector output is determined by two high-intensity LEDs. Design Mate 3 completely wired, tested, and calibrated, with technical data, is priced at $54.95.

Also available from Continental is a matching blank utility box. You can use it to house instruments of your own design whose appearance will match the Design Mate family. The utility box is the same size and shape as the Design Mate instruments. It's made of durable, high-impact, high-temperature plastic and is furnished with predrilled metal bottom plate and mounting hardware. The utility box sells for only $5.50.

For comprehensive specifications on the three Design Mate instruments, a 20-page illustrated catalog is yours for no charge. Write Continental Specialties Corporation, 44 Kendall Street, Box 1942, New Haven, Connecticut 06509, or Box 7809, San Francisco, California 94110, or use check-off on page 118.

125 Hz crystal filter for Drake R-4C

Sherwood Engineering has recently announced the availability of a crystal filter, 125 Hz wide at the 6 dB points, designed specifically for the Drake R-4C communications receiver. The new filter is completely compatible with the standard accessory filters offered by the R.L. Drake Company, and is being marketed as an adjunct to those with more standard bandwidths.

The new 8-pole crystal filter, the Sherwood model CF-125/B, has a 2.5 shape factor at the 6 and 60 dB points (bandwidth of about 325 Hz at -60dB), and exhibits less than 1 dB passband ripple. The input and output impedances are 50 ohms. Ultimate attenuation is greater than 100 dB. The 11 dB insertion loss of the CF-125/B is similar to that of the Drake accessory filters.

For the CW operator who is looking for maximum selectivity, particularly during CW contests, this filter offers a significant improvement in receiving capabilities under adverse operating conditions. Due to careful design, the crystal filter does not display excessive ringing, even with strong signals. One well-known 160-meter operator, who used a CF-125/B filter during a recent 160-meter CW contest, reported excellent results and concluded that it was one of the finest CW filters ever offered to the amateur community.

The new CF-125/B carries a full money-back guarantee if you're not satisfied, and is priced at $125 from Sherwood Engineering, 1268 South Ogden Street, Denver, Colorado 80210.

Morse-code reader

The Atronics code reader is a compact, solid-state instrument that decodes Morse directly from your speaker and displays the resultant message in alphanumeric form on the front panel. A choice of readout size is available. The model CR-101 characters are 0.65 inch high by 0.42 inch wide (16.5 by 10.7 mm); model CR-101A characters are 0.2 inch high by 0.15 inch wide (5 by 3.8mm).

All characters, including punctuation, are displayed one at a time. Code speed, on-off, and audio level are set by front-panel controls. The speed control, with settings between 0-10, is used as an indicator only. For any setting, code speeds between 70-140 percent of that setting can be decoded. For example, if the code reader is set for 14 wpm, it will display any code speed between 10-20 wpm.

A light-emitting diode above the speed control indicates the expected length of a received dot. Another light-emitting diode above the level control indicates mark (on) and space (off). The only connection required is a line between a phone jack on the code reader rear apron and your receiver speaker.
terminals. Input impedance of the code reader is 1000 ohms.

A radio teletype interface module (model TU-102) is available as an optional accessory. The TU-102 accepts 5-level code (start, five data bits, two stop bits). Teletype speed can be selected for 60, 75, or 100 wpm. Auto features CR, LF, FIG and letters are provided automatically.

The model CR-101 and CR-101A are priced at $225 and $195 respectively; the model TU-102 RTTY interface module is $85.00 (a $10.00 installation charge is made if the TU-102 is purchased separately). For more information write Atronics, P.O. Box 77, Escondido, California 92025, or use check-off on page 118.

hand-held scanning monitor

A hand-held scanner is a real convenience when you're walking around and want to keep on top of the action on the vhf and uhf bands. The Electra Company announces an addition to its product line called the Bearcat Hand-Held Scanners. Two models are available, a two-band version covering the low- and high-vhf bands, and a single-band version that covers uhf. Both models feature four-channel operation including LED channel indicators and individual channel lockout switches. Also included are an auto-manual selector switch and a volume and squelch control.

The Bearcats come equipped with a telescoping antenna, but provision for an optional loaded (rubberized) flexible short stub antenna has been included.

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HAL Communications Corp.
Box 365, 807 E. Green Street, Urbana, Illinois 61801
Telephone (217) 367-7373

Weight is only 11 ounces (312g); size is 6¼ x 1½ x 2½ inches (16x4x7cm). Four AA type dry cells are used for power. Sensitivity on vhf is 0.6 microvolt; on uhf, it's 1.2 microvolts. Audio output is 250 milliwatts. Scan rate is eight channels per second. Convenience features include a built-in belt clip and jacks for optional external antenna, earphone, battery charger, and ac adapter. Both Bearcat models are priced at $129.95 (crystals not included). For more information, write The Electra Company, 300 South on East County Line Road, Cumberland, Indiana 46229, or use check-off on page 118.

automatic voice identifier

Newly introduced by Racom, Incorporated, is the Series 1500 voice identifier. Featuring high-reliability, all-solid-state circuitry, the Series 1500 uses the patented Racom disc principle (no tape loops) in conjunction with an electric timer that can be programmed in the field. No relays are used, although an option is available for those who might desire a "dry closure."

The Series 1500 can be field programmed to identify after each programmed time period, identify once after the last transmission, or identify after each transmission. Dual transmissions are prevented by a built-in channel monitor that can sense either audio or dc voltages. Operational status can be checked by illuminated indicators on the front panel. You can record any message, such as your dispatcher's voice. An erase interlock circuit ensures against accidental erasure of the recorded message. The Series 1500 automatic voice identifier can be mounted in a rack or on your desk.

Delivery from Racom is 4-6 weeks after receipt of order. For more information write Racom, Incorporated, 5504 State Road, Cleveland, Ohio 44134, or use check-off on page 118.
There is an awkward range of hole sizes for electronic sheet metal and PC board material for which a series of miniature hole saws work very well. The Blair Equipment Company offers a set of seven hole saws in steps from one-quarter to five-eighths inch (6.5 - 16mm) with an interchangeable common arbor that obviates any need for drilling a pilot hole first. The arbor has a spring-loaded pilot which recesses into the arbor as the hole saw blade approaches the work, so you don't need a pilot hole for the arbor pilot to pass through. The blades, which are precision made, cut clean continuous chips through metals, shim stock, wood plastics, rubber, cardboard and other materials, leaving almost burrless holes. Each high-speed cutter is good for over 3000 holes in sheet steel and may be used with any ¼-inch (6.5mm) electric drill. The arbor has a high-speed steel automatic center point to avoid the need to center punch. A depth rod adjusts depth of cut up to 3/16 inch (5mm).

Blair specializes in automobile body equipment and markets these saws through stores catering to the auto body repair trade, but they are also available from Brookstone Company, Peterborough, New Hampshire 03458 for $20.95.

IC op amp cookbook

This new book by Walter Jung not only explains the basic theory of the IC op amp in a down-to-earth and easy to read manner, it also shows by example how to effectively use op amps in useful circuit applications. Fully illustrated, this practical book is bound to appeal not just to amateurs, but to anyone who has an interest in modern, linear design techniques - including amateurs, technical and engineering students, and practicing technicians and engineers.
The book is organized into three parts: Part I introduces the IC op amp and discusses general considerations, Part II covers practical circuit applications, and Part III consists of two appendixes of manufacturers' reference material.

Chapter 1 covers basic theory, which includes the ideal and nonideal op amp, with detailed analysis of error sources and dynamic characteristics. Chapter 2 describes early IC innovations, and discusses in detail the circuitry of such popular general-purpose types as the 709, 101, and 741.

Specialized units are also introduced and their general uses discussed. Chapter 3 covers general operating procedures, such as nulling, frequency compensation, and protection against abuses and failures.

The remaining 5 chapters of the book discuss the application of op amps in such circuits as voltage and current regulators, precision rectifiers, limiters, comparators, logarithmic amplifiers, instrumentation amplifiers, analog multipliers, low-level preamps, active filters and equalization circuits, power booster stages, sine-wave oscillators, multi-vibrators, function generators, and voltage-controlled oscillators.

Unique IC op amps are also treated, such as programmable op amps, operational transconductance amplifiers, and quad current-differencing amplifiers.

This book is quite a departure from previous works of its subject and style. In terms of depth and content on applications of IC op amps, it is a virtual tour-de-force; 591 pages with over 250 circuit diagrams to pick from. And, unlike too many other applications handbooks, the circuits are clearly annotated, with the governing design equations given as well as the particular component values. Throughout the book emphasis is given to selecting the optimum IC for the job.

The book is not a textbook, nor is it a cookbook in the true sense of the word. It is really a "how to" cookbook that reaches the real-world level and approaches design problems as they actually occur. For this reason it is probably the single most valuable book available on IC op amps. If you now use op amps, or would like to, you'll find this book worthwhile. $12.95 from Ham Radio Books, Greenville, New Hampshire 03048.
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FLEA MARKET

RECONDITIONED TEST EQUIPMENT for sale. Catalog $3.40. Wafer, 2629 Nickel, San Pablo, CA. NABIL


AMATEUR CALL SIGN PINS $1.00 each, "2", "3", or "4"; or 2 lines engraved. Blue, black, red, green. Guaranteed. Holly, Box 3926-S, Hollywood, Florida 33024.

KLW PRODUCTS, Larsen ants, icom, police, and fire scanners. Send for prices. Not given over phone. Narwiz Electronics, 61 Bellot Road, Ringwood, N. J. 07456.

WANTED small prop pitch motor. Will pay cash or trade large prop pitch motor. Call collect to Al Hart, 313-585-0600.


ETCHED CIRCUITS glass epoxy, drilled and plated. Printed circuit board. 40500A, Ready Circuits, P. O. Box 34, Pinesdale, Montana 59859.


COMPUTER Hobbies! - Bargain hunt and sell via ON LINE. 18 issues/year - $3.75. Free sample issue from: ON LINE, 24657 Santa Cruz Hwy., Los Gatos, CA 95030.

MANUFACTURERS, DISTRIBUTORS, DEALERS! The Memphis Hamfest had 3,500 registrations last year. When have we expected this year? Saturday and Sunday, October 2 & 3, at State Technical Institute, 420 MacArthur Road. Security, motels, restaurants — a great location for a great event! Contact Harry Simpson W4WSP, Box 27015, Memphis, TN 38127. Telephone 901 350-5707.

OMTRAC, U43MHT, 40 watts, 4 frequencies, with GBL synthesizer, 5kHz split, illuminated display, touch-tone, shock mounting, all accessories & manuals. Like new in excellent condition. For $420 or best offer. Bob Graft, WB8OYQ, 218 Rebecca Lane, Normal, Ill. 61761. (309) 452-0232.

CANADIAN JUMBO SURPLUS and Parts Catalogs, Brochures, Books, ETCO-HR, Box 741, Montreal "A" H3C 2V2.

FREQUENCY COUNTER BOOKS, Jan. 76 HR, double sided glass epoxy includes 500 MHz synthesizer, circuitry, 41 LED board, instructions, and parts source listing $15.00 complete. Popular Electronic Keyer Board $20.00. CSI Electronic, 5201 Cameron Court, Lincoln, NE 68507.

PORTA-PAK the accessory that makes your mobile really portable. Just plug into your radio. In stock: P. O. Box 477, Somers, Wisc. 53178.

AUDIO-LD TIMER KIT. P.C. board, instructions, less batt. case, $16.50 ppd. J. Isenagle, Box 635, Port Huron, Mich. 48061.

RTTY TERMINAL UNIT: P.LL decoder, AFSK generator, built-in cabinet, wired and tested, $165.00. Save, separate boards & kits available. Com Tech Electronics, P.O. Box 73, Rensselaer, N. Y. 12144.


WANTED: Old radio book on transcription discs, any size, any speed. Also wire recordings. Billy Sheldon, 1107 Coburn Drive, Chattanooga, Tenn. 37415.

TSS20, NEVER USED with CW filter and external VFO, AC only, $65. Heath SB300/400 complete. Jim, W9QY, 1500 Independence St., Alton, Illinois 62002.

TRAVEL-PAK QSL KIT — Send call and 25c; receive 2 QSL cards, return. Samco, Box 203, Wynnystalk, N. Y. 12198.

DIRECT CONVERSION RECEIVER KITS for AM or SW, write W8OYM, 1305 North Bell Avenue, Chicago, Illinois 60614.

FREE Electronics Surplus Catalog. Electronic Specialties, 1659 Wemore, Tucson, AZ 85705.

TOUCH TONE PADS, used A.E., $5.00 each. Sam Cowan, W2OAJ, Box 118, Elmwood, NE 68026.

NEW CANADIAN MAGAZINE, "Electronics Work Shop", 5th yearly, sample $1.00. ETCOB, Box 741, Montreal, H3C 2V2.

The World's Greatest Sending Device

Now available from Palomar Engineers - the new Electronic IC KEYER. Highly prized by professional operators because it is EASY, precise, and MORE ACCURATE.

It transmits with amazing ease CLEAR, CLEAN-CUT signals at any desired speed. Saves the arm. Prevents cramps, and enables anyone to send with the skill of an expert.

SPESIAL RADO MODEL

Equipped with large specially constructed contact points. Keys any amateur transmitter with ease. Sends Manual, Semi-Automatic, Full Automatic, Dot Memory, Squeeze, and Lamic - MORE FEATURES than any other key. Has built-in sidetone, speaker, and volume controls, BATTERY OPERATED, heavy shielded die-cast metal case. FULLY ADJUSTABLE contact spacing and padding. The perfect paddle touch will AMAZE you.

Every amateur and licensed operator should know how to send with the IC KEYER, EASY TO LEARN. Send anywhere on receipt of price. Free brochure sent on request.

Send cash or money order: IC KEYER $87.50 postpaid in U.S. and Canada. IC KEYER LESS PADDLE $67.50. Add 6% sales tax in California.

Italy write iVT, P.O. Box 37, 24203 Canto, Elsewhere send $92.00 (U.S.) for IC KEYER or $72.00 (U.S.) for IC KEYER LESS PADDLE for air parcel post delivery worldwide.

Fully guaranteed by the world's oldest manufacturer of electronic keys. ORDER YOURS NOW!
**flea market**


WANTED: Heath HW-100 with AC supply and a 3 to 10 element meter beam in good condition. WAC3R0, George Peck, P. O. Box 243, Caldwell, N. J. 07002.

FOR SALE: Genave GTX-2007, factory tone pad, 4 channels, mint cond, $240. Heatkit SB-102. A1 shape, make offer. WA2NZQ, Curtis R. Olson, P. O. Box 215, Regent, N. Dak. 58650.

MANUALS for most ham gear made 1940/65, some earlier. Send SASE for specific quote. Peter Ma- cham Associates, 19 Loretta Road, Waltham, Mass. 02154.


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

VHF TRANSCEIVERS FOR SALE. Knight TR106 six meters, TR108 two meters $76, W6TYX, 614-268-7797.

SIDESWIPER only $13. Airmailed USA. Kungs import, Box 257, Kungsbacka, Sweden.

ALTAIR 880 OWNERS, add output with LED displays at few dollars. For complete, easy-to-build plans, checkout program; and demonstration. computer game program: forward $5.00. (Standard continental U.S.) To Computer Industry, Inc., 1600 Penwood Drive, Hampton, Va. 23666. Satisfaction Guaranteed.

MOTOROLA HT220, HT200, Pageboy, and other popular 2FM transceivers (Standard, Regency, etc.) service and modifications performed at reasonable rates. WA4FRV, (804) 272-8403.

DEFLECTION YOKES - For 1" Vidicon with transformerless deflectors. New precision yokes, $10.00 each while they last. Add 50c postage. P.O. Box 323. Bloomington, Ill. 61701.

SILVER MICAS, one percent, short leads, pulls down to $1.00. Send SASE for list. WPLWO, Box 127, Waterfall, N. Y. 13165.

AIRCOPLIES for Gov't surplus gear, $6.50 each. P. W. 120 Bestwood Rd., Cali. 93036.


FERRITE beads 30,000 Mhs $2.00 Doz. Wider bandwidth 300,000 MHS $10.00. Specify core size and mix. Pack and ship 50c USA & Canada. Air parcel post delivery world wide 15% to 20% percent tax in Calif. Send for free brochure.

**THE TIGER**

15% Savings on Gas

A Capacitive Discharge Ignition system absolutely guaranteed NOT to interfere with your radios & equally guaranteed to improve your auto's operation & gas mileage.

No reiring necessary. Engine cannot be damaged by improper installation. Either of three models fits any vehicle or stationary engine with 12 volt negative ground, alternator or generator system. Uses standard coil & distributor now on your engine. Dual switch permits motor work or tune-up with any standard test equipment.

Write for free booklet that not only is the BEST description of CDIs, but also explains the need for such a system. Current prices assured till July 1st.

D-D ENTERPRISES
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San Francisco, Calif. 94119
KENWOOD GIVES YOU A CHOICE FOR 2-METER SSB

KENWOOD'S TV-502 TRANSVERTER PUTS YOUR TS-520 OR TS-820 ON THE 2-METER BAND...SSB AND CW. SIMPLY PLUG IT IN AND YOU'RE ON THE AIR

OR GO ALL THE WAY WITH THE BEST...THE TS-700A

Ever tried 2 meter SSB or CW? How about the OSCAR satellite? Tune the band with a VFO instead of fixed channel crystals and experience DX-ing on VHF. In fact, there's a VHF QSO party coming up on September 4 and 5. FMers improve your scores...beginners try it for the first time. You don't need a big antenna to do it either...anything from a coat hanger to -- -- ? The OSCAR satellites (6 & 7) are waiting for you too! Or go exotic with meteor scatter or tropospheric ducting. The "Sky is the limit" on VHF SSB and CW.

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116 EAST ALONDRA/GARDENA, CA 90248

KENWOOD...pacesetter in amateur radio
flea market

YAESU FT-101 OWNERS. Add Fast-Slow-No AGC easily. For complete details send dollar (creditable towards dues) to JS. April News Letter, International Fox-Tango Club, 448 Lake Dora Drive, W. Palm Beach, FL 33411.

PC's, send large S.A.S.E. for list. Semtronics, 2602 N. High St., Columbus, Ohio 43209.

YAESU OWNERS — Send a dollar (creditable towards dues) for June issue of widely acclaimed FT Newsletter. International Fox-Tango Club, 448 Lake Dora Drive, W. Palm Beach, FL 33411.

FIGHT TVI with the RSO Low Pass Filter. For brochure write: Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada M1S 3B4.

RTTY — NS-1A PLL TU (RTTY Journal 1/76) FSK/AFSK. Wired/tested $29.95 ppd. Boards, parts kits available. Send check in full to Stinette Electronics, Tavares, Fl. 32778.

FREE flyer of unusual surplus equipment and components: military RF, semiconductors, coils, capacitors, etc. Free gift with order. Gold Electronics Company, Dept. H, Box 1814, Rochester, N.Y. 14602.

NAMEBADGES $1.25, name and call sign $1.75. Engraved plastic with pin or clips. Black, white, red, blue, green, woodgrain. Include payment with order. Club emblem and hamfest badges. SASE for catalog. Donan's Engraving, P. O. Box 73155, Lakewood, Ohio 44107.

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VARIABLE CONDENSORS, Johnson 154-3, 19-488Pr. 2 KV, used, excellent condition, $12 each or $30, postpaid. Box 297, Sabana Seca, P. R. 00749.

ADD A TOUCH OF CLASS. Mod-U-Line cabinets, ST-5-Style MCM 17-12 gray $27.97. 500 styles available. Many other electronic parts stocked. Stamp brings info. NuData Electronics, 104 N. Emerson St., Mt. Prospect, IL 60056.

TELETEXT EQUIPMENT FOR SALE for beginn- ers and experienced operators. RTTY machines, parts, supplies. Special beginners' package consists of Model 15 page printer and F5-3 decoder $125.00. Atlantic Surplus Sales, 3730 Nauvoo Ave., Brooklyn, N. Y. 11224. Tel: (212) 372-0349.

TELETEXT MACHINES, Model 33, $550.00. Model 35, $650.00. Perfect condition including models for computer share time. Tony, K9HJU, 312-349-9002, after 5 p.m.

TELETEXWTR PARTS, gears, manuals, supplies, tape, toroids. SASE list. Teletronics, Box 8873, Ft. Lauderdale, Fl. 33310. Buy parts, late models.


VHF EQUIPMENT, Clegg Venus and power supply, 6 meter SSB transceiver, $140. Interceptor 6 and 2 meter receiver, $120. Tom Hamilton, 392 W. Lincoln, Birmingham, Mi. 48013.


QLS'S — BROWNIE W3CJ — 3035B Leigh, Allentown, Pa. 18103. Samples with cut- alover $50. 500 MHz PRESCALER divide by 10 or 100, input N 5000, minimum $90 o. Plans & parts list $5.00. CBS Enterprises, P. 0. Box 1356, Cocoa Beach, Florida 32931.

BUY — SELL — TRADE. Write for free mailer. Give name, call letters, complete stock of major brands, new and reconditioned equipment. Call or write for deals. We buy Collins, Drake, Swan, etc. SSB & FM, Associated Radio, 8012 Conner, Overland Park, Ks. 66204, 913-381-5931.

ALDELCO SEMI CONDUCTOR SUPERMARKET

RF DEVICES
2K3117J 4W 400 MHz $5.95 2K3117K 4W 400 MHz $7.95
2K3123 4W 400 MHz 1 $5.95 2K3123 4W 400 MHz $7.95
2K3851 4W 400 MHz 1 $7.95 2K3851 4W 400 MHz $9.95
2K3857 4W 400 MHz 1 $9.95 2K3857 4W 400 MHz $11.95
2K3941 4W 400 MHz 1 $12.95 2K3941 4W 400 MHz $14.95
2K3947 4W 400 MHz 1 $15.95 2K3947 4W 400 MHz $17.95

2K3951 4W 400 MHz 1 $18.95 2K3951 4W 400 MHz $20.95
2K3955 4W 400 MHz 1 $21.95 2K3955 4W 400 MHz $23.95
2K3961 4W 400 MHz 1 $24.95 2K3961 4W 400 MHz $27.95
2K3967 4W 400 MHz 1 $28.95 2K3967 4W 400 MHz $30.95
2K3977 4W 400 MHz 1 $32.95 2K3977 4W 400 MHz $34.95

WEIGHT DUTY RECEIVERS
200 Volt 100 Amp D08 $5.50
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100 Volt 2 Amp Silicon Rectifier RCA $19.95
100 Volt 2 Amp Silicon Rectifier Opa $19.95
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ZEIERS 1K7404 to 1N7594 400 Mea cs. to 1N7428 to 1N74541 with... $1.95 100 assorted zener diodes unmarked...

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STUD RECTIFIERS
2 AMP EPOXY BRIDGE RECT.
50 Volt 40 Amp $1.95 100 Volt 40 Amp $3.95
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400 Volt 40 Amp $5.95

MONEY BACK GUARANTEE

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50 Volt 40 Amp $1.95 100 Volt 40 Amp $3.95
100 Volt 40 Amp $3.95 400 Volt 40 Amp $5.95
400 Volt 40 Amp $5.95

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50 Volt 40 Amp $1.95 100 Volt 40 Amp $3.95
100 Volt 40 Amp $3.95 400 Volt 40 Amp $5.95
400 Volt 40 Amp $5.95
Build a 2 meter or 220 MHz Transceiver.
10 Channel Scanning . . . 15 Watt

You can put it all together for only $219.95

PA144/15 - 15 Watt Power Amplifier

TX 144B or TX220B Transmitter Kit

A one watt exciter using four RF transistors, two diodes, and one integrated circuit. The RF transistors are operating well below their ratings allowing long keying periods without damage. Nominal output 1/2 watts. Deviation adjusted to 10kHz. IC audio with clipping and active filter. All spurious outputs down 30db or more. Temperature compensation crystal trimmer. Zener regulated oscillator. Uses readily available 12 or 18 MHz crystals (18 MHz for 220). All tuning coils prewound. Designed to provide multi-channel operation for the TX-series transmitters. It features an extra set of contacts that may be wired to the CD-1 crystal deck for 10 channel transceiver. The extra contacts may also be used to switch L.E.D. indicators. The switch has 11 positions.

CD-2 Crystal Deck

Complete with cabinet, speaker, hardware, L.E.D.'s, all accessories and full assembly instructions.
(Crystals and microphone not included.)

<table>
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<tr>
<th>Item</th>
<th>Price Each</th>
<th>Quantity</th>
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<tr>
<td>Transceiver TRX 144 Kit</td>
<td>$219.95</td>
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<tr>
<td>Transceiver TRX 220 Kit</td>
<td>$219.95</td>
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Shipping Information:
All shipments are F.O.B. Binghamton, N.Y. 13902. Shipments will be made by the most convenient method. Please include sufficient funds to cover shipping and handling. Figure shipping charges on a weight of 6 pounds. Allow 3 to 4 weeks for delivery.

Terms: C.O.D., cash or check with order. We also accept BankAmericard and Master Charge.

Claims: Notify VHF and the carrier of damage within seven (7) days of receipt of shipment.

Returns: Obtain authorization from VHF before returning any merchandise.

Prices and Specifications: Subject to change without notice. Export prices are slightly higher.

Order Form

Name ____________________________  Total: ____________________________
Address __________________________
Shipping __________________________
City ____________________________  NYS Resident ____________  Sales Tax: ____________
State ____________________________  Total: ____________________________
Zip: ____________________________  Enclosed: ____________
Master Charge or BankAmericard No: ____________________________
Bank No: ____________________________  Expiration Date: ____________________________

More Details? CHECK-OFF Page 118

The World's Most Complete Line
OF VHF - FM KITS AND EQUIPMENT

Vhf Engineering
Division of Brownian Electronics Corp.
320 Water St. P.O. Box 1921
Binghamton, N.Y. 13902  607-723-9574

July 1976
PC BOARD negatives made photographically from your magazine's artwork. Now obtain professional results quickly, simply. $4 x 5, $3.00 or $5.00 for 10 or more, Emer, WWII, 1004 1/2, Apache Road, Richmond, Virginia 23235, 804-722-8460.

NEED HELP holding your PC board while you solder your components? My fixture will sit on your kitchen table and adjust to fit PC boards up to 6½" wide (length unlimited). Order now. Only $4.50 for 12 vs. 80 cents (made resident add 25¢). W. N. Wellman Co., Box 7222A, 451 Saline Rd., Southfield, Mi. 48075.

EXCLUSIVELY HAM-TELETYPE! 21st year. RTTY Journal, articles, news, DX, VHF, classified ads. Sample 35¢. $3.50 per year. Box 8279, Royal Oak, Mich. 48073.

OSCAR 7, SSB-CW TRANSIT CONVERTERS. For 28 or 50 MHz input at 20 mw, 432 MHz output at 1 watt. Stocking for immediate delivery. For 28 or 50 MHz input at 20 mw. 432 MHz output at 1 watt. Stocking for immediate delivery. (Minimum order $4.00). W. N. Wellman Co., Box 7222A, 451 Saline Rd., Southfield, Mi. 48075.

Coming Events


MISSOURI: Antique Aircraft and Amateur Radio Show, July 24 and 25, 1976. Slater Memorial Airport. Registration $1.00 in advance: $1.50 at the door. Buffalo burger feed Saturday night and Sunday noon. Talk-in 3963 kHz, 146.94 and 146.88. Information, advance tickets, Dale Berlins, WC8NF, 117 North Broadway, Slater, Missouri 65549, (816) 529-2173.

MEMPHIS IS BEAUTIFUL IN OCTOBER! The Memphis Hamfest, bigger and better than the 3,500 who attended last year, will be held at State Technical Institute, Interstate 40 at Macon Road, on Saturday and Sunday, October 2 and 3. Demonstrations, displays, MARS meetings, fleamarket, ladies’ fleamarket, tool and hardware show, informal entertainment. Many outstanding prizes. Dealers and distributors welcome. INSIDE CONTACT: Harry Simpson, W6SCF, Box 27015, Memphis, TN 38127. Phone 901-358-5707.

AMERICAN-TASMANIAN CONTEST to celebrate the bicentennial year of Australia. The call areas in all U.S. states and provinces, plus many foreign areas in the country's four public service frequency bands! Complete information, contest rules, and entry blanks will be available. 1st. Closed August 20. 2nd. Closed September 15. 3rd. Closed October 30. 4th. Closed November 30. 5th. Closed December 30. Contact Manager, P.O. Box 1010, Launceston Tasmania 7250, Australia.


HELP WANTED

CREATIVE YOUNG MAN TO WORK IN DESIGN OF TWO-WAY RADIO ANTENNAS. MUST HAVE KNOWLEDGE OF HAM ANTENNAS, BE WELL ACQUAINTED WITH INFORMATION IN ARRL ANTENNA HANDBOOK, AND BE EQUIPPED WITH MACHINE SHOP PRACTICE, COMPANY IN CHICAGO SUBURBS. WRITE OR CALL HERB BLEASE, 304 Stewart Avenue, Addison, Illinois 60101, (312) 543-9350.

BARRY ELECTRONICS

HAM HEADQUARTERS


Barry Electronics
512 BROADWAY, NY, NY 10012
212-925-7000

Flea Market

This Month's Specials

NEW

Fairchild VHF Prescaler Chips

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<td>1100FC</td>
<td>High Speed Dual 5-4 Input</td>
<td>$15.40</td>
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<tr>
<td>1105FC</td>
<td>1 GHz Counter Divide By 4</td>
<td>$27.40</td>
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<td>1105G</td>
<td>1 GHz Counter Divide By 4</td>
<td>$110.50</td>
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<tr>
<td>1106C</td>
<td>UHF Prescaler 750 MHz D Type</td>
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<td>1114DC</td>
<td>Dual TTL VCM</td>
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<td>1144DC</td>
<td>Dual Front Detector</td>
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<td>1158C</td>
<td>ECL VCM</td>
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<td>1170DC</td>
<td>600 MHz Flip/Flop With Reset</td>
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<tr>
<td>1183DC</td>
<td>1 GHz 248/256 Prescaler</td>
<td>$29.90</td>
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Radio Components

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Tubes

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<td>6672</td>
<td>6.95 6191</td>
<td>$1.95</td>
</tr>
<tr>
<td>5842</td>
<td>3.25 7299/6F39A/10/1250</td>
<td>$4.25</td>
</tr>
</tbody>
</table>

Just Arrived!

This month's selection of new and replacement parts.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collins KWM Transmitter, Mini, extra set of tube plus manual</td>
<td>$499.95</td>
<td></td>
</tr>
</tbody>
</table>

MHz electronics

2543 N. 32ND STREET
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We have all types of test equipment.

More Details? CHECK—OFF Page 118
Tops on both ends in 220-MHz service

Not only is Midland’s Model 13-509 one of the most popular “220” mobiles around, it’s the basis of more repeater stations around the country than any other chassis. The reasons are easy to spot: It’s rugged. It’s reliable. It’s easy to work, and work with. As it comes, Midland’s “220” mobile delivers full 10-watt RF output, switches to 1-watt, and uses an ADL circuit preset at 5 KHz, but adjustable 3 to 16 KHz. The receiver section has a complete multiple FET front end coupled with a high Q resonator filter and ceramic filters in both IF stages. There’s an instantaneous final protection circuit monitoring VSWR and accessory connector for tone burst or discriminator meter.

CHECK THE SPECS:

- Frequency Coverage: 220-225 MHz
- Circuitry: 30 transistors, 2 FETS, one IC, 12 diodes
- Modulation Type: F3
- Power Source: 13.8 VDC, negative ground
- Current Drain: Transmit high, 3.1 amps, receive 220 MA
- Antenna Input: 52 ohms
- Size: 2 1/2” h. x 6 3/4” w. x 8 1/2” d.
- Weight: 4 lbs.
- RF output Power: 10.0 watts/1.0 watts
- Frequency Deviation: Adjustable 3-15 KHz
- Audio Input: 10K ohms
- Modulation System: Variable reactance circuitry
- Modulation Type: FM, FM/UHF, AM
- Frequency Stability: ±10 PPM at -10°C
- Receiver Type: Dual conversion superheterodyne with FETS, cavity resonator filter, ceramic filter
- I.F. Frequencies: 1st. 10.7 MHz; 2nd. 455 KHz
- Sensitive: Nominal 0.5 uW for 20 dB
- Spurious Response: -60 dB
- Audio Output: 2.0 watts at 10% distortion, 4.0 watts maximum
- Audio Impedance: 8 ohms
- Hum and Noise Ratio: -60 dB

Try Midland 2-Meter too

15-Watt/1-Watt Output Power • 12 Channel Capability

Complete multiple FET front end with high Q resonator filter, ceramic filters in both IF stages, ADL circuit. Individual frequency trimmers for each crystal position. Connector for tone burst and discriminator meter.

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With crystals for 223.5 simplex, microphone, mounting bracket

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312-848-6778
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July 1976
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Make this comparison:

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THEN
Check these features:

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Appearance: slim silhouette all black metal
Serviceable: easy access to separate receive and transmit circuit boards
PLUS: 6 pole xtal filter for superlative receiver operation
and:
trimmers on receive and transmit xtais: standard 10.7 MHz 1st IF.

and specs:
Rec. Sens.: .2uV for 12 db
SINAD ...
Adjacent channel rejection: ±30 kHz 55 db ...
Spur. Resp.: more than 65 db ...
Audio Output: 500 mw ...
Power output: Hi 3 w, Lo 1 w ...
Audio Quality: Distortion free, crisp, clear receive and transmit.

NOW
Look at the Price:

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
<th>Battery</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTX-1</td>
<td>$249.95</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>GTX-1T</td>
<td>$299.95</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

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More Details? CHECK-OFF Page 118

july 1976 103
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- 1KW Rating

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- Plug-in Prescaler

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Factory assembled units are tested and calibrated to specifications.

SPECIFICATIONS

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>BASIC</th>
<th>WITH PRESCALER</th>
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<tr>
<td>50 MHz</td>
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</tr>
<tr>
<td>10 MHz</td>
<td>2.5 Mhz</td>
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</tr>
<tr>
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<td>25 MHz</td>
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<td>0.000001 Hz</td>
<td>2.5 Hz</td>
<td></td>
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</tbody>
</table>

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---

<table>
<thead>
<tr>
<th>FREQUENCY (MHz)</th>
<th>MODEL</th>
<th>POWER INP. (watts)</th>
<th>NOM. PWR. OUTPUT (watts)</th>
<th>NOM. CUR. (amps)</th>
<th>SIZE</th>
<th>PRICE</th>
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<td>144-148</td>
<td>PA1-212B</td>
<td>1</td>
<td>4</td>
<td>12</td>
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<td>60</td>
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<td>C*</td>
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<td>PA30-120BC</td>
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<td>120</td>
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<td>400-470</td>
<td>PA2-40C</td>
<td>1</td>
<td>4</td>
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<tr>
<td></td>
<td>PA10-35C</td>
<td>5</td>
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<td>35</td>
<td>6</td>
<td>B*</td>
</tr>
<tr>
<td></td>
<td>PA10-35CL</td>
<td>5</td>
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<td>B*</td>
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<tr>
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<td>PA10-70C</td>
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<td>70</td>
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<td>15</td>
<td>70</td>
<td>18</td>
<td>D*</td>
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</table>

Sizes: Inches: A. 2.25 x 5 x 2. B. 6.5 x 5 x 2. C. 6.5 x 7.5 x 2. D. 6.5 x 10 x 2.

MM: 57 x 127 x 50.8. 165 x 127 x 50.8. 165 x 190 x 50.8. 165 x 254 x 50.8.

LINEAR AMPLIFIER: *13.8VDC.
The Model FRG-7 is a precision-built communications receiver with continuous coverage (500 kHz to 29.99 MHz) featuring:

- Drift Canceling Circuit
- RF Attenuator
- Noise Suppression Circuit
- 5 kHz Direct Dial Readout
- Ceramic IF Filters
- AC-DC or Internal Battery
- Hi Sensitivity
- Excellent Stability
- USB/LSB/AM/CW
- Triple Conversion

Completely Solid State Circuitry for Stable Trouble-Free Operation ■ Built-in Front Mounted Speaker ■ RF Attenuator for Reception of Local or High Powered Stations ■ Outstanding Frequency Stability through the use of Drift Cancellation Circuit (Wadley Loop) ■ Recording Output Jack provides Constant Output Level Regardless of Audio Volume Control Settings ■ 3-Position Audio Range Selector 1. Normal (Broad) 2. Narrow (Hi & Low Cut Off) 3. Low (Hi Cut Off) ■ Excellent IF Receiver for VHF/UHF Converters.

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Building HF or VHF power amplifiers? You'll find them described in detail in both the ARRL Handbook and the Radio Handbook. And you'll find that EIMAC tubes are the overwhelming choice of expert equipment designers for 1.8 to 1296 MHz service.

The Radio Handbook features a deluxe amplifier using the 3-1000Z for HF service plus other HF or VHF designs built around the 3-500Z, 4CX1500B, 8877 and the 8874. The ARRL Handbook describes a multiband HF amplifier using the 8877, plus other designs featuring the 3-500Z, 8873, 4CX250B and 3CX100A5. And there's plenty of information about design and construction of transmitting equipment using EIMAC power tubes in both handbooks.

For tube information, contact Varian, EIMAC Division, 301 Industrial Way, San Carlos, California 94070. Or contact any of the more than 30 Varian Electron Device Group Sales Offices throughout the world.