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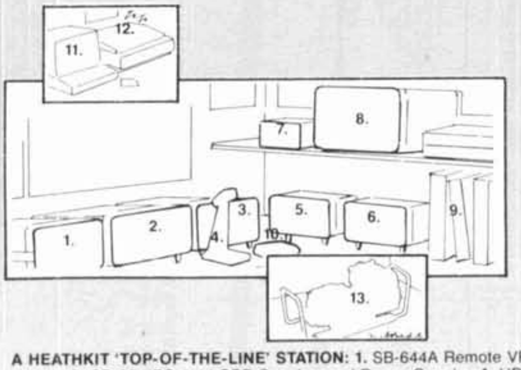

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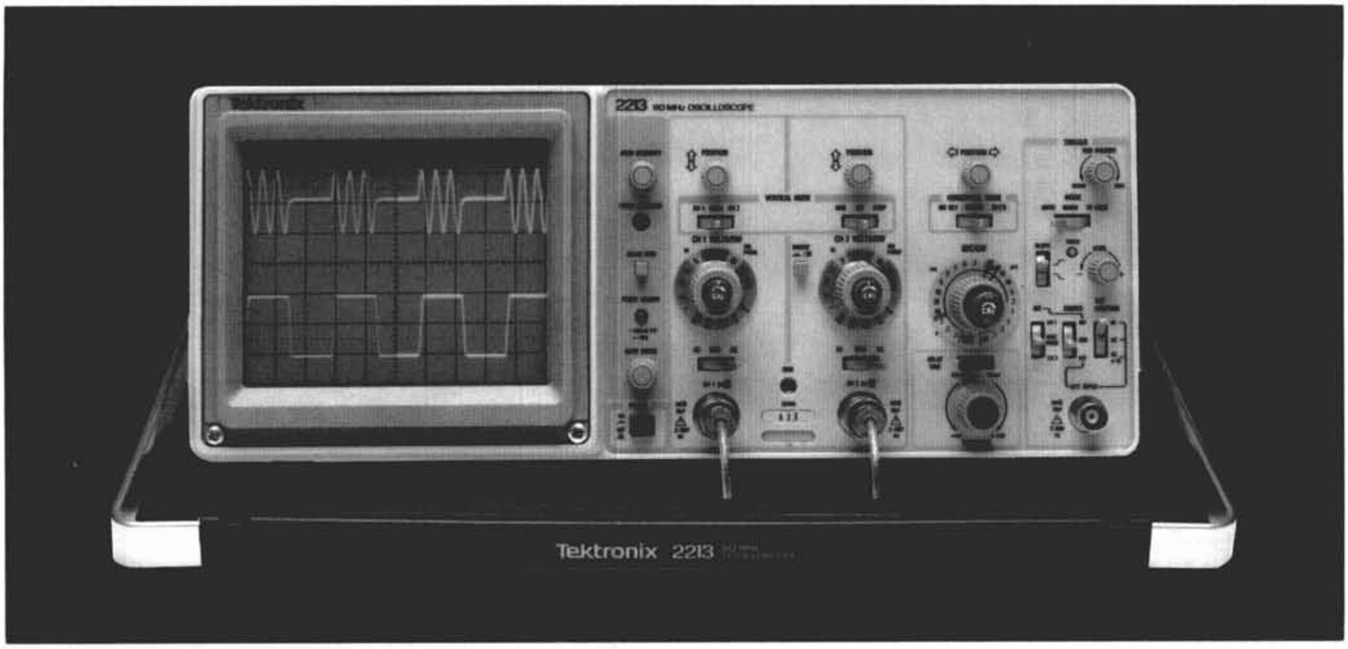

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Observation & Opinion

This month, we are presenting a guest editorial by Pat Hawker, G3VA. Pat is the author of the Technical Topics column in *Radio Communication, the monthly magazine of the Radio Society of Great Britain. His column is read by Amateurs around the world,* many of whom subscribe to *RADCOM* just to see what Pat has to say. Here is an example of his work, excerpted from the December, 1981, issue. I think you'll find it interesting. **Editor.**

ionospheric outlook

Those of us who depend on the ionosphere for most of our contacts have had, for many years, some inkling that man's activities may be introducing subtle change in those fickle layers. Why, for example, were there numbers of reports of apparently authentic long-delay echoes in the decade before 1939, yet so very few, if any, in modern times? The phenomenon of ionospheric cross-modulation and the creation of artificially enhanced layers resulting from very high power transmissions have been ascribed to increasing the temperature of free electrons; but does such radiation have any permanent effect? Then again, there is the very real worry that many aerosol sprays may eventually strip away part of our protection from high-energy ultra-violet rays. It is not only hf operators who have some cause to worry.

There continues to be genuine concern that high power ELF and VLF transmissions, such as those used for communicating with submarines or for the Omega navigational system, induce the precipitation of electrons from the earth's magnetosphere into the ionosphere. Such precipitation is believed to cause irregularities in the ionosphere sufficient to disrupt or degrade ELF and VLF communications. A research program aimed at determining whether such transmissions affect the free electron content of the ionsphere, and thus have effects beyond ELF and VLF range, is being undertaken by Lockheed under contract from the U.S. Office of Naval Research. This experiment includes a SEEP (stimulated emissions of energetic particles) satellite that will carry sensors able to observe electron precipitation while a number of high-power terrestrial transmitters are keyed on and off.

hybrid microelectronics

By now most of us have at least a nodding acquaintance with integrated circuits (including, these days, LSI, large scale integration, and VLSC, very large scale integration) and also, of course, with the use of discrete components assembled on printed circuit boards. But there is an increasingly important intermediate step, no longer considered a merely transitional stage, between the use of PCB assemblies and fully integrated circuits. This is the so-called hybrid technology, in which circuits are assembled as hybrid modules using "thick" or "thin" film circuits, often with special "chip" forms of discrete components.

Manufacturers often buy up standard types of IC devices in chip carrier form for fixing into the hybrid modules. The modules may finish up looking like large IC devices but inside may include single or multiple layers. A wide variety of enclosures and packages have been developed, some suitable for the dissipation of appreciable electrical power. Marconi, for example, has designed transmitter/receivers in hybrid form dissipating up to 100 watts.

Hybrid technology is already being used for large-volume consumer electronics in power-supply regulators, fusible resistors, car electronics, medical pacemakers, and the like. There do seem to be many potential applications in Amateur Radio equipment, provided that hundreds or thousands of identical modules are required. Clearly, the technique is not suitable for one-shot prototype equipment, but on the other hand it would be very well suited for kits or perhaps as building-block modules. For communications applications, hybrid technology has a useful advantage over fully integrated devices, in that, with the use of lasers, it is possible to accurately trim resistor values during manufacture. It can also provide significant size reductions, when compared with conventional PCB techniques.

Racal, for example, uses thick-film hybrid circuit modules for a number of communications units, including lightweight man-pack transceivers incorporating frequency-hopping (spread-spectrum) based on custom-LSI and thick-film-hybrid circuits. Indeed, this technology seems to offer quite substantial advantages over the rival techniques, in that it is rather more flexible and thus more suited to circuits requiring critical adjustment than is the fully integrated approach. But it is not a technology for experimental breadboard units!

Pat Hawker, G3VA

comments

burglar alarm RFI

Dear HR:

My neighbor installed an ULTRAR™ ultrasonic home alarm system by Universal. Soon after, the neighborhood was aroused by a series of false alarms. I traced the problem to my 25-watt 2-meter transmitter, 100 feet away.

A service man in the factory gave me the following information: A radio transmission will trigger the alarm; and the ultrasonic transducers should not be pointed at the window (where the 2-meter signals apparently enter). After hearing this, I suggested to my neighbor that he not send the alarm back, because they probably would not find anything wrong with it. I hope this will solve some puzzles of false alarms triggered by mobiles or stationary transmitters.

Kurt Bittmann, WB2YVY
Centereach, New York

a vote for Baudot

Dear HR:

Note was taken on a letter concerning slow ASCII, appearing in the June, 1981, issue of *ham radio*. It is my impression that the writer of the note has not taken into consideration the actual typing rate of slow ASCII — say 45.45 Baud. The typing rate is on the order of 41 words per minute. This results from the need for at least 11 bits in the ASCII frame, as compared with the 7.42 bits in the Baudot frame. There are many fast typists in the Baudot group; they would feel cramped if they had to handle things at a 41-WPM rate. Of course, if the parties concerned have plenty of time to make a transmission, the slow rate is of little consequence.

The Baudot Code, by virtue of its having fewer signaling elements, appears to be more efficient, suitable for teleprinter communications over hf radio circuits. In fact, the five-unit code is well standardized around the world, making it possible for many types of machines to intercommunicate. Telex is still five-unit based. It may be that the European people will not go overboard for ASCII, at least in the near future. Meanwhile, we have efficient microprocessor programs for converting ASCII to Baudot and vice versa, so let that serve for the time being.

I am quite well satisfied with the alphabet as contained in the Baudot code. After all, we are not sending business letters to each other over the air.

Robert H. Weitbrecht, W6NRM
Redwood City, California

proud to be a ham

Dear HR:

During my 23 years as a licensed Amateur I've never heard of John Reinartz until now. Of course I knew that Amateurs were responsible for introducing the use of short waves after WWI, but I never knew the details.

Thanks for this enlightening article. It makes one proud to be a member of the ham community.

David Raskin, W5TYL
Ranchos de Taos, New Mexico

AFSK generator

Dear HR:

WA3PLC was too pessimistic in his discussion of his AFSK generator in the July, 1981, issue. The third harmonic of a triangular waveform is 1/9th the amplitude, not 1/9 the power. It is thus 19 dB below the fundamental, not 9.5 dB.

In fact, total harmonic distortion (THD) of a triangular waveform is only 1.47 percent, versus 23.4 percent for a square wave. While both square and triangular waveforms are made up of an infinite succession of odd harmonics, the harmonic amplitudes are much lower with the triangular wave. By "flat-topping" the triangular wave in such a way that the rise and fall times are 1/3 cycle, all harmonics evenly divisible by three are eliminated. Total harmonic distortion of this waveform is only 0.215 percent better than that of many inexpensive "sine wave" generators.

Alan Bloom, N1AL
Santa Rosa, California

Regarding the letter from N1AL, he is correct about the third harmonic of a triangular waveform. The amplitude of the third harmonic is 1/9 of the fundamental as given by the equation in the article. Since power is given by $P = V^2/R$, the power ratio of the harmonics must equal the square of the amplitude ratio.

$$\frac{P3}{P1} = \frac{V3^2}{V1^2}$$

$P3P1$ = *power in 3rd harmonic, fundamental*
$V3, V1$ = *amplitude of 3rd harmonic, fundamental*

Since the amplitude ratio is 1/9, the power ratio is 1/81. Thus taking

$$10 \log P3/P1 = -19.1 \text{ dB}$$

Thus the AFSK modulator has better spectral purity than I had thought. This further reduces the need for the RC lowpass filter, but still, the higher margin of safety won't hurt either.

N1AL's remarks about the "flat-topped" triangle were interesting. The waveform would, however, be harder to generate with the "jumps" at 1/3 of the period unless it were done digitally. The triangle was used because only two components are required when the LM567 is used.

By the way, a perhaps more subtle error has shown up in the article. In the equation, t, is the time index, not the period.

Thomas B. Zeltwanger, WA3PLC
State College, Pennsylvania

(Continued on page 36)

presstop

Two-meter Amateur Radio outlawed? Not yet, but it could be very soon. Here's why.

A problem of significant importance to Amateur Radio is cable leakage from Community Antenna Television (CATV) systems. Interference *from* leaking cable systems into Amateur stations (and the reverse situation of interference *to* cable systems) is becoming an issue of increasing magnitude. Incidents of interference from leaking cable systems operating on mid-band frequencies to legitimate Amateur Radio operations, especially in the 144-148 MHz band, have increased at an alarming rate. The problem is aggravated by the inherent proximity of the cable systems to Amateur stations. Both operate in residential areas, and co-location is unavoidable.

Cable television is technically a nonbroadcast, or closed, service, and therefore no interaction between cable systems and any radio service should occur. In fact, however, this is far from true, and interference between cable systems and Amateur stations, often resulting in lawsuits against Amateurs in local courts, is increasing at a rate that demands FCC attention.

The cable television service is regulated by Part 76 of the FCC rules, just as the Amateur service is regulated by Part 97. Section 76.605 (a) (12) of the Commission's rules limits cable leakage to 20 microvolts per meter measured at a distance of ten feet from the cable at frequencies of 54-216 MHz. The main concern of the FCC is primarily with the potential for harmful interference to ground/air communications and navigation services. A leak measured at 20 microvolts per meter at ten feet can cause interference to a nearby Amateur receiver and, by the same token, such a cable leak will allow a significant amount of signal to enter the cable from a nearby high-power Amateur transmitter.

To further aggravate the situation, a Notice of Proposed Rule Making has been released by the FCC the intention of which is to relax the cable leakage requirements to a maximum level of 100 microvolts per meter measured at ten feet from the cable. The ARRL has taken a strong stand in this matter and has filed a brief opposing the proposal to relax leakage standards. An increase in permissible cable-signal leakage will have a more profound effect on Amateur Radio operations than on any other radio service.

The portion of a cable system that creates the biggest problems, in terms of cable leakage interference, is the drop cable from the pole to the home. The shielding of this flexible coaxial cable is less effective than is the solid aluminum hardline shielding around the cable on the pole. The drop cable moves around in the wind because of its flexibility, and the connectors used, being low-cost items, are far more subject to corrosion than are the communications-grade devices familiar to Amateurs. And all of these weaknesses are present in high-density areas, close to Amateur VHF stations. An increase in permissible leakage levels to 100 microvolts per meter at 54-216 MHz may not increase interference to aeronautical stations, but it most certainly will create or increase interference to Amateur 144-148 MHz operation. Further, cable leakage interference works both ways. Since Amateur stations are primarily located in residential areas, increases in the number of cases of interference to cable subscribers by local Amateur VHF transmissions will result.

Another potential problem for Amateurs resulting from the explosion in consumer electronics technology comes from the American Telecommunications Corporation (ATC), a subsidiary of General Dynamics Corporation. In a petition received by the FCC on December 8, 1981, ATC requests a waiver of part 15.7 of the rules to permit more liberal operating conditions for cordless telephones in the frequency band of 1.6-2.0 MHz. The FCC also received a letter dated October 27, 1981, from the Personal Radio Section of the Electronic Industries Association suggesting interim technical standards for cordless phones. The EIA letter is being considered a petition for waiver along with the ATC petition.

Both petitions propose to use carrier current techniques on the power wiring in the home. The EIA petition proposes that the maximum signal fed into the power line shall not exceed 500 milliwatts. The ATC petition states that the present standard in part 15.7 is not adequate and asks the FCC to set a new standard. What effect such a change in rules might have on 160-meter operation is not known, but surely it will be anything but beneficial. One wonders how many more attempts industry will make to muscle in on Amateur Radio frequencies.

microprocessor-based repeater controller

Some interesting ideas in repeater design

This article describes a fairly sophisticated repeater controller with autopatch that can be built for less than $175, depending upon parts availability and construction techniques. It is intended as a design example, which uses the power of the microprocessor in an Amateur Radio application.

A repeater controller is the device that, when connected to a transmitter and receiver, provides all audio and control signals for the complete operation of a repeater and, in this case, autopatch. In addition, we will interface the system with a control receiver, a logging recorder, and a phone line.

The repeater controller must monitor the repeater input (by means of the receiver squelch) and turn the transmitter on when a signal is present. This is referred to as the Carrier Operated Switch function (COS) sometimes known as the Carrier Operated Relay, or COR. This COS function also includes the time-out (typically 3-5 minutes) timer. Also included is a "courtesy beep." The time-out timer does not reset until a small amount of time has elapsed after a carrier disappears from the receiver input. When the timer resets, the controller indicates this reset by sending an audible beep on the repeater output. This beep forces users to pause between transmissions (or risk having the repeater execute time-out), so that other users may have access, particularly in an emergency.

The controller should have a well-defined external interface so that the rf portions of the repeater system can be easily connected. This requirement implies a standard level for audio signals and TTL-compatible inputs and outputs for the logic and control signals.

The logic polarity of the control lines should be chosen so that, when an input is disconnected, the tendency for TTL gates to default to a logic 1 keeps the controller in a reasonable state. For example, pulling the receiver squelch line, which is active low, does not inadvertently cause the controller to lock the transmitter on. Audio inputs should be of high impedance and outputs of low impedance to minimize loading effects. The phone-line interface should be 600 ohms.

design considerations

Our first design goal was to keep hardware to a minimum. We built the entire project on three 5 by 7 inch (12.7 by 17.8 cm) circuit boards. (Wire-wrap techniques will yield even smaller areas.) In keeping with this goal, we implemented functions such as COS and the Morse identifier in software, as opposed to the more traditional hardware approach. The entire system is of solid-state construction except for the phone-line relay.

The second design goal was a fairly extensive set of features. We needed a means for changing the repeater call sign without a major software change. Multidigit Touchtone^{TM}* commands were desired. We also included a software-based real-time clock to aid in autopatch logging.

---

*Touchtone is a registered trademark of the American Telephone and Telegraph Company.

By **Bob Witte, KB0CY,** 2253 Evelyn Court, Loveland, Colorado 80537

FCC compliance

It was impossible for our repeater group to supply a control operator for the system 24 hours a day. The FCC's recent interpretation of the rules regarding repeaters requires that a control operator be present when an autopatch is in use. To comply with this rule and still provide a means of accessing the autopatch for emergencies, we used a procedure in which, if a special access code is used, the autopatch can be accessed regardless of control-operator availability; however, only the number 911 (emergency telephone number in our area) can be dialed. This restriction is enforced by the processor monitoring the tone-decoder output.

The software also supports enhanced use of the repeater identifier to include repeater status with respect to autopatch availability and emergency power. The letters **AP** appear after the call sign if the autopatch is available; the letters **BAT** appear if the repeater is operating from emergency (battery) power.

The IDer sends the word **LOVELAND** at the end of the ID according to the following algorithm: if the repeater has been idle for more than ten minutes, the suffix (**LOVELAND** in this case) is always appended. If the repeater has been active, then the suffix is added only on every fourth ID so that it doesn't become annoying.

The suffix is control-operator programmable to any arbitrary message up to 24 characters. Thus, the repeater functions somewhat as a "billboard" for the club, with a typical message being **MEETING SATURDAY**.

You might ask if anyone really listens to all this Morse code from the repeater. The answer is that anyone interested in using the autopatch soon picks up the key letters **AP** regardless of his code speed. The message suffix scheme has worked out quite well as it takes only a small percentage of the membership copying the ID and commenting on its message to keep repeater users informed. Perhaps it provides, at least, a small incentive for Technician-grade licensees to increase their code speed!

The controller operates from a 13.6-volt supply (12 volts nominal), as does all the equipment at our installation. This allows one common 12-volt supply with automatic switching to battery backup. The power supply has a TTL-compatible output, which indicates the source of power in use.

hardware organization

The hardware is organized into three separate subsections mapped into three separate boards, but this is certainly optional.

decoder board

The decoder board (**fig. 1**) has two functions, to decode Touchtone signals fed to it from either the control receiver or audio board and to generate Touchtone signals controlled by the local (front panel) pad. (The local pad could be eliminated, but is a useful debugging tool.)

The audio source for the decoder is chosen by two analog switches (U1), which are controlled by the control receiver squelch line so that the control receiver always has priority. U2 level shifts the TTL control inputs. The tone decoder (M-917) is a decoder module made by Teletone.

A properly decoded tone is signalled by the strobe (pin 6 of M-917) going high just after the binary code appears on line D0 through D3. These lines are level-shifted by the 4050 CMOS buffer (U3), and are further buffered by TTL drivers U4,U5. The four right-column keys (**A**,**B**,**C**,**D**) are further decoded by U6 to provide active low, single-line outputs. One of these outputs is connected to the remote reset line on the processor board and can be accessed by the control link in case of processor failure. U5 was included to buffer the signals to a set of front-panel LEDs, which display the decoder outputs (**Table 1**).

The encoder uses a Motorola 14410 chip.[1] Some autopatch systems regenerate the Touchtones as they enter the system; we chose not to add the extra complexity and have found the system to be quite reliable.

audio board

The audio board (**fig. 2**) accepts inputs from various sources and sums them for output to the decoder, transmitter, phone line, and logging tape. U2 is arranged in the summing-amplifier mode and mixes several signals. The output of U2 goes through analog switch U6 (controlled by the processor) to U3. U3 sums the audio from U7 (an NE-555 oscillator) so that the phone line never hears an ID or beep. U4 drives the isolation transformer, and U5 is driven by the isolation transformer. The isolation transformer provides a dc isolated connection to the phone line. The audio signals to and from the phone line are switched by the analog switches, which are controlled by the processor. The patch is a simplex arrangement in which the audio from the phone line is cut off when a station is transmitting; this eliminates the need for any balanced network, as in a duplex patch, and it also provides a means of instantly muting the audio from the phone line. The NE-555 oscillator generates all tones (ID, courtesy beep, signaling tone). U1 is a limiting amplifier for the local microphone.

Audio level. In our repeater system we adopted a standard audio level of 2 volts p-p at 1 kHz, which corresponds to transmitter or receiver 5-kHz deviation. This may seem like a minor point, but before we

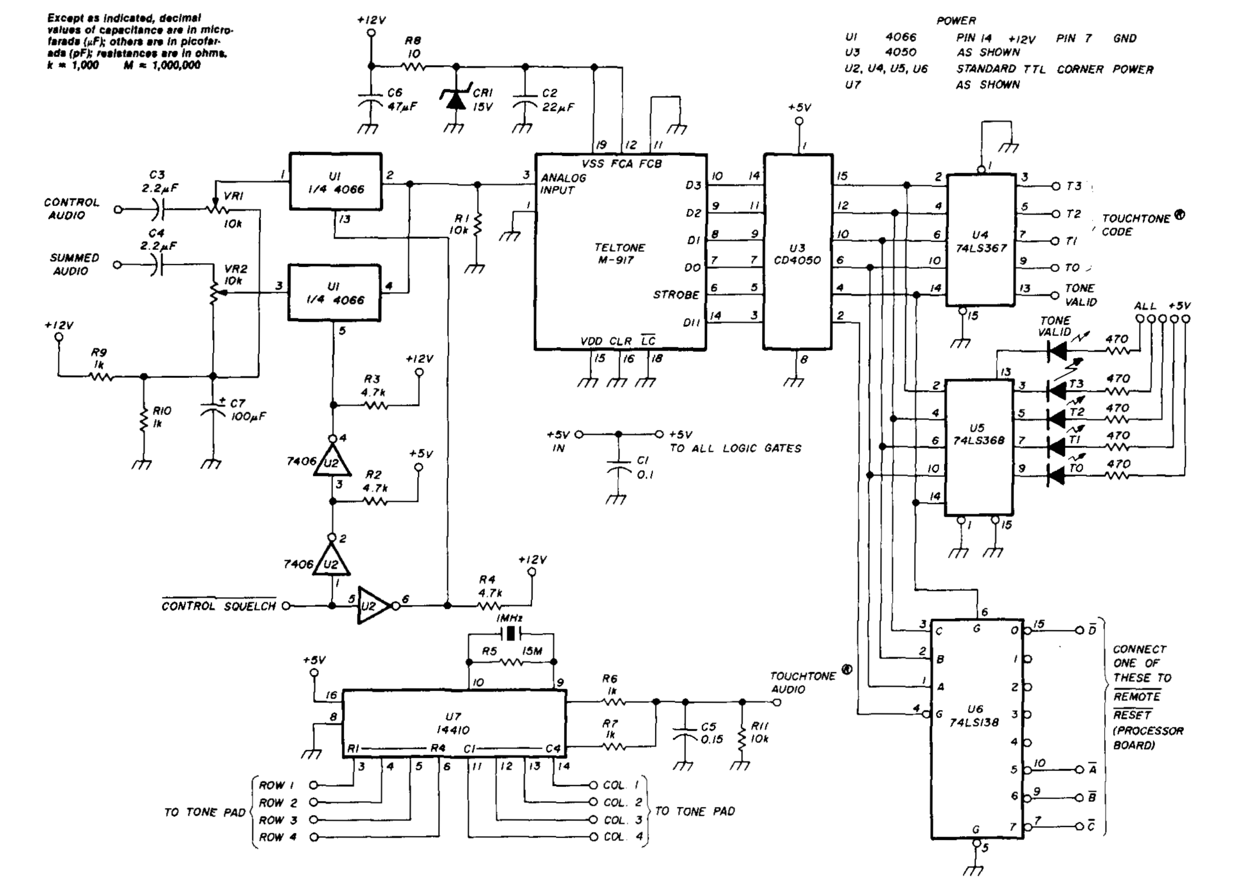

fig. 1. Dual-tone, multi-frequency (DTMF) decoder board. Decodes control tones from various sources and provides digital outputs for the processor. Also includes a DTMF encoder for the local keypad.

table 1. Front-panel LEDs, which show the decoder outputs.

	Touchtone™ LEDs T3, T2, T1, TØ
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
Ø	1010
*	1011
#	1100
A	1101
B	1110
C	1111
D	0000

adopted this approach, incompatible and unknown levels were a major source of problems. An audio level of 2 volts p-p works well with a single 12-volt supply system, allowing enough dynamic range without sacrificing noise immunity.

Other input and output signal levels can be accommodated by adjusting VR1 and VR7 and/or by changing a few resistor values (see reference 2).

Level Adjustments. Connect a 2-volt p-p, 1-kHz sine wave signal to the receiver input and adjust VR1 for 2 volts p-p at the output of U2. This sets up the basic reference for the system. VR7 may then be adjusted for proper transmitter level — in our case, 2 volts p-p. Access the autopatch and adjust VR4, while the dial tone is present, for 2 volts p-p at the output of U2.

The dial tone is usually the largest signal received from the phone line; therefore, it makes a good reference. Adjust VR3 for a Touchtone **5** having a p-p value of 2 volts at the output of U2. VR5 can best be adjusted by comparing the local pad's level on the

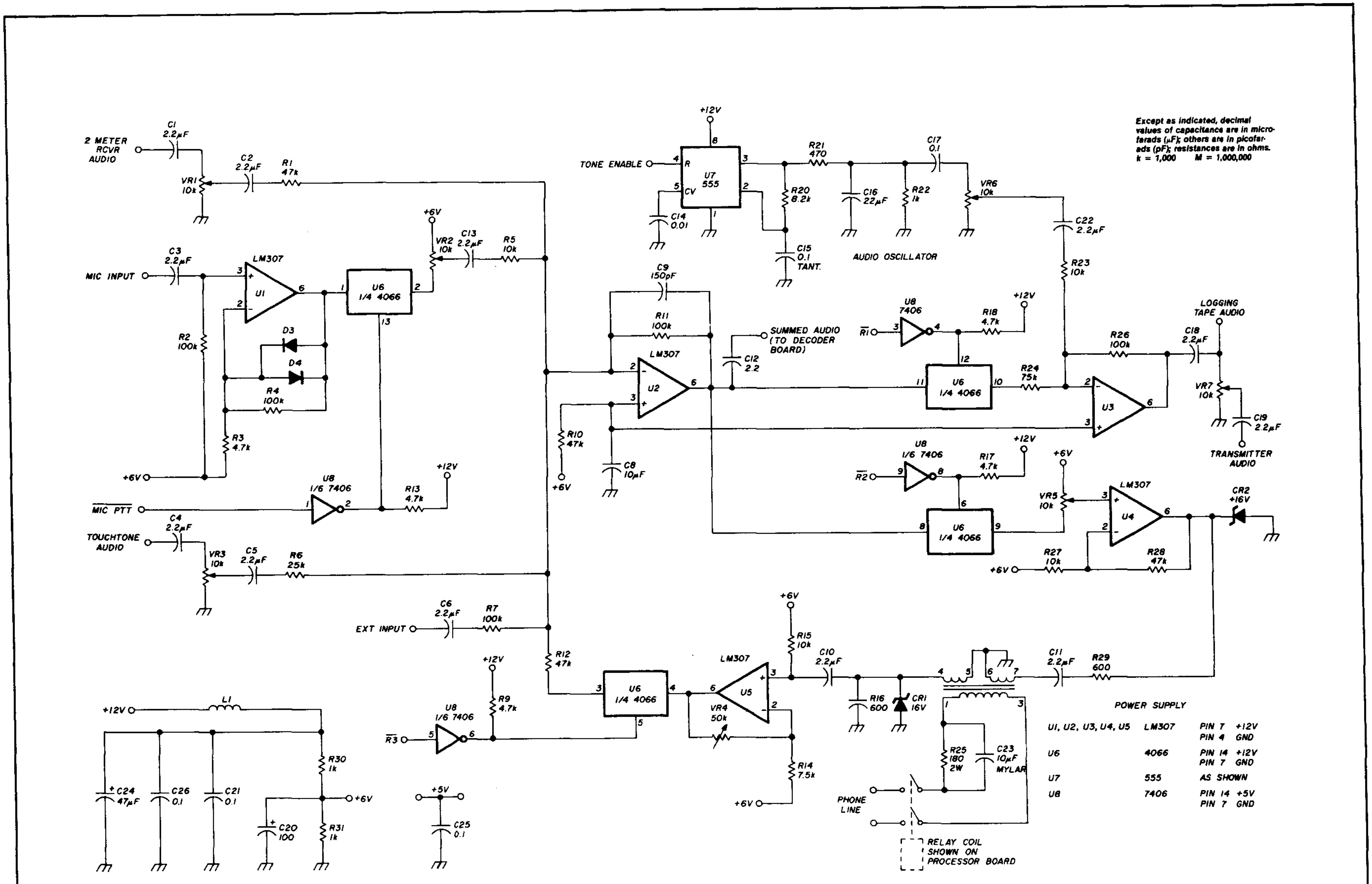

fig. 2. Audio board sums audio from several sources and supplies audio to the transmitter, logging tape, phone line and tone decoder.

phone line with a telephone Touchtone pad on the same line. The audio oscillator and microphone levels are best set by listening on the transmitter output frequency.

processor board

The processor board (**fig. 3**) performs virtually all the control functions for the repeater. The microprocessor is an Intel 8035 with onboard RAM and IO. Its clock is a precise 1 MHz, which is divided down from the 2-MHZ oscillator. The clock is connected to an internal counter that interrupts the processor each time the counter overflows. The processor keeps track of how many times it is interrupted; therefore it can keep track of time — this is how the real-time clock is implemented. The crystal-oscillator approach was chosen rather than using the 60-Hz line voltage as a time base since the battery backup feature is desirable.

The processor has several software timers which time various events (such as time since last ID, autopatch duration, and carrier-operated switch functions). One of the more interesting uses of the real-time clock is automatic logging of time and date in Morse code (onto the logging tape) when an autopatch call has been completed. This feature reduces the burden on the user to remembering only his call sign and getting it onto tape.

Morse code identification

The repeater's call-sign ID in Morse is performed by the processor turning the NE-555 oscillator on and off. The call sign is entered through the DIP switches by loading the shift registers, then the data are clocked in serially. The switch registers are set according to a table lookup (**table 2**). The proper code is found by locating the desired character in the table, then entering its associated binary code into the switch.

Because call signs vary in length, a means for allowing for variable length was incorporated. The processor will default to sending all six characters unless it encounters a 1 in the leftmost bit. For example, to program KBØCY, find all the letters and their associated binary codes:

K	00010100
B	00001011
Ø	00000000
C	00001100
Y	00100010

switch programming

The switches are programmed to a 1 when the switch is open. The programmed switches would be as follows for KBØCY; 00010100 00001011 00000000 00001100 00100010 10000000 The last switch has its leftmost bit set, since KBØCY does not use the sixth character. The software automatically adds /**R** onto the end of the callsign to indicate repeater operation.

table 2. Morse-code table.

character	binary	character	binary
0	00000000	I	00010010
1	00000001	J	00010011
2	00000010	K	00010100
3	00000011	L	00010101
4	00000100	M	00010110
5	00000101	N	00010111
6	00000110	O	00011000
7	00000111	P	00011001
8	00001000	Q	00011010
9	00001001	R	00011011
A	00001010	S	00011100
B	00001011	T	00011101
C	00001100	U	00011110
D	00001101	V	00011111
E	00001110	W	00100000
F	00001111	X	00100001
G	00010000	Y	00100010
H	00010001	Z	00100011

other processor functions

The basic-instruction fetch of the processor is performed by outputting the address onto DB0-DB7 (and P20-P23), which is then latched by U2 (**fig. 3**). U3 is the EPROM that holds the program and outputs the instruction or data onto DB0-DB7. **ALE** (pin 11) *is the address latch enable. Since it is a divided-down* version of the processor clock, it makes a good test point for determining whether the processor chip is alive.

The T1 input (pin 39, U1) to the processor is one of several special-purpose input lines that are easily accessible by the software. Here it is used for the **NOT TONEVALID** signal. T0 is a similar line, and it is used for the **NOT CARRIER** signal. This input is scanned by the processor's interrupt routine, and the Carrier-Operated Switch (COS) function is performed using it. It is essentially the logical OR of all the various inputs that are used to turn on the transmitter: COS1-COS3, manual COS, Mic PTT, receiver squelch, and control squelch. The processor can be reset by powering it on, by the front-panel reset switch or, as previously mentioned, by one of the output lines from the decoder board.

The 8243 IO Expander, U4 is an 8035 family chip that provides additional IO ports easily. It is used here to drive various outputs: analog switch control lines (R1-R3), transmitter PTT line, tone enable, tape enable, patch relay, and the trigger outputs. The trigger outputs are software-controlled lines, which are intended to provide for future expansion of the repeater system. A particular control code sent to the repeater will cause one of the trigger outputs to go

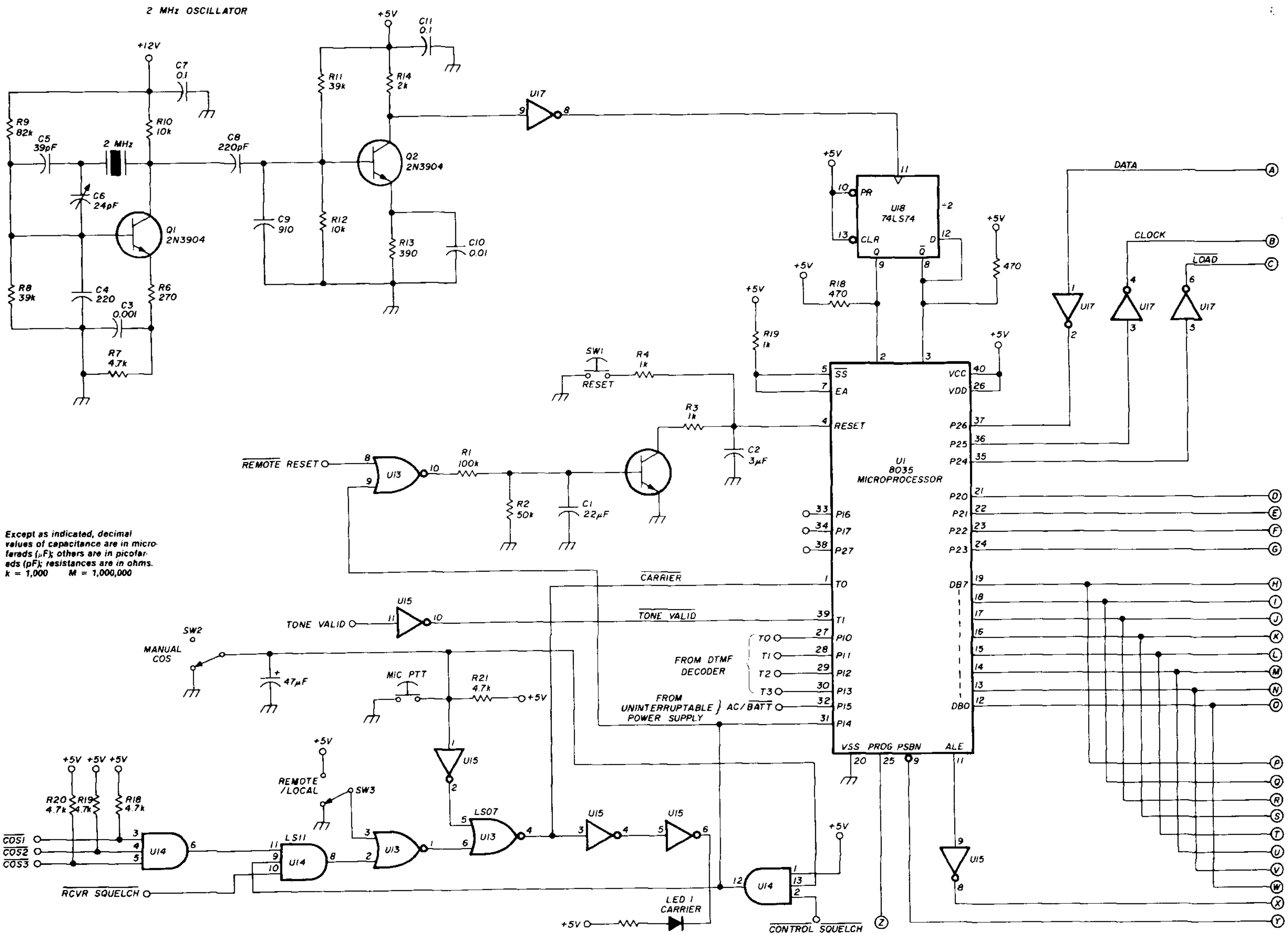

fig. 3. Processor board. Controls all functions of the repeater by monitoring the Touchtone™ decoder and various other control lines. The 2-MHz oscillator provides the time base for the software clock. The power supply is the 8035 IC (U1) as shown; all others are standard TTL corner power.

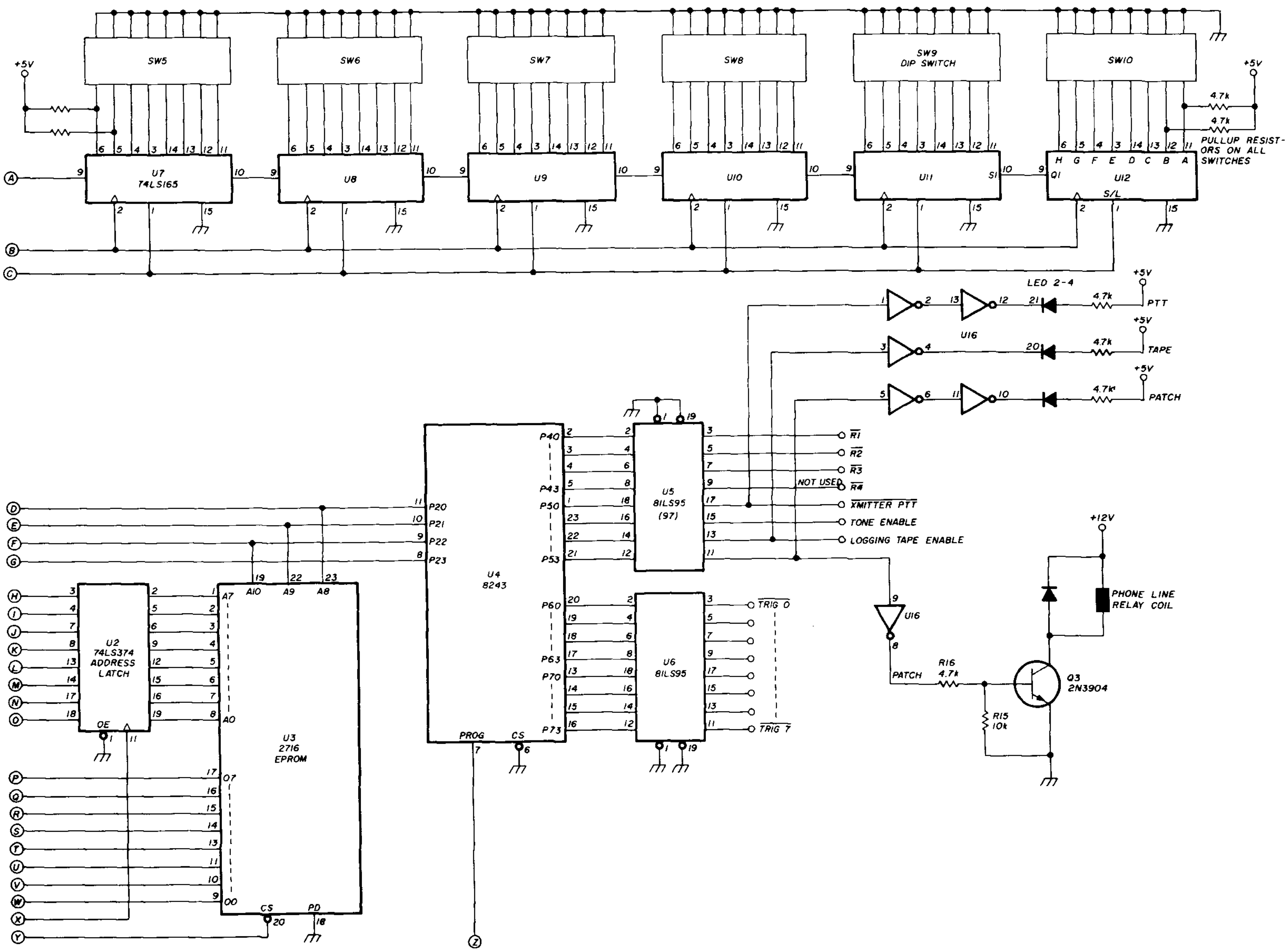

fig. 3. Processor board, continued.

low for about 60 milliseconds, thereby allowing it to trigger some external device.

Suppose an antenna relay were to be added to the system. The external device (antenna relay) would have two active low TTL compatible inputs, one to connect the relay to antenna 1 and the other to connect the relay to antenna 2. These inputs would be connected to two different trigger outputs. The appropriate antenna would be chosen by sending the control code for the desired trigger output.

P10-P17 and P20-P27 on the processor are the lines of the on-chip IO ports. Lines P10-P13 are used for entering the code from the decoder board along with the **NOT TONEVALID** signal. Line P14 is used to indicate to the processor that the current Touchtones are coming from a control source (that is, either the control receiver or the front panel). Line P15 is used to tell the processor whether ac or battery power is being used.

The manual COS switch and the Mic PTT switch are used to operate the repeater locally; that is, they simulate a carrier on the input of the receiver and cause the processor to act accordingly. The remote/local switch determines whether the repeater is in repeat mode or if it can be operated only from the front panel. The COS1, COS2, COS3 inputs were included to allow for further expansion of the system. These inputs can be used by any external device that needs to turn the transmitter on. These inputs are, logically, ORed with the receiver COS input (the processor can't tell the difference); so if the external device gets latched into the on mode, the processor will eventually time out and shut down the transmitter.

table 3. Abbreviated parts list. Most part values are not critical. Resistors are 1/4 watt unless otherwise noted; all TTL parts can be low-power Schottky (LS) or standard TTL. VRs are multi-turn trimpots.

	decoder subsection
U1	4066 CMOS switch
U2	7406 inverter (oc, or open-collector outputs)
U3	4050 CMOS buffer
U4	74LS367 TTL buffer
U5	74LS368 TTL buffer (inverting)
U6	74LS138 TTL decoder
U7	MC14410 DTMF encoder
Decoder module	Teletone M-917
	audio subsection
CR1,CR2	16 volt zener, 1 watt
CR3,CR4	silicon general-purpose diode
T1	audio transformer, 1.4:1, center-tapped primary (Western Electric transformer 2578 or similar)
U1-U5	LM307 or 741 op amp
U6	4066 CMOS switch
U7	555 timer
U8	7406 inverter (oc, or open-collector outputs)
	processor subsection
Q1-Q3	2N3904
SW5-SW10	DIP switch (8 switches, 16-pin package)
U1	Intel 8035 microprocessor
U2	74LS374D flip flop
U3	2716 EPROM
U4	Intel 8243 IO expander
U5,U6	81LS95 or 81LS97 buffer
U7-U12	74LS165 shift register
U13	74LS07 2-input NOR gate
U14	74LS11 3-input AND gate
U15,U16	74LS04 inverter
U17	74LS04 inverter
U18	74LS74 D flip-flop

control functions

Following are some of the control functions:

1. Disable autopatch.
2. Enable 911 autopatch.
3. Enable full autopatch.
4. Program ID suffix.
5. Set time of day.
6. Set date.
7. Enable repeater.
8. Disable repeater.
9. Hardware reset.
10. Send all Morse characters.
11. Enable courtesy beep.
12. Disable coutesy beep.
13. Reset autopatch timer.

user functions

All control and user codes have the following format: ***a b c**

where * represents the star on the conventional Touchtone pad and a,b,c, are digits 0-9. The following user functions have been implemented:

*195 **autopatch access**
Our repeater output frequency is 147.*195* MHz — normal autopatch access mode. The pound symbol, #, is used to shut the patch off (that is in keeping with the procedure of using * to access a patch using # to bring it down).

*911 **emergency autopatch**
This is the emergency 911-only mode described earlier.

*200 **time and date**
Used to transmit time and date in Morse code.

*222 **ID (repeater status)**
This function can be called to determine autopatch status or to read any message on the IDer.

*364 **Touchtone test**
This test is initiated by sending *364. After the repeater responds with the signaling tone, the user hits, in any order, all twelve keys on his pad. The repeater will respond either with the letters OK or with the characters that were not successfully received. Of course, it may be necessary to have someone else initiate the test sequence if the user's pad is totally useless.

parts

The following sources are recommended for obtaining parts (**table 3**) for the project:

Digital, Linear ICs:

Jameco Electronics
1355 Shoreway Road
Belmont, California 94002

Advanced Computer Products
P.O. Box 17329
Irvine, California 92713

Radio Shack

Touchtone Decoder:

Teletone Corporation
10801 120th Avenue N.E.
Kirkland, Washington 98033

Current price for M-917 module is $85

summary

This system was implemented on the Loveland Repeater 147.795/195 located west of Loveland, Colorado. Since the final version of this project was installed, we have experienced excellent reliability. I welcome any response to this article, and I hope it can lead to an exchange of some new ideas on applications of microprocessors and repeater-system design. I have arranged for 2716 EPROM's to be zapped with appropriate software for a nominal charge (send me a SASE for further information).

acknowledgment

Many thanks to Virgil Leenerts (WØINK), Glenn Engel (WBØHXS), Joyce Witte (KAØDEH) and the members of the Loveland Repeater Association for various forms of assistance.

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ham radio

More Details? CHECK—OFF Page 98

blanking the Woodpecker

part three: an audio blanker

In the first of this series of articles,[1] I pointed out that the Russian over-the-horizon (OTH) radar, or "Woodpecker," is transmitted at a very precisely defined pulse repetition frequency — usually 10 Hz. This fact leads to the possibility of locally generating a similarly precise frequency to control a noise blanker. The second article[2] investigated a circuit that could be connected to the existing noise blanker circuitry in a transceiver, making it possible to blank out the Woodpecker.

An MM5369 crystal oscillator/divider was used to generate a precise 60-Hz square wave. This was divided by six using a CD4018 CMOS IC, to give a very precise 10-Hz signal. The 10-Hz signal was processed through a series of CMOS Schmitt trigger circuits (all part of one MM74C14) to give an output pulse whose width and phase could be varied manually. By adjusting the phase of the output, one can synchronize it with the incoming Woodpecker interference. By adjusting the width of the output, one can use it to turn the noise blanker in a receiver off for precisely the duration of the Woodpecker pulses and no longer.

It is obvious that this approach is useful only when one has a receiver with a noise blanker that can be connected to the synchronous circuit. For those with receivers with either no noise blanker, or a blanker that cannot readily be connected, another approach is necessary. The circuit described in this article is an audio blanker that can be connected to the audio output of the receiver. There is therefore no need whatever to tinker with the internal workings of the set. It can be used to very good effect on receivers such as the Yaesu FRG-7.

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i-f versus audio blanking

The ideal place to blank a noise pulse in a radio receiver is early in the i-f stages. This is because the pulse becomes broadened as it passes through the narrow selectivity stages, and therefore a longer, more noticeable blank space is needed to remove it. Also, if you do the blanking in the audio stages, it may be too late to stop the noise from triggering the AGC circuit, thus muting the receiver's sensitivity. In the case of the Woodpecker, the first of these considerations is not a problem, as its pulses are already very wide (typically 15 milliseconds). The AGC swamping is a problem, however, because the Woodpecker can get very strong — at times over S9 +20. So there is a price to pay with the audio circuit, as compared with the i-f blanker. Because it is an outboard device, it does not reduce the AGC swamping caused by a really strong Woodpecker signal.

Even so, the circuit turns out to be very effective. The reason for this is that it is not only AGC swamping that reduces readability; the Woodpecker itself is at least as serious a cause of loss of intelligibility in the desired signal. This can be demonstrated by observing the problems that arise even when the Woodpecker is only operating at moderate levels. Consequently, an audio stage blanker can give considerable relief from the interference.

audio blanking

Basically, the audio blanker is an audio amplifier that can be turned on and off by a control signal. In this case, that control signal is supplied by exactly the same circuit used to control the transceiver i-f

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noise blanker, minus the final transistor.

There are a number of possible means of gating an audio amplifier. Perhaps the easiest way is to use a field-effect transistor as a switch at the input to the audio amplifier. There are two ways of using an FET as a switch: as a series-pass element or as a shunt element.

Block diagrams of audio blankers using FET switches in these ways are shown in **fig. 1**. Both depend on the fact that when an FET is switched on by the appropriate control voltage at its gate, the resistance between source and drain is quite low (a few hundred ohms). When it's in the off condition, the resistance between source and drain is very high. In this way the FET is similar to the conventional bipolar transistor. They differ, however, in that the gate of the FET presents a very high impedance to the control signal.

In the case of the series blanker, when the FET is switched off the amplifier circuit (including FET) presents a very high impedance to the incoming signal, and the output of the amplifier is low (or, at least, somewhere near the input impedance of the amplifier by itself), and the signal appears at the output of the amplifier, as required.

In the case of the shunt blanker, when the FET is switched on, it tends to short the incoming signal to ground, resulting in no output from the amplifier. When the FET is off, its high impedance means that it plays no part in the proceedings, and the amplifier does its normal job.

Both these types of FET switches can be used together if desired. I have found that in practice the series FET switch works perfectly well by itself, and it is the approach that has been followed in the circuits described in this article.

a working circuit

There are a number of points to consider when putting the above scheme into practice. First, it is essential that none of the blanking control signal gets into the audio chain, otherwise one merely substitutes a locally made series of noise pulses for the Woodpecker.

Second, one has to ensure that the audio signal one wants to hear is not tuned off and on too quickly. Otherwise the effect is to introduce switching spikes into the audio due to the sudden drop in the audio output to zero (and back up again). In other words, the control signal must turn the audio off gently.

The third consideration is the type of FET to use as switching element. I have used only junction FETs (presumably MOSFETs would work). However, one can use either P-Channel or N-channel JFETs. This choice dictates the way one applies the control signal

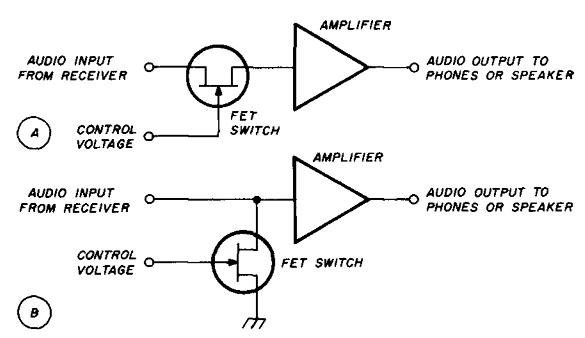

fig. 1. Basic theory behind audio blanking. An FET switch controls the audio to the main amplifier. Top diagram (A) shows series blanking; (B) shows shunt blanking.

to the FET. A negative-going control signal is necessary to turn off an N-channel FET, while a positive-going control is needed to turn off a P-channel FET.

The final decision to be made is the type of audio amplifier, its gain, and its input and output impedances.

design

In developing the audio blanker circuit, I have done a lot of "tweaking" — the circuit is more or less conventional, but the component values have been chosen as much by trial and error as any other means. Part of the trouble stems from the fact that a particular type of JFET tends to vary in its specifications from component to component, so to get a circuit to work reliably with a range of FETs takes some care. The full circuit of the audio blanker is shown in **fig. 2**.

To avoid the problem of the control signal getting into the audio chain, and also to minimize audio switching transients, it is necessary to soften the edges of the output from the digital stages that generate the control signal. In **fig. 2**, U1 (an LM741) is used as a unity-gain buffer between the CMOS and the rest of the circuit. A large capacitor, C1 (33 μF), from the output of U1 to ground, effectively turns the sharp-edge digital waveform into one with sloping sides. Note that U1 is operated from a single power supply using ground as the negative bus.

Capacitor C2 and diode CR1 operate as a diode clamp, which means that the control voltage applied to the gate of the N-channel JFET, Q1, drops to about −9 volts to switch Q1 off (depending on the voltage at which the CMOS is operated — here 9 volts). The control waveforms at various points in the circuit (marked with arrows) are shown in **fig. 3**. Q1 is an MPF102, but a variety of other N-channel JFETs should work equally well. The only requirement is

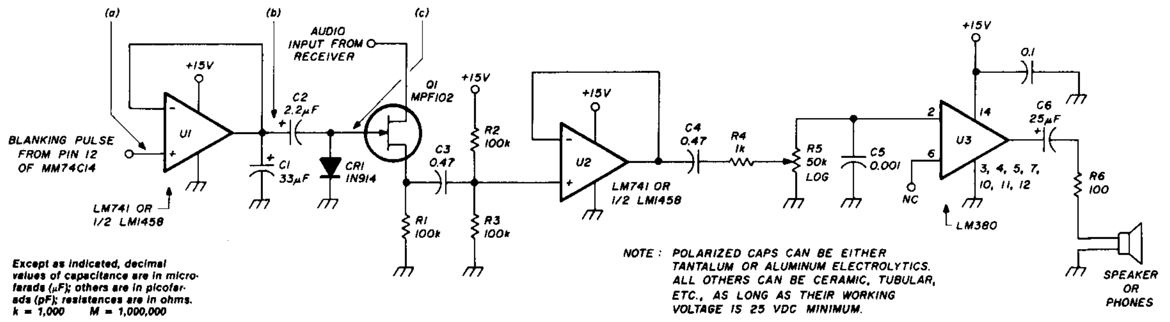

fig. 2. The audio blanker circuit. Note that the circuitry to generate the control voltage pulses was described in reference 2.

that Q1 must be switched off when the control voltage goes below about −7 volts. If necessary the CMOS voltage can be increased to ±15 volts, or U1 required to give a gain of 1. This will allow the control signal at the gate of Q1 to go to about −14 volts which should switch anything off!

JFET Q1 is in the input leg of op amp U2 (LM741). It is isolated from U2 for dc by capacitor C3. Voltage-divider resistors R2 and R3 set the dc operating point for the noninverting input of U2. U2 is arranged as a unity-gain buffer. Instead of using two LM741s, it is also possible to use one LM1458 dual op amp. However, not all types of op amps work in this circuit.

The main amplifier consists of U3, an LM380 audio amp. This is arranged in the simplest possible way (reference 3). It is isolated from the dc output level of U2 by C4. R4 limits the current drawn from U2 if R5 is set to zero. C5 and C6 in effect tailor the frequency response of the amplifier: increase C5 to cut treble, decrease C6 to cut bass. The output volume is set by R5. Depending on the sensitivity of the output speaker or phones, R6 may be omitted.

No special adjustments are necessary, but a little tweaking of the values may not go amiss. Readers may have noted that the CMOS is operated in these circuits at 9 volts, while the analog stages run on 15 volts. While these voltages can both be obtained from the same source, the object of using separate supplies is to minimize the possibility of digital spikes getting into the audio through the voltage buses.

One further important point should be noted. The control signal fed into U1 should be taken from pin 12 of the MM74C14 Schmitt trigger IC described in the previous article, *not* from the transistor or from pin 11 of the MM74C14. This is because a negative-going control signal is needed to turn off Q1.

operation

Apart from the volume-control knob on the audio blanker, the circuit is controlled in the same way as for the i-f blanker; that is, set the width control about half way, adjust the phase until the Woodpecker is muted best, then narrow down the width as far as possible without bringing back the interference.

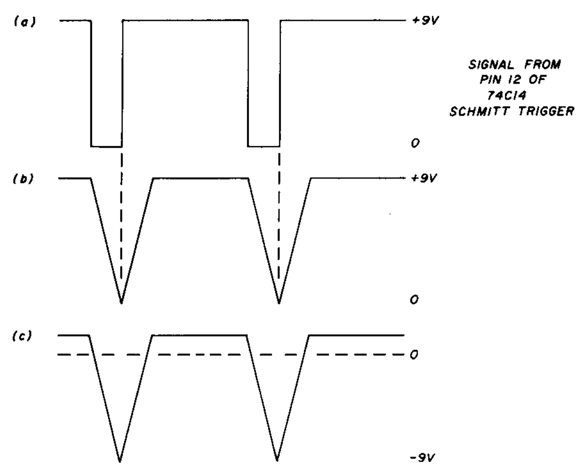

fig. 3. Waveforms to be found at various points in fig. 2.

conclusion

The audio blanker described here works well in curbing the Woodpecker, despite the fact that it does not remove the AGC swamping that can occur when the interference is strong. This circuit was actually developed before the i-f blanker, and I have used it on an FRG-7 for over two years. The model illustrated in the photograph is also equipped with a 10/16-Hz switch to allow the Woodpecker to be blanked when it occasionally switches to 16 Hz. Details of this circuit will be given in a future article.

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3. "Linear Applications," Vol. I, Application Note AN-69, National Semiconductor, 1973.

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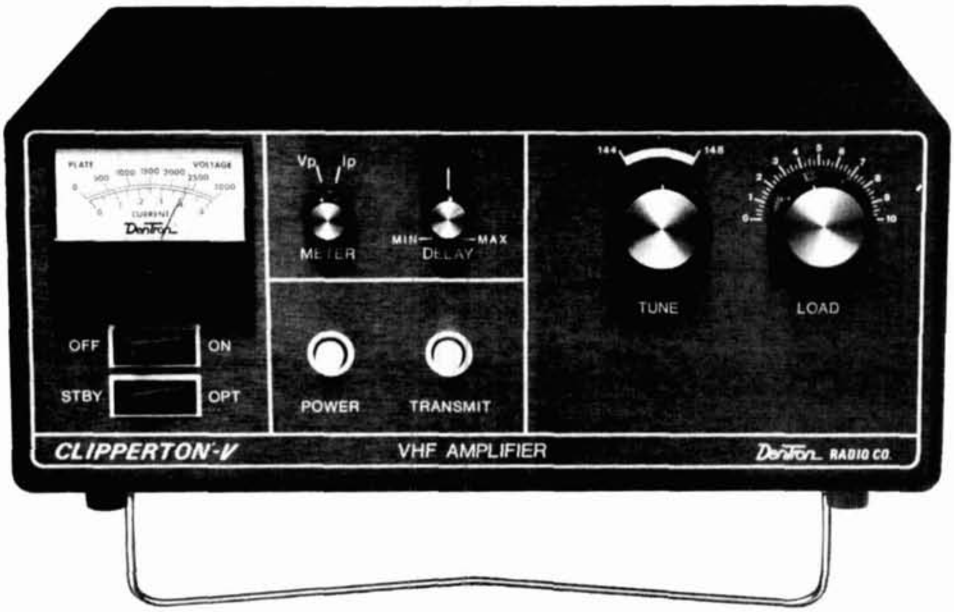

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ham radio TECHNIQUES

Bill Orr W6SAI

Let's face it: one of the few remaining areas of experimentation available to the average Amateur is in the field of antennas. A lot of interesting antenna configurations can be built with wire, tubing, coaxial cable, and an SWR meter. On the other hand, construction of modern, digital communications equipment is outside the expertise of many Amateurs.

One of the pleasures of writing this column is getting letters from readers who are doing their own thing and experimenting with unorthodox antenna designs. I'm going to cover some of these designs in this column.

The tools required, in addition to those listed above, include a large notebook for writing down your experiments and results, and the enthusiasm to investigate and improvise. Armed with these — and plenty of caution when it comes to climbing towers and trees — any Amateur can enjoy the fruits of his labors. It's a great feeling to get an S-9 plus report on your new antenna experiment.

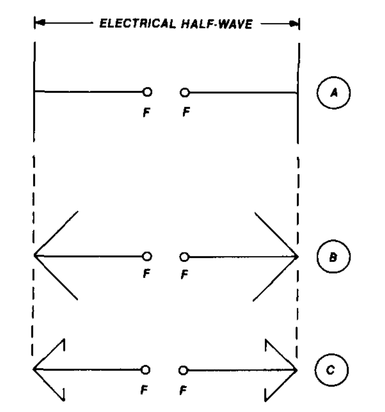

fig. 1. Evolution of the W1PLH compact dipole. (A) End-loaded dipole; (B) Loading wire folded inward; (C) Loading wires folded inward and bent.

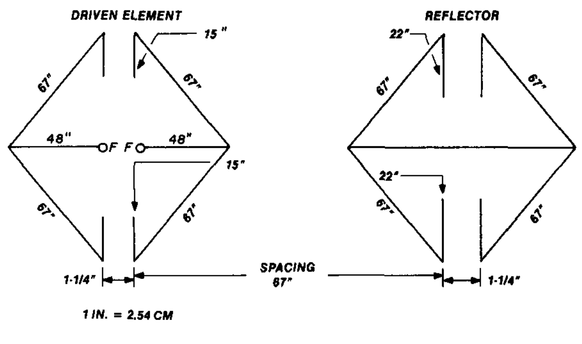

fig. 2. This looks like a quad but it is an oblique view of a Yagi! Folded and loaded elements are used in the W1PLH compact beam antenna. Elements are made of wire and strung on X-frames in the manner of a quad. A quarter-wave matching transformer and balun feed the beam at points F-F, as shown in *fig. 3*.

the W1PLH mini-beam for 15

Charlie Windslow, W1PLH, has spent a lot of time experimenting with compact antennas. His tools are a noise bridge, an SWR meter, and an old Viking Ranger II that he uses as an rf source for his experiments. (Charlie must be a pack-rat like myself. He told me he now has a collection of two noise bridges and seven SWR meters!)

His primary experiment was with a wire dipole antenna (**fig. 1**). To make a more compact antenna, he shortened the dipole and added "wings" on the end. When the wings were short and at right angles to the dipole, the input impedance and performance were comparable to that of the original dipole. Bandwith (frequency span between high SWR points on either side of the resonant frequency) was somewhat improved.

When the wings were folded inwards, as shown in the second illustration, the antenna seemed to work as well as before but both bandwidth and input impedance decreased. So far, so good.

The next step was to fold the wings

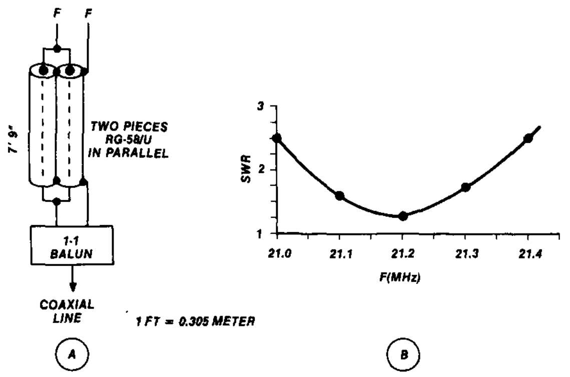

fig. 3. Quarter-wave transmission line transformer is made of parallel connected lengths of RG-58/U coax. Representative SWR curve for the W1PLH beam is shown at right.

back upon themselves until the antenna looked like the third illustration of **fig 1**. This was to be the basic element of the W1PLH Yagi (**fig. 2**). The beam is about 5 feet 7 inches on a side, with five-foot-seven-inch spacing between driven element and reflector. Design frequency is 21.2 MHz.

Input impedance of the small beam runs about 15 ohms at resonance, so Charlie made up a simple linear matching transformer made of two parallel-connected quarter-wave sections of RG-58/U in parallel (**fig. 3**). The final SWR curve of the design is also shown in **fig. 3**. Front-to-back ratio at the design frequency (middle of the 15-meter band) was approximately 12 dB. Adjusting the length of the open reflector stubs on a local signal provided optimum performance.

Power gain? Hard to tell without elaborate measuring equipment, but Charlie has worked plenty of DX with the miniature antenna and seems to be able to hold his own in competition.

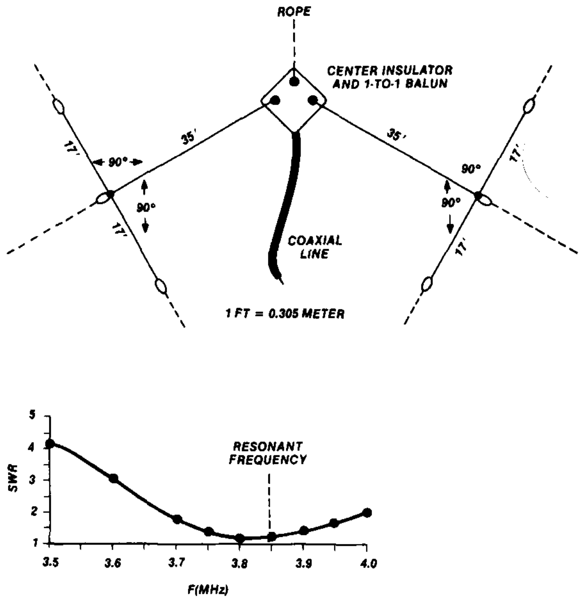

fig. 4. Oblique view of the W1PLH compact 75-meter end-loaded dipole. Joints of antenna are tied off to convenient trees and supports by insulators and rope. Overall length of antenna is only 70 feet. SWR curve is shown below.

the W1PLH short dipole for 75

Charlie has adapted his wing dipole for 75 meters, as shown in **fig. 4**. The overall length of the dipole is 70 feet, with 17-foot wings at each end to establish antenna resonance. The antenna at W1PLH is 25 feet high at the center, and the ends are about 15 to 20 feet above ground. The whole thing fits comfortably on a small lot. The antenna is fed with a 1-to-1 balun and about 100 feet of RG-8/U transmission line. The resonant frequency of the antenna can be adjusted by trimming the tips of the 17-foot sections. Resonance is also affected by height above ground.

Considering how low the antenna is and the loading effect of the end sections, the SWR curve across the 80-meter band is remarkably good.

the W2CZS inverted-V dipole for 80

Stan, W2CZS, has been an active ham since he was licensed as 1BHT in 1926. He divides his time between sailing on Barnegat Bay and working 80 meters. As so often happens, Stan ran into a space problem when he contemplated a good 80-meter antenna. Over the years he evolved a simple antenna that can operate across the whole 80-meter band with a low value of SWR. All it takes is a little physical exercise to adjust the antenna to one of three pre-chosen frequencies (**fig. 5**).

Stan's basic antenna is a folded or inverted-V. A 30-foot-high pole supports the center of the antenna and the two wires of the dipole form an angle of approximately 90 degrees. The ends of the dipole are tied to 8-foot poles with steps on them.

The main wires of the antenna are

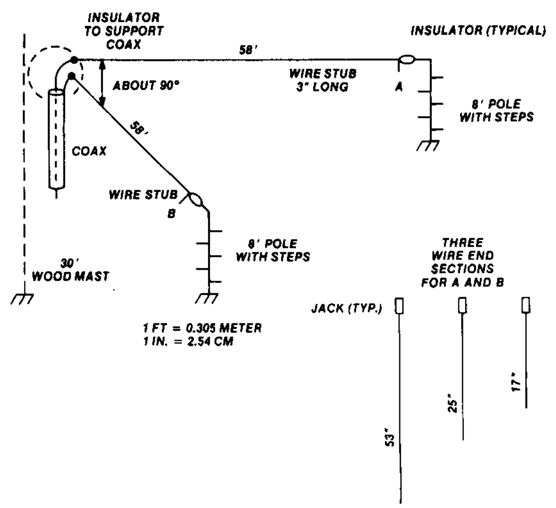

fig. 5. The compact 75/80 meter antenna at W2CZS. Stan has tip sections that he adds to each end of the V-dipole to alter length to his favorite spots in the band. It's easy to climb the 8-foot poles at the ends of the antenna and insert the tip section jacks into the wire stubs. Antenna is fed with RG-8/U coaxial line at apex.

58 feet long and are resonant at 4.0 MHz with an SWR of very close to 1:1. At the end tie-off point on each wire, a short section of wire hangs down from the insulator. To reach a lower frequency with a low value of SWR, Stan climbs each pole and clips a wire stub which hangs down from the end of the antenna. He can thus get a very low SWR on any frequency he wishes to work on the 80-meter band.

For example, two 25-inch stubs will lower the resonant frequency of the antenna to 3685 kHz and two 53-inch stubs lower the resonant frequency to 3555 kHz. Two 17-inch stubs provide low SWR at about 3800 kHz.

So there you are! Stan placed tip jacks on the ends of the antenna wires; the stubs are made of No. 12 solid wire and plug directly into the jacks. It takes but a moment to snap the wires into position.

This is a nifty antenna for those hams with a so-called "solid-state" transmitter that requires a very low value of SWR to load to full power. With just a little leg work, you can drop the SWR to near-unity at any point in the 80-meter band you choose. And the exercise is good for you!

the "all-band" antenna at W4GW

I can never get used to all these new-fangled calls. At least the ones starting with "W" sound natural. Now I find Ed Cushing, ex-W4QVJ, masquerading around as W4GW. What next?

In any event, regardless of the callsign, Ed has been around a long time and has tried many antennas. The one he recommends for high-frequency use has been around a long time, too — except that most hams have forgotten about it or have never heard of it. I guess you can call it an all-band antenna since you can tune it to any frequency in the 3.5 to 30 MHz range, including the new ham bands to be forthcoming at 10, 18, and 24 MHz. Best of all, it is only about 100 feet long (**fig. 6**). Ed says this antenna has very few compromises as it has no traps, and provides usable gain on some bands. Here's how it works:

On 80/75 meters, it is very close to a full dipole. On 40 meters it is two half-wavelengths long; on 20 meters it is close to two full-wavelengths and provides some gain over a dipole. On 15 meters it is four half-waves in phase and provides nearly 5 dB gain over a dipole. And on 10 meters, it acts as a center-fed long wire.

The two phasing stubs are made of open-wire TV "ladder line" (not ribbon), shorted at the bottom. The feedline is made of a random length of similar open-wire line, with an antenna tuner at the station end of the line. Ed notes that good quality glass insulators should be used to support the stubs, as considerable voltage occurs across these insulators on certain frequencies. If a problem exists with tuning up at any one frequency, changing the length of the feedline a foot or two will clear up the difficulty.

Ed has a bunch of trees on his property that made it impossible to put up a tower and rotary beam without removing some trees and damaging the appearance of his lot. So as a workable compromise he uses this antenna, plus a delta loop, with outstanding success on all bands!

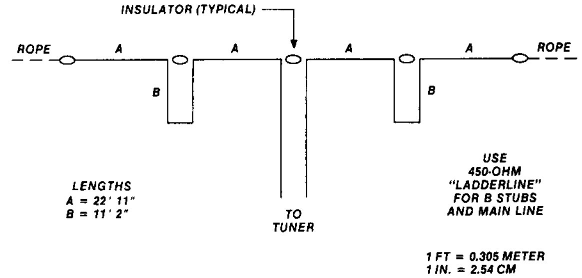

fig. 6. The 15-meter collinear array of W4GW provides nearly 5 dB gain on that band and also works on all bands from 3.5 MHz to 29.7 MHz, including the new 10, 18, and 24 MHz bands-to-be! The antenna is an "oldie but goodie."

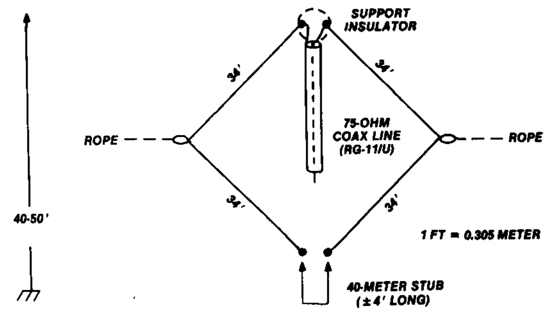

fig. 7. The two-band quad loop of W7CJB can be hung from a 40-foot-high tower. On 80 meters, the antenna operates as a dipole folded back upon itself. On 40 meters, the antenna acts as a quad loop, horizontally polarized. The bottom end of the antenna is open for 80 meters and closed with an adjustable, shorted stub for 40 meters.

the first transatlantic contact revisited

A short time ago I mentioned the first transatlantic ham QSO might have been made between the U.S.A. and England, rather than the famous contact between 1MO/1XAM and 8AB (France).

The purported QSO that brought this matter up was one reported in the August, 1931, issue of *QST* magazine; it was between 2AGB (U.S.A.) and 2JL (England) about a month before the famous QSO that has gone down in history as No. 1. Was this interesting story true, and how could it be verified? Efforts to contact either 2AGB or 2JL were futile. A friendly letter from the present holder of the call G2JL indicated he is not the original G2JL.

Now the matter seems to be finally settled by a letter from G6JP, George Jessop, the unofficial historian of the Radio Society of Great Britain and one of its former presidents.

George, an old friend of mine, looked into the matter and found that the original 2JL had been located in Crowley, Middlesex, England, and had used only a low-power spark transmitter. George talked the matter over with G2UV, who had known 2JL personally and had himself been involved in the early transatlantic test. G2UV, Bill Corsham, said that 2JL had not taken part in the tests, nor had he been capable of such a contact with his equipment.

The only other possibility was 2JF in Liverpool, who was quite active at the time and who might have made an early contact. But G2UV knew him also, and said that no such contact had taken place. So that seems to be the end of the matter. Unless more convincing evidence turns up, the original U.S.A./France contact still stands as the first transatlantic QSO. The first reception of an American Amateur in Europe was reported by 2KW in Manchester, England, who heard American 2FP just one day before the first transatlantic tests began!

And so it goes. Viewing those early days from these later days, it is remarkable that the early history of Amateur Radio is as well documented as it is. For those who are interested in the fascinating story of early Amateur Radio I recommend the book *Two Hundred Meters and Down* by Clinton B. DeSoto, ex-W1CBD, and obtainable from the American Radio Relay League, Newington, Connecticut 06111. It is a great story about the "roots" of Amateur Radio!

the 80-40 meter loop antenna of W7CJB

To wrap up this column, let's look at the simple two-band loop that is used at W7CJB. Old timers will recognize this, but it may be a new idea to some of our recently licensed friends (see **fig. 7**). Basically, it is a loop dipole that is opened opposite the feed point for 80-meter operation. This point is jumpered for 40-meter operation. The antenna is 34 feet on a side and is fed at the apex with 75-ohm coaxial line (RG-11/U). A good (but not exact) impedance match is obtained on each band and the antenna loads properly with most transmitters having a nominal 50-ohm antenna preference.

The loop can be hung vertically from a tower, or tilted outward from the tower if height is a problem. It has been used with towers as short as 40 feet.

With the bottom of the loop closed, the bottom legs are trimmed to provide resonance in the 40-meter band. The loop is then opened and resonance checked in the 80-meter band. You can temporarily fold back equal lengths of wire in the lower legs to find resonance at 3.9 MHz; you can then clip this off and use a four foot stub to short the antenna for 40-meter operation. The clip-on stub is a quick method of band changing, and costs next to nothing.

last call!

I have a few reprints of my series of articles entitled "Design Consideration for Linear Amplifiers." This series ran in *ham radio* in 1979, and it's a compendium of engineering information for those interested in building high-frequency linear amplifiers. A copy is free (except for postage).

Write to me at Varian EIMAC, 301 Industrial Way, San Carlos, California 94070, and ask for a copy. Please send three 20-cent stamps to cover postage (or whatever amount first-class mail will cost by the time this issue of HR reaches you!). Overseas readers, please include four IRCs with your request.

Note: Interested in build-it-yourself antennas? Send for *The Radio Amateur Antenna Handbook* by W6SAI and W2LX. It's available from Ham Radio's Bookstore, Greenville, New Hampshire 03048 for $6.95 plus $1.00 to cover shipping and handling.

ham radio

performance capability of active mixers

Part one: Basic mixer characteristics and interfering effects during the signal-handling process

Depending upon the application, a large variety of circuits are used in passive and active mixers. It appears that mixers have a figure of merit expressed in the form of intermodulation distortion performance (intercept points of the order *1, 2, 3...n*), suppression of harmonics and isolation, cut-off frequency, and local oscillator drive.

The simple mixer consisting of one diode is generally found only in small pocket radios. Any high-performance receiver or synthesizer application requiring mixers will make use of the harmonic-canceling effect of double-balanced mixers in a lattice configuration. Passive mixers have used either vacuum diodes, germanium diodes, silicon diodes or hot-carrier diodes. Two of the basic requirements for these mixers are perfect match of the transformers and perfect match of the diodes. As the diodes are used in what is called "large-signal application," the same nonlinear performance of the transfer characteristic that is responsible for mixing generates harmonics of the input frequency and of the local oscillator frequency; these may appear at the output of the double-balanced mixer if it is not carefully balanced. Perfect matching will prevent even-order harmonics from appearing at the output, and the so-called linear operation of the mixer, where the local oscillator does not drive the nonlinear device, will prevent excessive harmonic generation as such. Theoretically, mixers can be driven with square waves — another method of reducing harmonic combinations at the output.

While all passive mixers have losses, active mixers appear attractive because of their potential for showing gain. Using active devices as mixers, we must consider three different applications:

1. Additive mixers.

2. Multiplicative mixers.

3. Switching operation, where the active device is used as a switch and operated without dc voltage.

From a device point of view, we have three different possibilities:

1. Bipolar transistors in mixers.

2. Square-law-characteristic devices: junction field-

This article was originally presented as a paper by the author at the IEEE-sponsored Wescon conference on September 16, 1981.

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

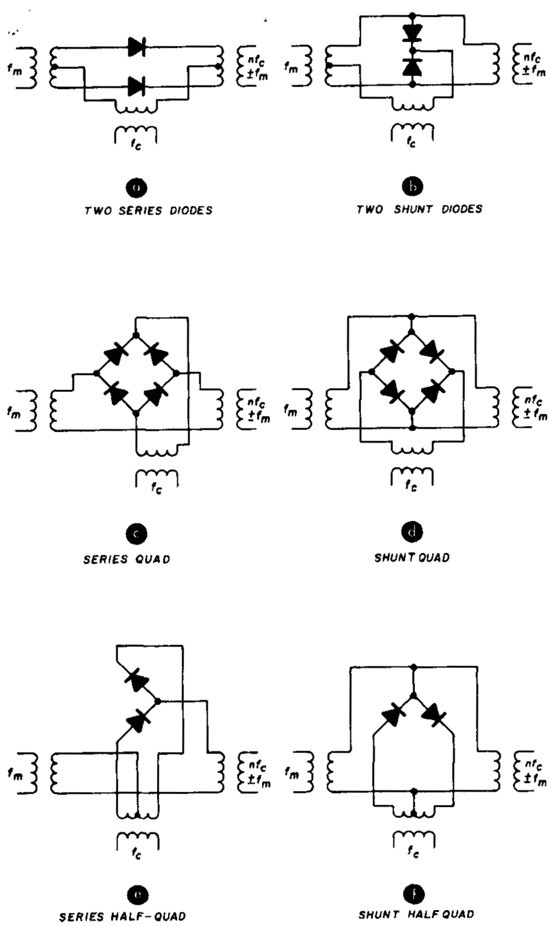

fig. 1. Series and shunt type mixers.

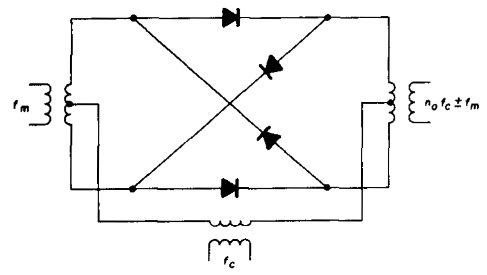

fig. 2. Standard-level double-balanced mixer.

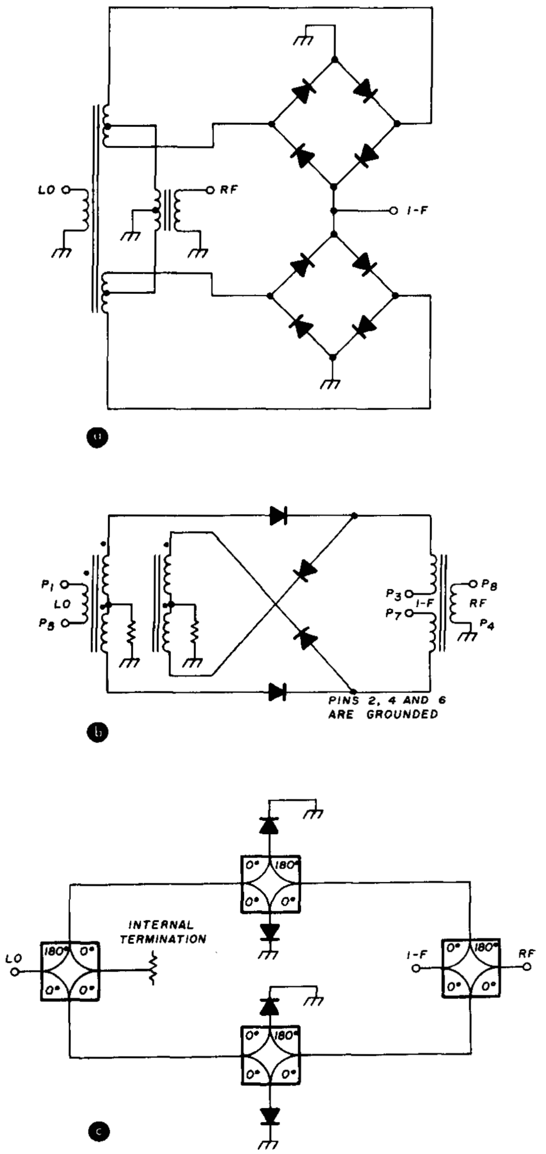

fig. 3. High-level double-balanced mixers, A and B, and termination-insensitive mixer, C.

effect transistors, MOS field-effect transistors, and enhancement field-effect transistors (VMOS).

3. Dual gate MOSFETS, or IC-type mixers.

This article shows some of the advantages, disadvantages, and high signal effects found in active mixers, their possible cures and trends. I should mention now that, for reasons explained very carefully in this article, either a) the passive mixer with special diode-ring configurations, or b) the field-effect transistors in a quad configuration used as a switch with no amplification is the ultimate choice for high performance. It has been shown experimentally that intercept points of +40 dBm are possible using active devices in passive mixers with about 6-dB loss and 6-dB noise figure.

Active mixers like synthesizers can be used in a constant-amplitude environment; however, in the more hostile environment typical of receiver applications, passive mixers are still less expensive, more reliable, and offer superior performance.

mixer basics

Mixing occurs in any nonlinear device where the V/I curve deviates from a straight line if and when two or more signals are applied to such a device. The ideal and so-called linear mixer is a square-law device, like a field-effect transistor, with the transfer characteristic

$$i_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_p}\right)^2 \qquad \textbf{(1)}$$

The transconductance is defined as the first derivative of d_i/d_v, and therefore

$$GM = \frac{2I_{DSS}}{V_p^2}\,(V_p - V_{GS}) \qquad \textbf{(2)}$$

This is called linear mixing. It can be seen that the transconductance, GM, is a linear function of the gate source voltage, V_{GS}.

Neglecting any nonlinear effects such as might be found in MOS field-effect transistors, or any reverse biasing effects as found in junction field-effect transistors, or inability to follow high-frequency input voltage as found in VMOS transistors, the square-law characteristic will generate only the second harmonic of the input and local-oscillator signal. A perfect match in a double-balanced configuration would cancel this.

This absence of a third-order term would theoretically prevent any odd-order intermodulation distortion product from occurring. Such a square-law characteristic is found in field-effect transistors as mentioned; and for small signals, silicon or hot-carrier diodes exhibit the same square-law characteristic.

A number of configurations are known using diodes in bridges to minimize harmonics at the output, and **figs. 1A** through **1F** show the series and shunt combination in which either two or four diodes can be used.

As shown in the literature,[1] even with ideal diodes of zero forward resistance and infinite reverse resistance, the conversion loss of either the series or shunt modulator is $20 \times \log(\pi) = (9.9\ dB)$. Practical modulators will have higher losses than this, as the diodes are not ideal.

Fig. 2 shows the ring or lattice double-balanced modulator as frequently used, and **fig. 3** shows the latest two most important derivatives of the double-balanced mixer, the two ring configuration and the termination-insensitive mixer. It has been explained very carefully in the literature[2] that all passive mixers are highly sensitive to changes in termination. The reason for this is that the non-zeroing effect of reactive currents at the output generates reflections inside the bridge and, therefore, causes distortion.

Double-balanced mixers are traditionally offered in 50-ohm input and output impedances and, as most rf applications now use 50 ohms, this is very convenient. It is extremely important that the input and output ports are balanced, and for this reason balun transmission-line transformers are used at these terminals. By using different wire sizes, the transmission-line transformer impedance can be changed to a different value. Additional external transformers can shift the impedance to almost any value required. **Fig. 4** shows a mixer with additional balancing at input and output. (The assumption that the 4:1 or 1:4 transformer provides ideal matching from unbalanced to balanced input or output is not necessarily true.) These discussions apply also to active mixers, as I have stressed that the input and output ports must be balanced to suppress harmonics.

The best passive mixers show an output intercept point of +30 to +35 dBm, use up to 64 monolithic diodes, and require up to +23 dBm of local-oscillator injection. A push-pull configuration of two balanced mixers can show isolation of up to +60 dB over an extremely wide frequency range; the insertion loss is in the vicinity of 5.5 dB and can be operated from 10

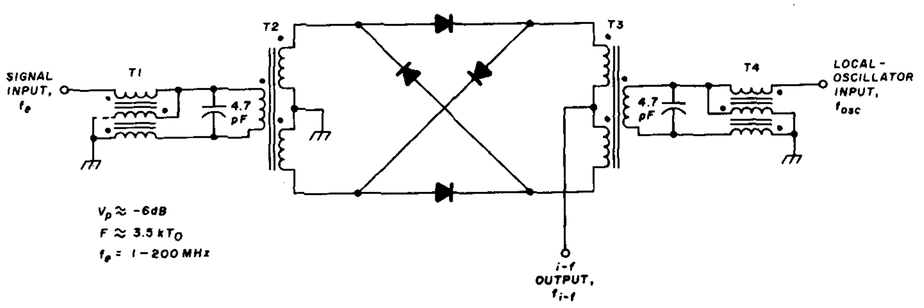

fig. 4. Practical circuit for a double-balanced mixer, including input and output balancing transformers.

kHz to several GHz, depending upon the transformers.

In the case of an active device, taking into consideration the linearities of the diode or active mixer, we can use the method of Fourier expansion to obtain the harmonic component of the local-oscillator pulse train of $0.2 = 2\pi/\omega$.

Fig. 5 shows the train of sine-wave tip current pulses if a sine wave, the local-oscillator signal, drives the slope of G that represents the transfer characteristic. The resulting output can be used to determine the time average conductance of the device as a function of the conducting angle. To do this, we use the Fourier cosine expansion

$$f(t) = a_0 + a_1 \cos \omega t + a_2 \cos 2\omega t + \ldots$$

$$= a_0 + \sum_{n=1}^{\infty} a_n \cos n\omega t \qquad (3)$$

where

$$a_0 = \frac{1}{T} \int_{-T/2}^{T/2} f(t)\, dt \qquad (4)$$

and

$$a_n = \frac{2}{T} \int_{-T/2}^{T/2} f(t) \cos n\omega t\, dt \qquad (5)$$

By defining $\theta = \omega t$ and integrating over $d\theta$, we obtain

$$a_0 = \frac{1}{\pi} \int_0^{\pi} f\left(\frac{\theta}{\omega}\right) d\theta \qquad (6)$$

and

$$a_n = \frac{2}{\pi} \int_0^{\pi} f\left(\frac{\theta}{\omega}\right) \cos n\theta\, d\theta \qquad (7)$$

From **fig. 5** it can be shown that the fundamental component

$$I_1 = \frac{2}{\pi} \int_0^{\phi} G(V_1 \cos \theta - V_x) \cos \theta d\theta$$

$$= \frac{2G}{\pi} \left(\frac{V_1 \phi}{2} + \frac{V_1 \sin 2\phi}{4} - V_x \sin \phi \right)$$

$$= \frac{I_p}{\pi} \left(\frac{\phi - \cos \phi \sin \phi}{1 - \cos \phi} \right) \qquad (8)$$

In a similar way, we obtain

$$I_0 = \frac{I_p}{\pi} \left(\frac{\sin \phi - \phi \cos \phi}{1 - \cos \phi} \right) \qquad (9)$$

and

$$I_n = \frac{2 I_p \cos \phi \sin n\phi - n \sin \phi \cos n\phi}{\pi\, n(n^2 - 1)(1 - \cos \phi)}, \; n \geq 2 \qquad (10)$$

As explained in my previous paper,[3] **fig. 5** can be drawn by plotting the normalized output, normalized voltage gain, and normalized mixing transconductance, S, as a function of normalized oscillator voltage. From **fig. 6**, we would see a practical value for $X = 0.75$, and we get a mixing (or conversion) transconductance $G_m = 0.56 \bullet G'_M = 1.25\ mS$ for a 2N3822 field-effect transistor. For a higher-order transfer characteristic, the approach would be the same, and the equation for I as a function of V would change.

As mentioned previously, we have three types of mixing:

Additive mixing. Additive mixing is based upon the

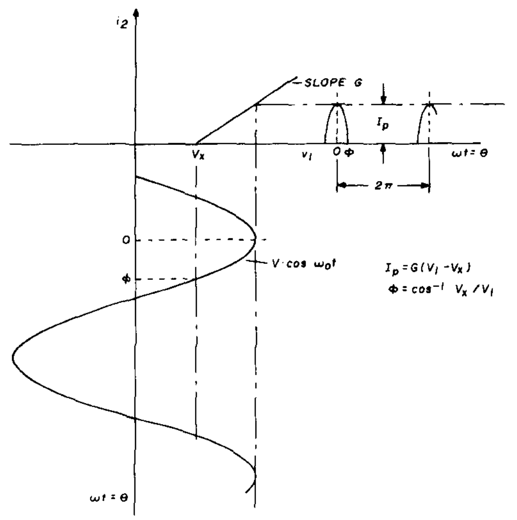

fig. 5. Sine-wave tips representing the time variable transconductance of a square-wave transfer-characteristic device.

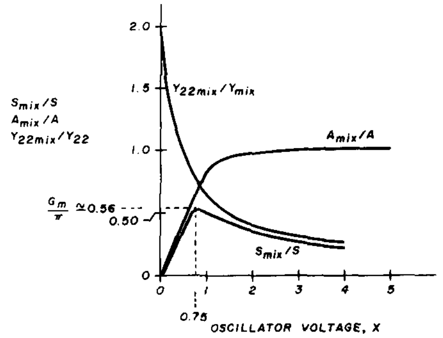

fig. 6. Normalized voltage gain, output impedance and mixing transconductance, S, for the FET.

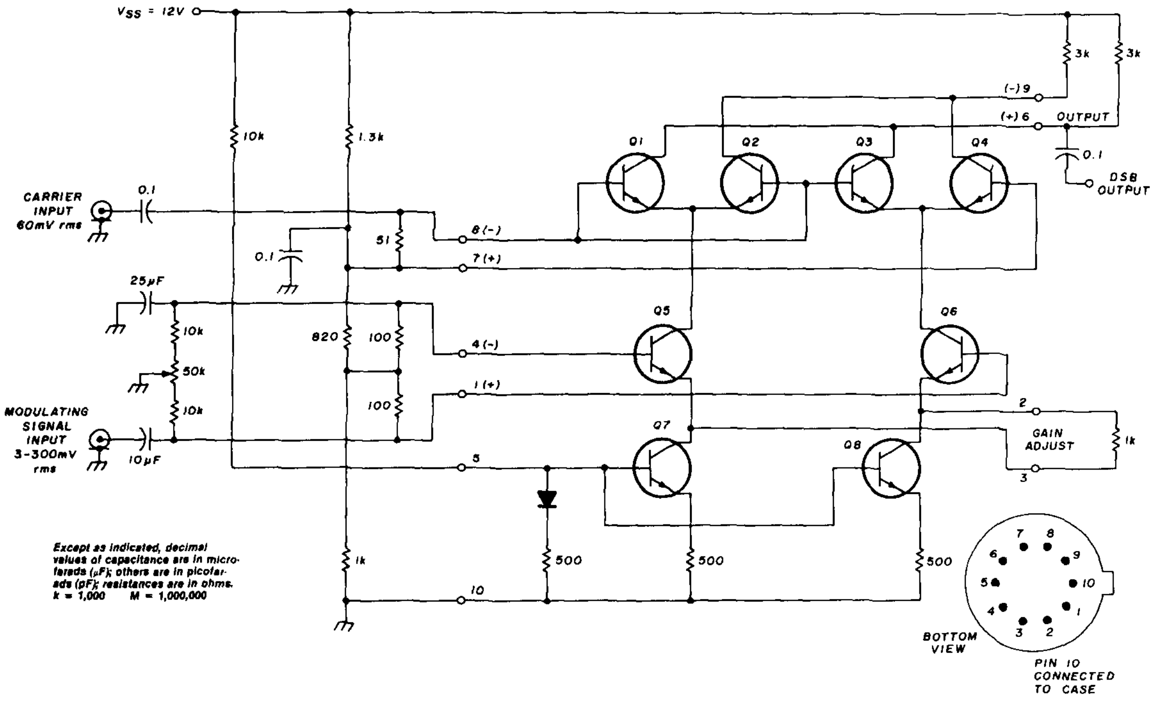

fig. 7. Active mixer using the Motorola MC1596.

fact that the two components $v_1(t)$ + $v_2(t)$ can be rewritten in the form

$$V = V_1 \cos \omega_1 t + V_2 \cos \omega_2 t \tag{11}$$

The expansion of this leads to the product

$$C(t) = \{\cos (A - B)t + \cos (A + B)t\}$$

Additive mixing would occur where the two signals are being fed in series. All field-effect and bipolar transistor mixers use the additive principle regardless of whether the local-oscillator signal is applied together with the rf signal to the same electrode (gate, base, source, or emitter) or to different electrodes.

Multiplicative mixing. Only in the case of a) a dual-gate MOSFET, and b) a differential amplifier with a constant-current source, can we use the term *multiplicative mixing*. However, the net result remains the same. The advantage in using multiplicative mixers is that isolation exists between the two ports, which means that very little or no interaction occurs between the rf and the local-oscillator port.

Fig. 7 shows a recommended circuit for the Motorola MC1596 integrated circuit, which is the basis for the Plessey mixer type SL6440 shown in its test circuit, **fig. 8**. Plessey reports an intercept point in the vicinity of +30 dBm, about 0-dB gain, and roughly an 11-dB noise figure.

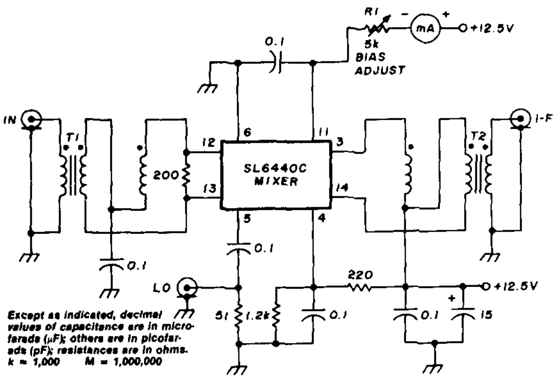

fig. 8. Recommended test circuit for the SL6440 active double-balanced mixer.

Mixing by switching. In the case of the double-balanced mixer using diodes, the diodes act as a switch. These switches must be fast enough to follow the local oscillator; therefore, hot-carrier diodes are used for high-frequency operation. Because of the switching, the input and output impedances are reflected at the output and input, and the mixer becomes transparent. The insertion loss is primarily determined by the fact that the sum and difference of the two signals is at the output, and only one of them is the wanted signal. If the input voltage is divided into two output voltages, we must have 3-dB loss. The additional losses occur from the fact that the diodes have series resistors, which are responsible for these losses. The amount of resistive loss is in the vicinity of 2 to 3 percent due to the 1-ohm resistance the diodes exhibit under switched-on conditions. Ideally, this type of mixing does not depend upon any transfer characteristic, and we will see later that if this type of operation is duplicated with active devices, we will obtain the best possible performance.

signal handling

The characteristic of the nonlinear device again can be expanded in the form:

$$
\begin{aligned}
g_m &= a_{01} \\
&+ \frac{a_{02}}{2!}v + \frac{a_{03}}{3!}v^2 + \frac{a_{04}}{4!}v^3 + \dots \\
&+ \left(a_{11} + \frac{a_{12}}{2!}v + \frac{a_{13}}{3!}v^2 + \frac{a_{14}}{4!}v^3 + \dots\right)\cos\omega_0 t \\
&+ \left(a_{21} + \frac{a_{22}}{2!}v + \frac{a_{23}}{3!}v^2 + \frac{a_{24}}{4!}v^3 + \dots\right)\cos 2\omega_0 t \\
&+ \dots
\end{aligned}
\tag{12}
$$

The following significant interfering effects can be distinguished:

a. Hum modulation, expressed by:

$$m_u \approx \frac{a_{12}}{a_{11}} V_u \tag{13}$$

where m_u = undesired modulation of carrier, and
V_u = = amplitude of the a-f voltage causing modulation.

b. Variation of the modulation depth, expressed by:

$$M \approx \frac{\Delta m}{m} = \frac{1}{4}\left(\frac{a_{13}}{a_{11}}\right) V_1^2 \tag{14}$$

where V_1 = average amplitude of desired signal.

c. Modulation distortion, expressed by

$$D_2 \approx \frac{3}{16}\left(\frac{a_{13}}{a_{11}}\right) V_1^2 \tag{15}$$

where V_1 = average amplitude of desired signal.

d. Cross-modulation, expressed by

$$K = \frac{m_k}{m} \approx \frac{1}{2}\left(\frac{a_{13}}{a_{11}}\right) V_u^2 \tag{16}$$

where V_u = average amplitude of undesired signal.

e. Spurious responses at $n_1 = 1$, $n_0 = x$, expressed by

$$\frac{V_1}{V_u(x,1)} \approx \frac{a_{x1}}{a_{11}} \tag{17}$$

where V_1 = average amplitude of desired signal, and $V_u(x,1)$ = amplitude of spurious signal giving the same output as the desired signal.

f. Spurious responses at $n_1 = 2$, $n_0 = x$, expressed by

$$\frac{V_1}{V_u(x,2)} \approx \frac{a_{x1}}{4a_{11}} V_u(x,2) \tag{18}$$

where V_1 = average amplitude of desired signal, and $V_u(x,2)$ = amplitude of spurious signal giving the same output as the desired signal.

The coefficients of **eq. 12** depend on the $i_2 = f(v_1, v_0)$ characteristics of the mixer. If, for example, the pseudo-static current I_2 of an additive mixer is shown as a power series,

$$I_2 = I_2(0) + pV + qV^2 + rV^3 + sV^4 + tV^5 + uV^6 + \dots$$

then for $V \rightarrow v + V_0 \cos \omega_0 t$, $I_2 \rightarrow i_2$, and since $i_2 - I_2(0) = g_m(t)v$,

$$a_{01} \approx p + 3/2rV_0^2 + \dots \tag{19}$$

$$\frac{a_{02}}{2} \approx q + 3sV_0^2 + \dots \tag{20}$$

$$\frac{a_{03}}{6} \approx r + 5tV_0^2 + \dots \tag{21}$$

$$a_{11} \approx 2qV_0 = 3sV_0^3 + \dots \tag{22}$$

$$\frac{a_{12}}{2} \approx 3rV_0 + 15/2tV_0^3 + \dots \tag{23}$$

$$\frac{a_{13}}{6} \approx 4sV_0 + 15uV_0^3 + \dots \tag{24}$$

$$a_{21} \approx 3/2rV_0^2 + 5/2tV_0^4 + \dots \tag{25}$$

$$\frac{a_{22}}{2} \approx 3sV_0^2 + 15/2uV_0^4 + \dots \tag{26}$$

The coefficients depend on the bias point. Using theoretical characteristics of the various mixers often leads to inaccurate results, because the influence of parasitic effects may be considerable.

The final part of this article discusses some practical circuits, including an active mixer with perfect termination, a passive double-balanced mixer with a termination stage, and a passive mixer with active devices. Finally, some suggestions are given for testing and analyzing mixer characteristics.

references

1. D.G. Tucker, *Modulators and Frequency-Changers*, Mc Donald & Co., Publishers Ltd., London, 1953, pages 72-75.
2. Ulrich L. Rohde, DJ2LR, "Optimum Design for High-Frequency Communications Receivers," *ham radio*, October, 1976.
3. Ulrich L. Rohde, DJ2LR, "The Field-Effect Transistor at V.H.F.," *Wireless World*, January, 1966, page 2.

ham radio

comments

(Continued from page 8)

lying SWR meters

Dear HR:

In the October, 1981, article on SWR meters, no mention was made of a serious fault in this family of meters. Lying SWR meters have been a major source of the confusion about SWR.

This meter, with slight variations, has appeared in the literature over a number of years. It has always had one fault: It gives correct indications only at one setting of R1 and R2, because the diodes are non-linear at low currents. If the pots are set at the low-resistance end, the meter will give optimistic indications of low SWRs. The scale the author shows in **fig. 3** can be correct at only one setting of the pots — and he does not tell how they were set when he made the scale.

The meter will give excellent results, though, if it is calibrated at one setting of the pots and the pots are left at that setting. Since the output level of almost all modern transceivers is adjustable over a wide range, it is not necessary to disturb the pots.

The meter is particularly good for permanent connection in the antenna line of a station. Moreover it is a better relative rf output indicator than the ones included in most transceivers.

Donald E. Johansson, WA4UPN
Tobaccoville, North Carolina

In response to the letter from Donald E. Johansson, WA4UPN, I would like to take this opportunity to make a few comments about the subject material and the general intent of the article. The article was intended to be a home project that could be built by an Amateur without extensive experience or lab-type test facilities. It was in no way claimed to be a state-of-the-art device but rather a handy device that is relative in nature rather than absolute.

As to the shortcomings of the unit, it, like many of its predecessors both commercial and homebrew, is not perfectly linear. This is because of the nature of the diodes, as discussed by Mr. Johansson. This in no way, however, reduces the use of such a device for Amateur applications.

As to the scale used for the reflected reading, it was developed with the aid of resistive loads at 21 MHz and 90 watts output power. This level was chosen to approximate today's transceivers. Performance of the completed units, two of which were built to insure that the unit could be duplicated from the manuscript, approximated that of a commercial unit of similar design.

Over the years there have been many articles published on the subject of SWR meters and their use, and many discussions as to their value to the Amateur. Arguments have been offered, both pro and con, as to the use of such meters and to what their readings really indicate about radiated power. In the course of this construction article I tried to avoid any empirical discussion of this nature and did not delve into the theory of transmission lines or antenna systems. The SWR meter article is strictly a weekend construction project, not a course on waves and fields.

My thanks to Mr. Johansson for his interest in the article and for pointing out the fact that this — and other meters of this type — should not be thought of as lab standards.

Ken Powell, WB6AFT
Boca Raton, Florida

on-air tune-up

Dear HR:

I would like to take exception to a statement made by Bob Locher, W9KNI, in his reply to a letter by Fred Streib, W6NA, in the September *ham radio*. Bob says that it is impossible to tune up a rig without putting the full signal from the final out to the antenna and thus on the air. Actually, it is easy to knock that signal down by 45 dB by using equipment that has been described in the ham magazines. All that is required is a transmatch (or in my case, a simple homebrew T-network tuner), a dummy load (which most hams already own, or should) and the K4KI tune-up bridge which was described in the December, 1979, *QST*. If Bob hasn't read this article, I would like to suggest that he does. I would likewise suggest that anyone else desiring to cut down on the unnecessary tune-up QRM on the bands read it.

The construction technique used by K4KI leaves something to be desired in the amount of radiated signal during tune-up. My technique was to use two Heath coaxial switches instead of a simple toggle switch to switch the bridge in and out of the line. I also used the toroid from a Heath HM-102 SWR meter (spare parts cost $2.00) for the bridge coupler element.

The use of this equipment forces the final to see an exact 50 ohm load even though the antenna itself may not be an exact match. Thus loading is exactly the same on the antenna as on the dummy load.

To me throwing two additional switches and adjusting two more controls is worth the effort, when I know that my tuning-up signal is 45 dB lower than it would be if I were tuning up on the air.

Wayne H. Sandford, Jr., K3EQ
Warrington, Pennsylvania

better than ever

Dear HR:

I didn't know if I'd like your magazine or not but I do — it's as good as *Ham Radio Horizons* ever was. I enjoy the fact that you've made it more technical than HRH but not so much that you need an EE degree to understand it. I really hope you continue along the lines you've established.

Paul E. Regan
Rye, Colorado

simple tests for TTL ICs

Checking 7400-series devices for homebrewing projects

The TTL IC tester described in the August, 1976, issue of *ham radio* is, I believe, a much needed test instrument for builders of modern equipment. Although suppliers of ICs guarantee the devices they sell — with promises of replacing them — the implication is that the buyer must test them. The low prices quoted indicate that something less than prime quality is being offered; thus the probability of there being some faulty units is high. Even supposedly prime-quality devices have been found to be faulty. Recently I bought two 7400s advertised as prime quality; each had one faulty gate!

The TTL tester described in *ham radio* is fine for someone building a circuit using fifty or more TTLs. However, I believe the person lured into building a circuit using only a few ICs, because of its simplicity and promised performance, needs a simple method of testing ICs. (Keyers and small counters are examples of such projects.)

It is my opinion that an elaborate tester is unnecessary, especially for homebrew projects using a small number of ICs of a few types. When the number of ICs reaches 50 or 100 or more, then a more elaborate unit, aimed at ease and speed of operation, is justified.

Thus, I'm submitting this description of a simple method of testing TTL ICs. All the necessary gear is usually available in most Amateur stations — particularly those of homebrewers. A voltmeter, 5-volt power supply, six or so clipleads with miniature alligator clips, and a resistor are all you need to check most TTL integrated circuits. Although not absolutely necessary, a DIP socket mounted in a small PC or perf board is helpful in handling the IC and its connections.

NAND gates

To check NAND gates such as the 7400, 7410, 7420, and 7430, connect +5V to pin 14, ground to pin 7, and a voltmeter to one of the gate outputs (pin 3, for instance on the 7400), (see **fig. 1**). The voltmeter should read, typically, less than 0.22 volt. To

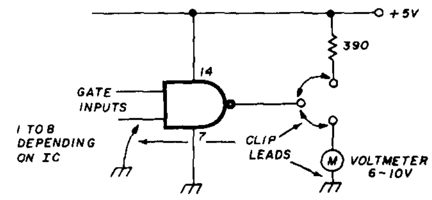

fig. 1. Test setup for checking NAND gates.

check fanout capability, connect a 390-ohm resistor between +5V and the gate output under observation. Voltage should read 0.4 volt or less (typically 0.22V). Check each gate output in this manner; that is, pins 3, 6, 8, and 11 on the 7400; pins 6, 8, and 12 on the 7410; and similarly on other NAND-gate ICs.

Remove the 390-ohm resistor, and with the voltmeter on the gate output, ground inputs of that particular gate, one at a time. Corresponding gate output voltage should increase to at least 2.4 volts as each input is grounded. Typical voltage is 3.3 volts; however, some units may show almost 4 volts. These are OK. Repeat this test on all gate outputs.

D-type edge-triggered flip-flops, 7474, are checked similarly (**fig. 2**). After connecting +5V and ground,

By Raymond F. Kramer, W6ALF, 1236 East Union Avenue, Fullerton, California 92631

connect the voltmeter to the Q output, pin 5 (or pin 9). With clipleads ground DATA pin 2 (or 12); also ground the CLOCK line, pin 3 (or 11). Now, ground PRESET pin 4 (or 10), momentarily. The Q output should increase to, and remain at least at, 2.4 volts — typically 3.5 volts. Ground CLEAR pin 1 (or 13) momentarily. The Q output should decrease to, and remain at, 0.22 volts (typical). Moving the ground (cliplead) alternately from PRESET to CLEAR will cause the voltage at Q to change from high (3.5V) to low (0.22V). With the voltage at Q at a low state (0.22V), remove the ground clip from DATA pin 2 (or 12). Then *momentarily remove* ground from the CLOCK line, pin 3 (or 11). The Q output should increase to at least 2.4 volts.

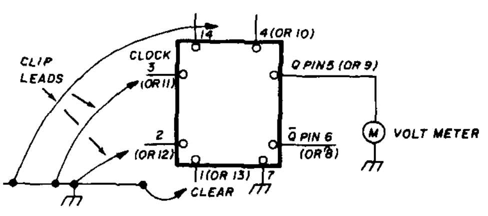

fig. 2. Checking edge-triggered flip-flops.

Restore the ground on the DATA line; momentarily remove the ground from the CLOCK line. The Q output should decrease to less than 0.4 volt. Momentary removal of the ground from the CLOCK line is a simple (and crude?) way to produce a positive-going clock pulse. An ordinary toggle switch, or, better yet, a spring-return switch instead of the cliplead would make the task easier, especially if many units must be tested.

Testing J-K flip-flops such as the 7470, 7472, 7473, 7476 and the decade counter, 7490, requires a little more equipment. The simple method of creating a clock pulse, described above, would give confusing results because of contact bounce. Thus, a no-bounce clock pulse is required. A simple way to achieve such a clock pulse employs a 7400 connected as a latch with spring-return switch operating the latch (**fig. 3**). A grounded cliplead could be used instead of the switch. Normally it would be on pin 5, then moved momentarily to pin 1 and back to pin 5. (An extra socket is required for the clock generator.)

The 7470 and 7472 may be checked in the same socket used for the 7474, 7400, and 7410. However, the 7473 and 7490 have terminals other than pin 14 for 5V and pin 7 for ground; and the 7476 requires a sixteen-pin socket. If testing is limited to ICs in the fourteen-pin DIP package, then three sockets allow

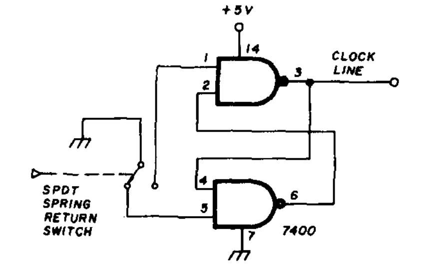

fig. 3. Method for testing J-K flip-flops. A no-bounce clock pulse is obtained by using a spring-return switch to operate the latch.

quite an array of ICs to be tested by this simple method. The 7473 uses pin 4 for 5V and pin 11 for ground, while for the 7490, 5V connects to pin 5, and ground connects to pin 10. To avoid adding a fourth socket, clipleads can be used to connect 5V and ground as required.

testing 7472s

The 7472 is representative of the J-K flip-flops, so its testing is described. Other J-K FFs may be tested similarly.

After the 7472 is plugged into the socket connect 5V and ground. Connect the CLOCK line from pin 3 of the clock generator to pin 12 of the 7472. Connect the voltmeter to the Q output, pin 8. With power on, ground PRESET momentarily (pin 13). The Q output should increase and remain at 2.4 volts (or more typically 3.5V). Ground CLEAR (pin 2) momentarily — the Q output voltage should decrease and remain at 0.22 volt typically — maximum of 0.4 volt.

Operate the switch on the clock generator. Q voltage should increase to 3.5V. Another operation of the switch and Q voltage should decrease to 0.22V. As the switch is operated, Q will alternate between high and low. With Q in the low state, ground K1, pin 9, and operate the clock switch. Q should change to high (3.5V). Remove the ground from K1 and apply it to J1, pin 3. Operate the clock switch — Q should decrease to low (0.22V). Repeat for K2 pin 10, J2 pin 4, K3 pin 11, and J3 pin 5 with the same results.

The 7470 is tested similarly; also the 7473. However, the 7473 has different terminals for 5V, ground, J, K and Q and has no PRESET or CLEAR. If clipleads are used to connect 5V and ground to the test socket, maximum cost effectiveness is achieved, particularly where only one or two ICs of a type are being checked.

The 7476 is a dual J-K FF, each with PRESET and CLEAR, and only one J and K input on each FF, in a sixteen-pin package. Testing is as for the 7472.

Fanout capability of flip-flops can be checked in the same manner as described for the NAND gates. Connect the 390-ohm resistor between 5V and $\overline{Q}$ or Q. When $\overline{Q}$ or Q is in the low state, voltage should be 0.4 volt or less.

Checking 7490s seemingly presents an added level of complexity; however, the simple tools described above can be used just as effectively. More time is required, since four FFs and several gates are involved, with four output lines to observe.

The test socket for the 7400 can be used if clip-leads are used to connect 5V (pin 5) and ground (pin 10). Pin 3 of the 7400 clock generator connects to pin 14, and pin 12 connects to pin 1 for decade counting. Reset lines pins 2, 3 and pins 6, 7 are connected to ground. The BCD output lines are pins 12, 9, 8 and 11 weighted as follows: pin 12 = 1, pin 9 = 2, pin 8 = 4, and pin 11 = 8. Counting is from zero to 9.

Resets should be checked before checking the counting function. Lifting ground momentarily from pin 2, 3 should reset count to ZERO. All outputs should read less than 0.4V (typically 0.22V). If ground is left on either pin 2 *or* 3, reset cannot take place.

Lifting ground from pins 6, 7 momentarily should reset to 9. Pins 1 and 11 voltages should be more than 2.4 volts, while pins 9 and 8 voltages are less than 0.4 volt. Reset the counter to zero to prepare for counting.

Each clock pulse; that is, each operation of the clock generator switch, should advance the 7490 count by one. The first clock pulse should cause the voltage at pin 12 to increase to 3.5V typically. Pins 9, 8 and 11 should remain low. The second clock pulse should cause the voltage at pin 9 to go high, others low. The third clock pulse causes voltage at pins 12 *and* 9 to go high; others remain low. The process continues until the count reaches nine — pins 12 and 11 are high. The next clock pulse brings all outputs to low.

More elaborate arrangements can be devised easily using a monostable multivibrator as a clock generator with an oscillator to drive it. Small discrete LEDS could serve as output indicators. Each LED can be connected to 5V through the 330-ohm line resistor, then to one of the outputs. The display would be reversed; TRUE would turn the LED off.

Simple test setups as described above should serve the occasional builder for most applications. Obviously, not all IC specifications are checked by these simple tests. For instance, rise and fall times, thus speed of operation, are not checked. When the construction project is expected to operate at speeds near the limit of TTLs, these tests may fail to reveal those faults.

ham radio

equations for determining antenna parameters

Horizontal antenna relative dB power gain versus terrain tilt, height, and vertical wave angle

If you're planning a new antenna installation, there are some questions you may ask:

1. I have enough money to either raise my present antenna or buy a new, larger antenna with more gain. Which option gives the most bang for the buck?

2. I live on the side of a hill that slopes 5 degrees downward to the east and 5 degrees upward to the west. What is the optimum tower height for 14-MHz low-angle radiation toward the east? Can I save money by using a smaller tower (that is, compared with another location on level terrain) if contacts toward the east are my major concern? How many low-angle, 14-MHz dBs will I lose toward the west?

3. I'm considering the purchase of either a 40-foot (12-meter) or 55-foot (17-meter) tower. How many dBs will I gain at low DX wave angles on each Amateur band with the higher tower?

4. I live on top of a hill, but the hill starts sloping downward 800 feet (244 meters) from my location. How much gain do I actually realize from this hill site at low DX wave angles for each Amateur band with an antenna H feet (or meters) above local terrain?

I have fitted equations to the data in the ARRL *Antenna Book* (reference 1), providing quantitative answers to the questions listed above. I've also written a program in BASIC that can be adapted to most of the popular programmable handheld calculators. This program and output listings are available to interested readers.*

calculator equations

Define: h = *antenna height in wavelength units,* λ, *above perfectly conducting ground*

F = *frequency (MHz)*

H = *antenna height, feet or meters*

then $h = FH/983.5$, *H in feet*

$h = FH/299.8$, *H in meters*

Define: θ = *vertical radiation angle (deg)*

*For a copy of the BASIC program and output listings, send a self-addressed envelope with 27 cents postage and $2.50 to cover reproduction costs to Robert W. Hume, KG6B, 1627 1st Street, Manhattan Beach, California 90266.

By Robert W. Hume, KG6B, 1627 First Street, Manhattan Beach, California 90266

$(\theta = 90 \text{ deg vertically upward})$

$\alpha = \text{ground tilt (deg)}$

$(\alpha = 0$ *for horizontal terrain;*
$\alpha < 0$ *transmitting downhill)*

The relative dB power gain, G_R, due to direct and reflected waves (from reference 1, page 46) is:

$$G_R = 20 \log_{10} \{\sin[360° h \sin(\theta - \alpha)]\} \quad dB\ power\ for\ \alpha < \theta < (180° + \alpha) \qquad (1)$$

The relative dB power gain G_{RR} due to change in antenna radiation resistance with height h is (from reference 1, page 54):

$$G_{RR} = -10 \log_{10} \frac{R_h}{R_0} \ dB\ power \qquad (1A)$$

where R_h = *radiation resistance at height h*

R_0 = *free-space radiation resistance*

For a half-wave horizontal dipole, the following fitted equations apply (reference 1, page 50):

$$(R_h/R_0 = (2.671\, h + 6.85\, h^2) \quad for\ h \lesssim 0.234 \qquad (2)$$

$$R_h/R_0 = \{1 + 0.419 \exp[-(h - 0.234)/0.6] \sin[700°(h - 0.234)]\} \quad for\ h \gtrsim 0.234 \qquad (3)$$

$$R_0 = 73\ ohms \qquad (4)$$

The ratio (R_h/R_0) is the normalized change in radiation resistance with height and depends on the type of horizontal antenna (*that is*, G_{RR} for a dipole and a Yagi is not the same).

The total relative dB power gain, G, due to both reflection and radiation resistance effects is

$$G = (G_R + G_{RR}) \quad G(\theta, h, \alpha)\ dB\ power \qquad (5)$$

Define a terrain tilt gain, G_α, about fixed values of θ_0 and h_0 as follows:

$$G_\alpha = G(\theta_0, h_0, \alpha) - G(\theta_0, h_0, \alpha = 0) \qquad (6)$$

G_α represents the relative dB power gain at ground tilt α compared with horizontal ground when h and θ remain fixed. Note that since h_0 is fixed, the G_{RR} part of G will subtract in the difference, giving a result depending only on the G_R part of G. Thus G_α is valid for any type of horizontal antenna.

The explicit solution for G_α is

$$G_\alpha = 20 \log_{10} \frac{\sin[360° h \sin(\theta - \alpha)]}{\sin(360° h \sin\theta)} \ dB\ power \qquad (7)$$

Table 1 (reference 1, page 18) gives representative wave angles, θ, for a 3500-mile (5600-km) path between New Jersey and England.

table 1. 3500 mile (5600 km) path wave angle, θ.

F (MHz)	θ_L (1 percent low)	θ_M (median)	θ_H (1 percent high)
7	10 degrees	22 degrees	35 degrees
14	6 degrees	11 degrees	17 degrees
21	4 degrees	7 degrees	12 degrees
28	3 degrees	5 degrees	9 degrees

The 1-percent low-wave angles, θ_L, are probably representative of marginal band opening and closing DX propagation conditions. Contest operation over a fixed 24-hour period could be enhanced by *radiation at low angles* during such periods.

terrain tilt

An important question relative to attaining ground tilt gain, G_α, is how close in and far out from the antenna must the terrain tilt by α degrees? In certain cases, where the terrain starts sloping too far from the antenna, (for instance, on the broad flat top of a mountain) it can turn out that the terrain is effectively flat. In other cases, a small slope only a few hundred feet in front of the antenna can have significant G_α gain effect.

The ground-reflection gain, G_R, has maxima at angles θ_m given by

$$\theta_m = \alpha + \sin^{-1} \frac{(2m-1)}{4h} \quad where\ m = 1,2,3,\ldots \quad and\ m \lesssim \left(\frac{4h+1}{2}\right) \qquad (8)$$

The first vertical maxima $(m = 1)$ is at

$$\theta_1 = \alpha + \sin^{-1}\left(\frac{1}{4h}\right) \quad for\ h > 0.25 \qquad (9)$$

The distances from the antenna to the near point, X_N, and far point, X_F, of the bounce zone required to support radiation at the first maxima θ_1 are given in reference 2 as

$$X_N = 7.12 \times 10^{-4} FH^2 feet = 2.33 \times 10^{-3} FH^2 meters$$
$$X_F = 2.37 \times 10^{-2} FH^2 feet = 7.77 \times 10^{-2} FH^2 meters \qquad (10)$$

As an example, a 14-MHz antenna at a height $H = 50$ *feet (15 meters)* has a first maximum bounce zone extending from $X_N = 25$ *feet (7.6 meters)* to $X_F = 830$ *feet (253 meters)* in front of the antenna. It is over this region that the ground slope is significant and over which it should be assessed to evaluate low angle G_α gain.

Figs. 1 and **2** show plots that demonstrate the significance of the equation results for low-angle radiation of interest to a DXer.

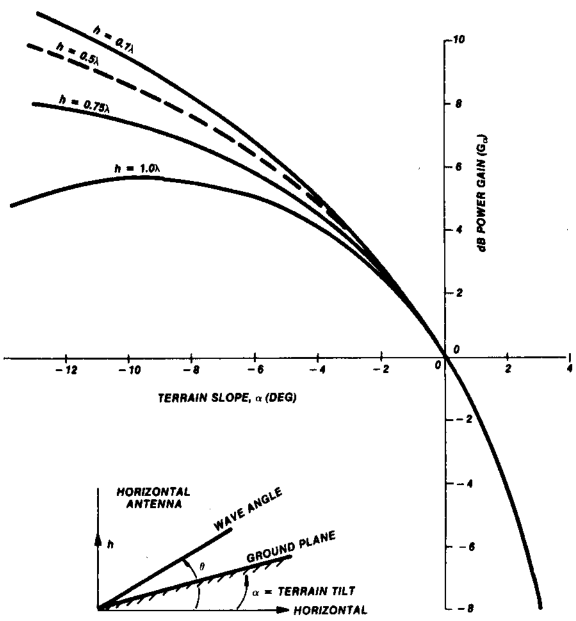

fig. 1. Horizontal antenna gain as a function of terrain slope (θ = 5 degrees).

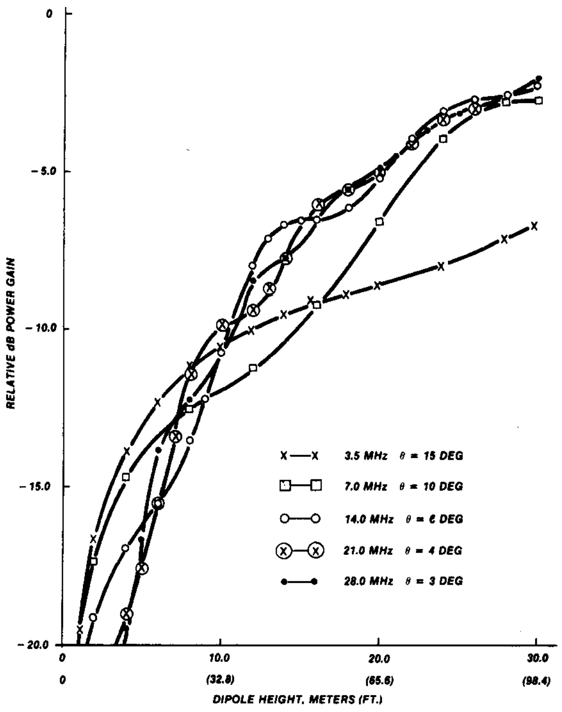

fig. 2. Dipole relative dB power gain as a function of height (level terrain; low wave angle).

references

1. *The ARRL Antenna Book*, 13th edition, American Radio Relay League, Newington, Connecticut.
2. *Reference Data for Radio Engineers*, ITT, 6th edition, page 31-12.

ham radio

More Details? CHECK—OFF Page 98

making waves

a close look at an unanticipated feature

Few will deny that electronics is becoming increasingly linked to digital techniques, apparently leaving the analog world behind. Careful consideration however will show that analog techniques have not been left in the past, and this is best illustrated by examining "digital" waveforms.

Pulses, ramps, sawtooths, and square waves are all collections of many sine wave harmonics and may be described by the Fourier theorem. Logic designers should be aware of this, since this "analog composite" can affect the final circuit and waveshape.

the Fourier theorem in brief

Any repetitive waveform is composed of sine waves, harmonically related with specific relative magnitude and phase relationships. A sine wave has only one harmonic, the fundamental. Symmetrical square waves have the fundamental and only odd harmonics. A sawtooth has both odd and even harmonics.

Fig. 1 shows the formation of a square wave. **Fig. 1A** has the fundamental and a smaller magnitude, in-phase third harmonic. It appears little more than a distorted sine wave. Adding the fifth harmonic as in **fig. 1B** will start to square the result.

At the addition of odd harmonics up to the fifteenth (**fig. 1C**), the summation looks quite square. Summing *all* odd harmonics would give a perfect sine wave. Interested readers can consult texts for the mathematical details of summation.

Fig. 1D is the result of adding *many* odd harmonics. Note the slight overshoot on the edges of **fig. 1C** and the definite "rabbit ears," or corner spikes, in **fig. 1D**. These rabbit ears are a result of a *finite* number of harmonics, a "mathematically practical" square wave.

the Gibbs phenomenon

Fourier dealt with numbers to infinity. Since practical bandwidth isn't infinite, a physicist by the name of Gibbs investigated the result of distortion caused by a limited number of harmonics. This is the Gibbs phenomenon, and it applies principally to waveforms with sharp corners.

As one adds odd harmonics, the rabbit-ear spikes of the square wave become narrower until they are infinitesimally thin. Limiting the harmonics yields

By Irv Gottlieb, W6HDM, 931 Olive Street, Menlo Park, California 94025

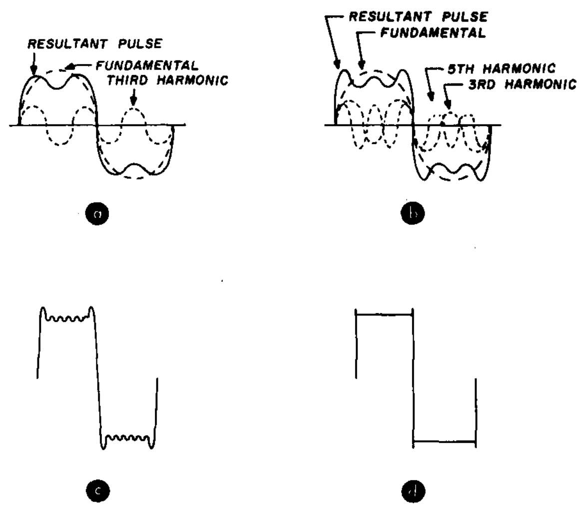

fig. 1. Evolution of a square wave from harmonics. *(A)* is fundamental and 3rd harmonic; *(B)* is fundamental, 3rd, 5th harmonics; *(C)* fundamental with odd harmonics up to 15th; *(D)* several hundred odd harmonics showing the Gibbs phenomenon corner spikes.

definite spikes. These spikes are not caused by circuit parasitics or inductive kickback; they are simply the sum of a finite number of harmonics.

now you see it, now you don't

The Gibbs phenomenon can be readily observed on low-frequency waveforms, say those at power-line frequencies. Oscilloscope bandwidth limitations, stray series-circuit inductance, and shunt capacitance all attenuate the spikes of faster waveforms.

Gibbs phenomenon rabbit ears depend on all harmonics starting with the same phase and magnitude described by Fourier. Since bandwidth reduction of measuring instruments involves both magnitude and phase shift of higher frequencies, the "mathematically perfect" square wave edges have little overshoot. The phenomenon still exists but is difficult to see at higher frequencies.

sawtooth generation

The Gibbs phenomenon can be quite prominent in a sawtooth waveshape. The sawtooth is the sum of many odd and even harmonics, and a representative waveform with ten harmonics is shown in **fig. 2**. The limitation of harmonics shows a pronounced Gibbs phenomenon overshoot.

It is well to emphasize that the summation in the square or sawtooth wave takes place in a *linear* circuit. No heterodyning is involved in these examples. One can sum lower-frequency harmonics in an op amp to synthesize any desired waveform. One such circuit is shown in **fig. 3**.

experimenting with harmonic combinations

The summing amplifier of **fig. 3** can be fed from a harmonic generator such as the one in **fig. 4**. Good results are possible by choosing a fundamental frequency in the 30 kHz range; input in **fig. 4** may be either a sine or square wave.

The resonant circuits in **fig. 4** should have a high ratio of capacitance to inductance for greatest purity at each harmonic output. Amplitude and phase adjustments are relatively independent. Stable phase-synchronous harmonics are generated — a task difficult to do with four separate oscillators.

The setup is simple for the sawtooth waveform. Phase adjustments are set so that all zero crossings occur at the same time and in the same direction relative to the fundamental. A dual-trace oscilloscope is best for this adjustment. Amplitude of the second harmonic is set for half that of the fundamental, the third harmonic is one-third amplitude, and the fourth harmonic amplitude is one-fourth the fundamental.

Combining these four sine waves in the summing

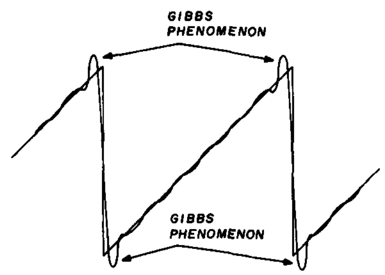

fig. 2. Sawtooth formed from fundamental and ten successive harmonics. Overshoot addition to sawtooth shape is due to Gibbs phenomenon.

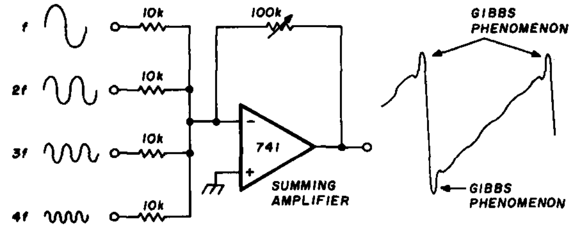

fig. 3. A summing amplifier capable of providing a rudimentary sawtooth wave from four harmonic sources.

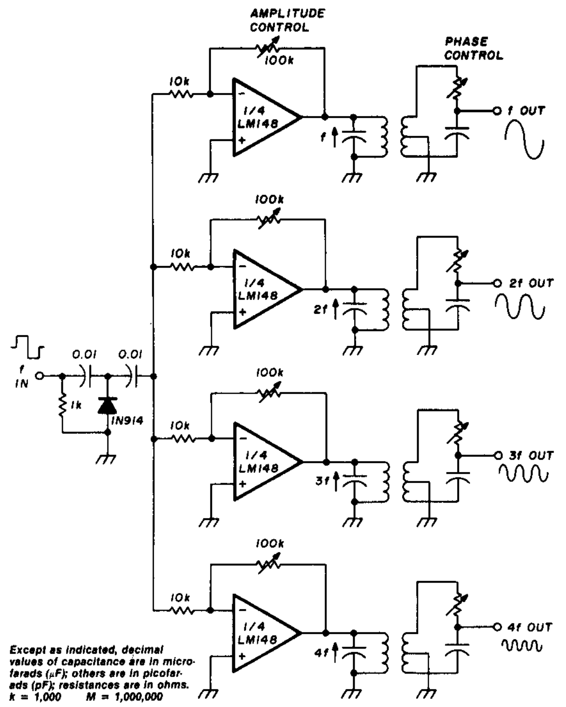

fig. 4. A four-frequency harmonic generator for synthesizing waveforms with the summing circuit of *fig. 3*.

circuit of **fig. 3** will produce a sawtooth with a clearly visible Gibbs phenomenon. Variation of amplitudes and phases can produce interesting waveforms with easily measured harmonic characteristics.

conclusion

The waveshapes discussed here are generally produced by specific digital circuitry. They can also be produced by linear circuitry using the predictable Fourier coefficients for each harmonic magnitude and phase. Awareness of the Gibbs phenomenon is bound to pay dividends. One thereby gains deeper insight regarding the simulation of musical tones. Or, perhaps, the erratic triggering of a logic circuit may be understood. And maybe it isn't semiconductor charge-storage, saturation, or inductive counter-EMF that is ruining your ideal waveform!

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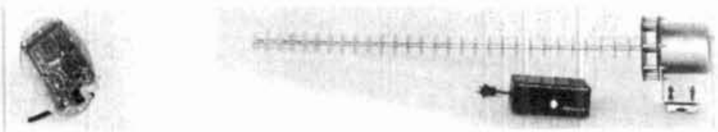

Prices including UPS shipment are as follows:

Model RP receiver package	$135
Model RP+ receiver package	$155
Model CB	$50

K. & S. Enterprises
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SURGE SHUNT

protects solid state communications equipment from damage caused by high-voltage transients entering the antenna system

These transients usually are caused by atmospheric static discharges or nearby lightning strikes.

The new **Model 1549 Surge Shunt** can be used with both receivers and transceivers having up to 200 watts output. Convenient UHF type coaxial connections are supplied. Price is **$24.95**

The arrester "pill" element has a long life, but can be easily and economically replaced if necessary.

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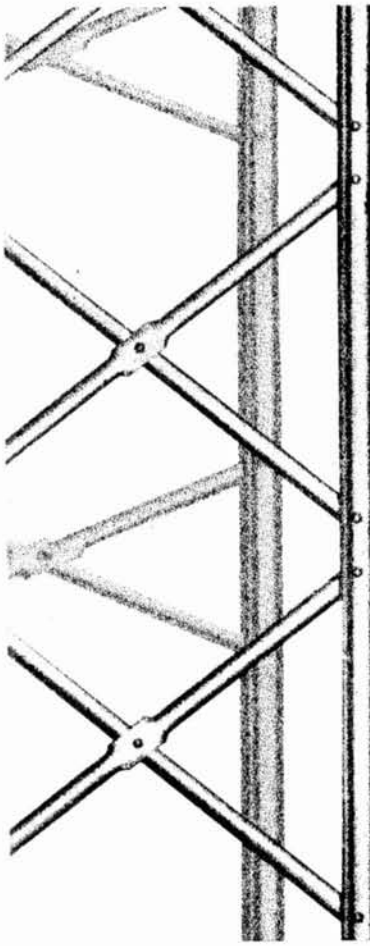

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Division of UNR Industries, Inc.
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Antenna Baluns

Model PB

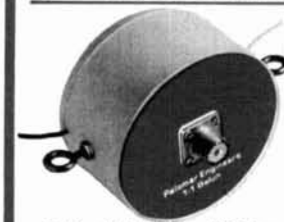
$14.95

350 watts PEP. 1.7 to 30 MHz. Low cost. High performance. Just right for transceivers. Specify desired ratio from table below:

Model	Ratio	Matches 50 ohms to
PB-1	1:1	50 ohms
PB-1.5	1.5:1	75 ohms
PB-2	2:1	100 ohms
PB-3	3:1	150 ohms
PB-4	4:1	200 ohms
PB-5	5:1	250 ohms
PB-6	6:1	300 ohms
PB-7.5	7.5:1	375 ohms
PB-9	9:1	450 ohms
PB-12	12:1	600 ohms
PB-16	16:1	800 ohms

Model 1K
$32.50

1 Kw CW, 3Kw PEP input. 1:1 or 4:1



Model 2K
$52.50

2 Kw CW, 6 Kw PEP input. 1:1 or 4:1

Beam Balun
$57.50

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An incredibly compact, full-featured, reasonably priced, all solid-state HF SSB/CW transceiver for both mobile and fixed operation. It covers 3.5 to 29.7 MHz (including the three new Amateur bands) and features digital display, IF shift, speech processor, and narrow/wide filter selection on both SSB and CW.

TS-130SE FEATURES:

- **80-10 meters, including three new bands**
  Covers all Amateur bands from 3.5 to 29.7 MHz, including the new 10, 18, and 24-MHz bands. Receives WWV on 10 MHz. VFO covers more than 50 kHz above and below each 500-kHz band.
- **Two power versions...easy operation**
  TS-130SE runs 200 W PEP/160 W DC on 80-15 meters, and 160 W PEP/140 W DC on 12 and 10 meters. TS-130V runs 25 W PEP/20 W DC input on all bands. Solid-state, wideband final amplifier eliminates transmitter tuning; receiver wideband RF amplifiers eliminate preselector peaking.
- **Digital display built-in**
  Six-digit green fluorescent tube display indicates operating frequency to 100 Hz, external VFO or fixed-channel frequency, RIT shift, and CW transmit-receive shifts. Analog subdial back-up.
- **Built-in Speech Processor**
  Increases audio punch and average SSB output power.
- **IF shift circuit**
  Very effective in eliminating interfering signals, by placing them outside the IF passband.
- **CW narrow/wide selection**
  "N-W" switch allows selection of wide or narrow bandwidths. Wide CW and SSB bandwidths are the same. Optional YK-88C (500 Hz) or YK-88CN (270 Hz) filter may be installed for narrow CW.
- **SSB narrow selection**
  "N-W" switch allows selection of narrow SSB bandwidth to eliminate QRM, when optional YK-88SN (1.8 kHz) filter is installed. (CW filter may still be selected in CW mode.)
- **Sideband mode selected automatically**
  LSB on 40 meters and below; USB on 30 meters and above. SSB REVERSE position on MODE switch.
- **RF Attenuator, built-in**
  Allows optimum rejection of IM distortion.
- **Single conversion PLL system**
  Provides improved stability and spurious characteristics.
- **Protection circuit for final amplifier.**
  For maximum reliability, the final amplifier is protected by circuitry that monitors VSWR and temperature. (TS-130V, VSWR only.) Output power is reduced when abnormal operating conditions occur. If especially severe operation is anticipated, optional cooling fan, model FA-4, may be added. Model TS-130S, with FA-4 installed, is also available.
- **Effective noise blanker**
  Eliminates pulse-type noise.
- **Compact and lightweight**
  Only 3-3/4 H x 9-1/2 W x 11-9/16 D (inches); weight 12.3 lbs.
- **Other important features include:**
  VOX for SSB, CW semi break-in with sidetone, one fixed channel, and 25 kHz marker.

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

More information on the TS-130 Series is available from all authorized dealers of
Trio-Kenwood Communications
1111 West Walnut Street
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Matching accessories for fixed station operation:

- PS-30 base station power supply (remotely switchable ON or OFF with TS-130SE power switch).
- SP-120 external speaker
- VFO-120 remote VFO
- MC-50 50kΩ/500Ω desk microphone

Other accessories not shown:

- FA-4 fan unit for TS-130SE
- YK-88C (500 Hz) and YK-88CN (270 Hz) CW filters
- YK-88SN (1.8 kHz) narrow SSB filter
- AT-130 compact antenna tuner (80-10 meters, including 3 new bands)
- MB-100 mobile mounting brackets
- KPS-21 base station power supply (also for TS-130SE)
- TL-922A linear amplifier
- PS-20 base-station power supply for TS-130V
- PC-1 phone patch
- HC-10 world digital clock
- MC-30S and MC-35S noise cancelling hand microphones
- MC-60 deluxe desk microphone
- SP-40 compact mobile speaker
- HS-4, HS-5, and HS-6 headphones

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

R-1000

High performance, easy tuning, digital display

The R-1000 high performance communications receiver covers 200 kHz to 30 MHz in 30 bands. An up-conversion PLL synthesized circuit provides improved sensitivity, selectivity, and stability.

R-1000 FEATURES:
- Covers 200 kHz to 30 MHz.
- 30 bands, each 1 MHz wide.
- Five-digit frequency display with 1-kHz resolution and analog dial with precise gear dial mechanism.
- Built-in 12-hour quartz digital clock/timer.
- RF step attenuator.
- Three IF filters for optimum AM, SSB, CW.
- Effective noise blanker. • Tone control.
- Built-in 4-inch speaker. • Dimmer switch.
- Wire and coax antenna terminals.
- Voltage selector for 100, 120, 220, and 240 VAC. Operates on 13.8 VDC with optional DCK-1 kit.

R-600

"Now hear this"...digital display, easy tuning

The R-600 is an affordably priced, high performance general coverage communications receiver covering 150 kHz to 30 MHz in 30 bands. Use of PLL synthesized circuitry provides maximum ease of operation.

R-600 FEATURES:
- 150 kHz to 30 MHz continuous coverage, AM, SSB, or CW.
- 30 bands, each 1 MHz wide, for easier tuning.
- Five digit frequency display, with 1 kHz resolution.
- 6 kHz IF filter for AM (wide), and 2.7 kHz filter for SSB, CW and AM (narrow).
- Up-conversion PLL circuit, for improved sensitivity, selectivity, and stability.
- Communications type noise blanker eliminates "pulse-type" noise.
- RF Attenuator allows 20 dB attenuation of strong signals.
- Tone control. • Front mounted speaker.
- "S" meter, with 1 to 5 SINPO "S" scale, plus standard scale.
- Coaxial and wire antenna terminals.
- 100, 120, 220, and 240 VAC, 50/60 Hz. Selector switch on rear panel.
- Optional 13.8 VDC operation, using DCK-1 cable kit.
- Other features include carrying handle, headphone jack, and record jack.

Optional accessories for R-600 and R-1000:
- DCK-1 DC Cable kit. • SP-100 External Speaker.
- HS-6, HS-5, HS-4 Headphones.
- HC-10 Digital World Clock.

TS-660

The TS-660 "QUAD BANDER" covers 6, 10, 12, 15 meters.
- FM, SSB (USB), CW, and AM
- Dual digital VFO's
- Digital display
- IF shift built-in
- 5 memories with memory scan
- UP/DOWN microphone
- All-mode squelch
- Noise blanker
- CW semi break-in/sidetone
- 10 W on SSB, CW, FM; 4 W on AM.

Optional accessories:
- PS-20 power supply
- VOX-4 speech processor/VOX
- SP-120 External speaker
- MB-100 Mobile mount
- YK-88C, YK-88CN CW filters
- YK-88A AM filter.

TS-530S

"Cents-ational"...IF shift, digital display, narrow-wide filter switch

The TS-530S SSB/CW transceiver covers 160-10 meters using the latest, most advanced circuit technology, yet at an affordable price.

TS-530S FEATURES:
- 160-10 meters, LSB, USB, CW, all amateur frequencies, including new 10, 18, and 24 MHz bands. Receives WWV on 10 MHz.
- Built-in digital display (six digits, fluorescent tubes), with analog dial.
- IF shift tunes out interfering signals.
- Narrow/wide filter selector switch for CW and/or SSB.
- Built-in speech processor, for increased talk power.
- Wide receiver dynamic range, with greater immunity to overload.
- Two 6146B's in final, allows 220W PEP/180 W DC input on all bands.
- Advanced single-conversion PLL, for better stability, improved spurious characteristics.
- Adjustable noise-blanker, with front panel threshold control.
- RIT/XIT front panel control allows independent fine-tuning of receive or transmit frequencies.

Optional accessories:
- SP-230 external speaker with selectable audio filters.
- VFO-240 remote analog VFO.
- VFO-230 remote digital VFO.
- AT-230 antenna tuner/SWR/ power meter.
- MC-50 desk microphone
- KB-1 deluxe VFO knob.
- YK-88C (500 Hz) or YK-88CN (270 Hz) CW filter.
- YK-88SN (1.8 kHz) narrow SSB filter.

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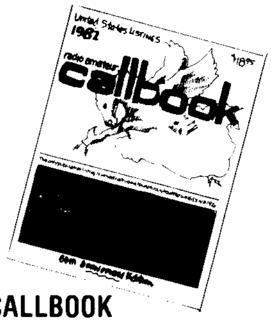
1982 U.S. RADIO AMATEUR CALLBOOK



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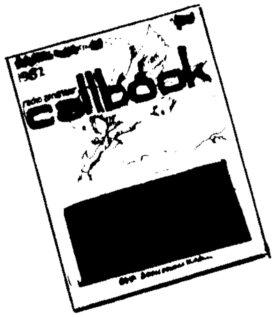

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☐21874 **Hardbound $34.95**

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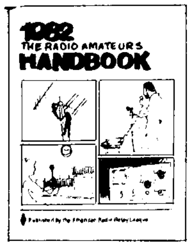

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This revised edition of **Band-Aids** contains a collection of the most often used operating aids, charts and tables that every Ham needs. Not only does it cover the fundamentals of operating, but it also contains operating aids for CW Communications, WWV and WWHH broadcasting schedules, DXCC check sheet and international prefixes, plus many other features. A handy reference data section includes conversion tables, metric data and abbreviations. ©1981, 156 pages.

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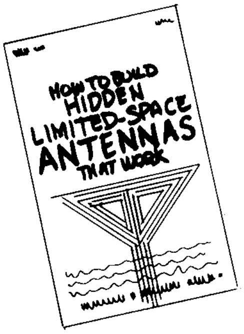

by R. J. Traister

Space problems limiting your signal? It doesn't have to be that way. How-to book complete with plenty of projects on how to put out that big signal. Projects include suspended multi-band vertical, window antenna, attic dipole, 20m indoor antenna, two meter coaxial and much more. Softbound 308 pages. ©1981.

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by Joseph J. Carr, K4IPV

All-in-one manual. Contains complete data on almost all receivers in use today. Written in an easy-to- read manner, this handbook includes basic receiver types; specifications for the latest ideas in parameter measurements such as sensitivity, noise figures, dynamic range, and selectivity measurements. Also covered are all types of modern receiver circuits, and a wide range of trouble-shooting ideas for both solid-state and vacuum tube receiver circuits. ©1980, 300 pages.

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PACKET RADIO

by Robert Rouleau, VE2PY and Ian Hodgson, VE2BEN

Packet Radio could be one of the most important technological developments in Amateur Radio this decade. Can you imagine getting your newspaper or paying bills through a computer terminal linked by radio with other computers? It's happening, **now**. And you should make yourself aware of all the amazing things packet radio can do for you. This comprehensive sourcebook explains all the principles of packet radio in an easy-to-understand, non-technical language. You'll learn all about modulation, bandwidths, polling, random access, data rates and more. Plus there is an overview of how the computer is integrated into the packet concept with discussions on the software and peripheral equipment that is used. Finally, the authors give you a detailed description of the packet system in use in the Montreal, Quebec area. ©1981, 1st Edition, 304 pages

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March

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W1AW Schedule

October 25, 1981-April 24, 1982 MTWThFSSn = Days of Week Dy = Daily
W1AW code practice and bulletin transmissions are sent on the following schedule:

EST	Slow Code Practice	MWF: 9 A.M., 7 P.M.; TThSSn: 4 P.M., 10 P.M.
	Fast Code Practice	MWF: 4 P.M., 10 P.M.; TTh: 9 A.M.; TThSSn: 7 P.M.
	CW Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M.
	RTTY Bulletins	Dy: 6 P.M., 9 P.M., 12 P.M.; MTWThF: 11 A.M.
	Voice Bulletins	Dy: 9:30 P.M., 12:30 A.M.
CST	Slow Code Practice	MWF: 8 A.M., 6 P.M.; TThSSn: 3 P.M., 9 P.M.
	Fast Code Practice	MWF: 3 P.M., 9 P.M.; TTh: 8 A.M.; TThSSn: 6 P.M.
	CW Bulletins	Dy: 4 P.M., 7 P.M., 10 P.M.; MTWThF: 9 A.M.
	RTTY Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M.
	Voice Bulletins	Dy: 8:30 P.M., 11:30 P.M.
PST	Slow Code Practice	MWF: 6 A.M., 4 P.M.; TThSSn: 1 P.M., 7 P.M.
	Fast Code Practice	MWF: 1 P.M., 7 P.M.; TTh: 6 A.M.; TThSSn: 4 P.M.
	CW Bulletins	Dy: 2 P.M., 5 P.M., 8 P.M.; MTWThF: 7 A.M.
	RTTY Bulletins	Dy: 3 P.M., 6 P.M., 9 P.M.; MTWThF: 8 A.M.
	Voice Bulletins	Dy: 6:30 P.M., 9:30 P.M.

1

WEST COAST BULLETIN — 9PM PDT (8PM PST - 0400 UTC) 3540 KCS, A-1, 22 WPM — 1.

2

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)
AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)
AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

3

4

WEST COAST QUALIFYING RUN — 4.

5

6

ORANGE COUNTY HAMFEST — Orange County Fairgrounds, Costa Mesa. Contact Cataline Amateur Repeater Assoc., P.O. Box 2197, Westminster, CA 92683 — 6-7.

INTERNATIONAL DX CONTEST — Phone — 6-7.

7

8

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10

11

W1AW QUALIFYING RUN — 11.

HARTFORD COUNTY ARA AUCTION — Annual auction of used equipment and "stuff" at the Veterans Memorial, Sunset Ridge Dr., E. Hartford — 11.

12

JEFFERSON BARRACKS ARC ANNUAL AUCTION & HAMFEST — Carondelet Sunday Morning Athletic Club, South St. Louis, Contact KØZFK — 12.

13

THE 22ND ANNUAL LAFAYETTE AMATEUR RADIO HAMFEST — Evangeline Downs Racetrack Club House, off Hwy. 167, 5 miles north of Lafayette. For more information contact AARA, P.O. Box 51174, Lafayette, LA 70505 — 13-14.

14

RANDOLPH ARA 3RD ANNUAL HAMFEST — Contact R.A.R.A., P.O. Box 203, Winchester, IN 47394 or W9VJX — 14.

STERLING-ROCK FALLS AMATEUR RADIO SOCIETY 22ND ANNUAL HAMFEST — Sterling H.S. Field House, Sterling, IL. Contact Rodney Cushman, 107 Main St., Galt, IL 61037 — 14.

15

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17

18

19

THE 3900 CLUB AND SOO-LAND REPEATER ASSOC. 6TH ANNUAL HAMBOREE — Marina Inn, South Sioux City. Contact WØFZO or KØTFT — 19-20.

20

SOUTHERN MICHIGAN ARS & CALHOUN COUNTY REPEATER ASSOCIATION'S 21ST ANNUAL MICHIGAN CROSSROADS HAMFEST — Contact SMARS, P.O. Box 934, Battle Creek, MI — 20.

PLAYGROUND ARC 12TH ANNUAL SWAPFEST — Okaloosa County Fairgrounds, Fort Walton Beach. Contact Joe Giangrosso, 304 Chickasaw Circle, Fort Walton Beach, FL 32548 — 20.

CIVIL AIR PATROL'S 2ND ANNUAL SPRING HAMFEST — Lake County Fairgrounds, Grayslake. For more information send SASE to Capt. Rehm, 637 Emerald St., Mundelein, IL 60060 — 20.

CHESTNUT RIDGE RADIO CLUB'S HAM RADIO FLEA MARKET — Education Bldg., Saddle River Reformed Church, E. Saddle River Rd. & Weiss Rd., Upper Saddle River. Contact W2EHD — 20.

21

WISCONSIN QSO PARTY — 1800Z, March 21 to 0200Z, March 22 (8 hrs.) — 21.*

TOLEDO MOBILE RADIO ASSOCIATION'S 27TH ANNUAL AUCTION & HAMFEST — Lucas County Rec. Center, Key St., Maumee. Contact KB8YD — 21.

YL ISSB QSO PARTY — 001 GMT, March 20 to 2359 GMT, March 21 (CW) — 20.*

22

23

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24

25

W1AW QUALIFYING RUN — 25.

26

27

NEBRASKA STATE CONVENTION — Kearney — 27-28.

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RAMAPO MOUNTAIN AMATEUR RADIO CLUB'S UHF/VHF QSO PARTY — 1600 hrs. (local), Saturday, March 27 to 2400 hrs. (local) Sunday, March 28 — 27.*

28

BALTIMORE ARC GREATER BALTIMORE HAMBOREE & COMPUTERFEST — Maryland State Fairgrounds Exhibition Complex, Timonium, MD. Contact G.B.H. & C., P.O. Box 95, Timonium, MD 21093 — 28.

DELAWARE VALLEY RADIO ASSOCIATION'S ANNUAL FLEA MARKET — New Jersey National Gaurd 112th Field Artillery Armory, Eggersts Crossing Rd., Lawrence Township. Contact D.V.R.A., P.O. Box 7024, W. Trenton, NJ 08628 — 28.

4TH ANNUAL LAKE COUNTY HAMFEST — Madison High School, Madison OH. Contact Lake County Hamfest, 5704 Middle Ridge, Madison, OH 44058 — 28.

CONEMAUGH VALLEY ARC 5TH ANNUAL HAMFEST — Sandy Bottom Sportsman's Club, Seward, PA. Contact Conemaugh Valley ARC, 2829 Bedford St., Johnstown, PA 15904 — 28.

29

30

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31

See Coming Events

operation upgrade: part 5

The fifth part in a continuing series designed to help you upgrade your ticket

This series of articles is being presented to help *you pass a higher grade* Amateur license exam, to give you the basic radio theory needed to pass a Novice, *Technician/General*, or *Advanced* class license test. After these basics are presented in as simple a form as possible, there will be articles covering Extra class license subjects.

This month we will examine the use of some active devices in oscillator circuits to generate either radio frequency (rf = 10 kHz to over 300 GHz) ac, or audio frequency (af = 20 to 20,000 Hz) ac.

a basic oscillator

There are a variety of methods of generating alternating current. The electromagnetic machine used to develop power-frequency ac is called an *alternator*. It must be rotated by some type of motor. The motor rotation may be developed by water wheels, windmills, electric motors, or gasoline engines. The rotation of a magnetic pole past coils of wire induces ac voltages into the coils.

Although in the early days of radio such electromechanical alternators were used to generate radio frequency ac for code transmissions up to 25 or more kHz by using many field poles, alternators today are usually limited to supplying power in the 30 to 800 Hz range. The lower the frequency of the ac generated by an alternator the more iron required in the machine and in the equipment with which it is used. Aircraft ac systems use 400 to 800 Hz ac to decrease the weight of their alternators and other components.

The *oscillators* used to generate af or rf ac in Amateur Radio equipment use either coils and capacitors, or resistors and capacitors, to determine the frequency at which the circuits can oscillate. Active devices are used to produce an amplified ac energy that is fed back to keep the circuits producing ac. There are a

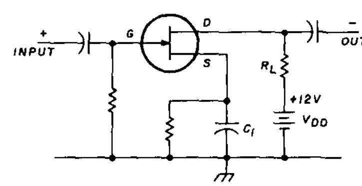

fig. 1. A basic JFET amplifier produces a 180° phase reversal of any input signal voltages.

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

great many types of oscillator circuits, but they usually require an in-phase (0° or 360°) feedback circuit *involving either one or two active device stages.* We will discuss some single device oscillator circuits first.

Before starting on oscillator circuits, let's look at the phase reversal that occurs in a standard amplifier, such as the *grounded source* amplifier shown in **fig. 1**. It is called a grounded source circuit because the source is held at ac ground potential by the bypass capacitor C_1. The input signal is fed to the gate, and the amplified output signal appears at the drain of the JFET. Suppose a positive-going signal is fed to the gate (indicated by the + in the diagram). Such a positive voltage will produce an increased drain current (I_D) through R_L. With an increase of I_D through R_L the voltage-drop across this resistor will increase. When the gate is driven positive the increased I_D through R_L produces an increased voltage-drop across R_L, resulting in the drain voltage becoming less positive. This is the same as saying the drain terminal becomes more negative. So, whatever polarity *signal is fed to the gate will show up as an amplified* signal of opposite polarity (180° out of phase) at the drain. Thus, the basic amplifier shifts the phase of *any signal fed to it by 180°.*

Armstrong oscillators

One of the oscillator circuits that can be used in a one-active-device (FET, BJT, VT) circuit is the Armstrong oscillator, **fig. 2**. In this circuit, if ac is developed in the L_1C_1 circuit for any reason, some of this ac voltage is fed through C_2 to the gate; it's amplified, and shows up across the drain circuit load, in this case the "tickler" coil. Capacitor C_{bp} bypasses one end of the tickler to ground, completing the ac drain circuit through the tickler to the source. The dc drain circuit is from D, through the tickler, RFC, V_{DD}, to S. Can you see that if the tickler coil is placed close to L_1, any expanding and contracting magnetic fields from it would induce an amplified ac into L_1? If the tickler turns are reversed, any ac voltage induced into L_1 would then be reversed 180° in phase. If the tickler is wound one way, ac induced into L_1 by varying currents in the tickler would be in phase (*regenerative*) and would add to any ac present in the LC circuit. The whole *stage* is then working to keep electrons in the L_1C_1 circuit oscillating. If the tickler turns are reversed, the ac EMF induced into L_1 would now be out of phase (*degenerative*) and would prevent the LC circuit from oscillating. *To start the LC circuit* oscillating at its normal resonant frequency, assuming regenerative feedback, it is necessary only to close the switch in the drain circuit. This produces a dc surge through the tickler coil. The result is a sud-

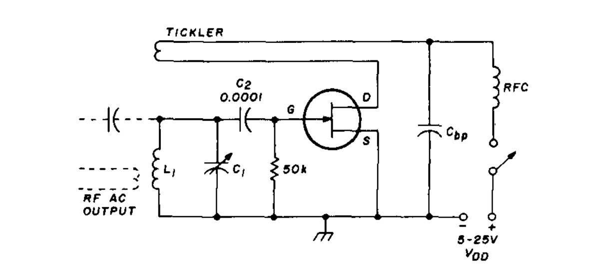

fig. 2. Armstrong oscillator circuit to generate rf ac.

denly expanding magnetic field from the tickler that induces energy into the LC circuit and starts electrons oscillating back and forth in it. (The tickler coil usually has about one-fourth as many turns as are us*ed in the LC circuit coil.*)

Back in the twenties, the Armstrong circuit using a triode vacuum tube was a very popular high-sensitivity oscillating detector and is still used as a 160, 80, and 40 meter detector-receiver by experimenting Amateurs. When used as a receiver, C_{bp} is made variable to control feedback and the point of oscillation. Earphones are connected in series with the switch.

tuned-input-tuned-output oscillators

The Armstrong circuit is an inductive feedback oscillator. The tuned-input-tuned-output circuit *shown in* **fig. 3** *is a capacitive feedback oscillator.* Both of its LC circuits are tuned to the same frequency, 3.7 MHz for example. When the switch is closed, L_2C_2 has an *"exciting" shock of current developed in* it, which drives this circuit into flywheel-type ac oscillations at 3.7 MHz. This ac frequency is fed to the L_1C_1 circuit by any natural drain-to-gate capacitance that might exist, or by distributed capacitance of circuit wires being near each other, or, if necessary, by adding a 5-pF feedback capacitor, C_{fb}, shown dashed.

In the early days of Amateur Radio this "self-excited" oscillator circuit, using a triode VT, was known as a TPTG (tuned-plate-tuned-grid) oscillator, and was used as a simple CW transmitter. Today it is almost never used as an oscillator unless a *quartz crystal* (xtal) is substituted for the L_1C_1 circuit. However, you may run up against this kind of oscillator in receiver or transmitter amplifier stages that have tuned input and tuned output circuits in them. If care *is not taken to prevent capacitive feedback coupling* in such amplifiers they may begin to oscillate instead of amplify! This is very undesirable. *Neutralization*, a form of degeneration discussed *in later articles, must* be used to prevent such oscillations.

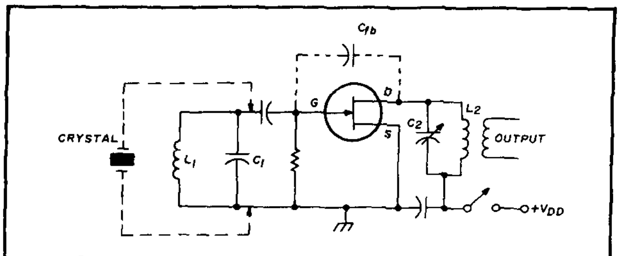

fig. 3. Tuned-input-tuned-output self-excited oscillator, or crystal oscillator if a crystal is being used as the input tuned circuit.

If a wafer of quartz crystal is sliced out of raw quartz, is ground perfectly flat, and is silver-plated on its two flat surfaces, it will have some very interesting characteristics. If the two plates are pressed together a voltage will be developed between the two plates. As the plates are released an opposite potential voltage will be developed between them. Conversely, if a dc voltage is applied across the plates the crystal wafer will contract. If the opposite polarity voltage is applied the wafer will expand.

These two reciprocal mechanical-electrical effects operate in much the same way as the electrostatic-electromagnetic effects of an oscillating LC circuit. The crystal must be ground precisely to the proper physical dimensions to vibrate and oscillate at the desired frequency, just as the inductance and capacitance values of an LC circuit must be chosen to produce oscillations at the desired frequency. In this circuit the crystal acts as a very high-Q LC circuit. Thus, by substituting the crystal (dashed) for the "self-exciting" L_1C_1 circuit in **fig. 3**, you would develop a very stable (unchanging frequency) oscillator. Although a few picofarads of capacitance across a crystal may lower its resonant frequency a few hundred hertz, crystals are considered to produce single-frequency oscillations. If you wish to change frequency when using a crystal-oscillator-type transmitter, you must switch in a crystal ground to some other frequency. Crystals are usually encapsulated in tiny plastic or metal holders, or cans, with two connector pins protruding out the bottom. The pins fit into special crystal sockets so that crystals of different frequencies may be plugged into the circuit when a change of frequency is required.

Hartley oscillators

One of many *variable frequency oscillator* (VFO) circuits is a combination inductive capacitive feedback circuit called a Hartley oscillator, **fig. 4**. Can you see that the resonant frequency in this LC circuit would be determined by C_1 across both L_1 and L_2 in series? Note that L_2 is actually a tickler coil of an Armstrong portion of this circuit. Also, that C_1, C_2 and C_3 form the drain-to-gate feedback capacitance for a capacitive-feedback-type of oscillator. Where on the coil the tap is placed determines the power output and the frequency stability of the oscillator. The fewer tickler turns the lower the power output but the better the frequency stability. The more tickler turns the higher the power output but the poorer the stability. A good compromise is to have L_1 with about twice as many turns as L_2. The radio-frequency choke coil (RFC) prevents the capacitance C_4 across the V_{DD} power supply from ac-shorting the tickler coil (L_2), which would stop oscillations.

Capacitor C_2 and resistor R_1 make up the *class C* (discussed later) grid-biasing circuit. Within limits, the higher the value of R_1 the greater the negative bias, the lower the power output, but the better the stability. R_1 may range from 10 kilohms to perhaps 2 megohms, depending on the requirements of the oscillator. C_2 is usually 50 to 100 pF. Although shown with a JFET, BJTs and VTs can be used in these circuits. The low impedance of the input circuit of a BJT may require the base connection (through C_2) be tapped down L_1 about half way.

Colpitts oscillators

The most popular of today's VFOs is the Colpitts, **fig. 5**, or one of its many variations. Whereas the Hartley uses a tap about two-thirds of the way down its LC circuit inductance, the Colpitts taps down the capacitance of the LC circuit by making C_3 about twice the value of C_2. C_1 in this diagram is a small trimmer capacitor used to tune the oscillator a relatively few kilohertz (across a single Amateur band, for example). Energy can be taken capacitively from the top of the LC circuit in any of these oscillators, or inductively by using a secondary coil coupled to L_1.

You are much more likely to see the Clapp form of

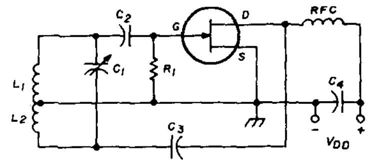

fig. 4. Hartley oscillator, shunt fed (no I_D flowing through a tuned circuit).

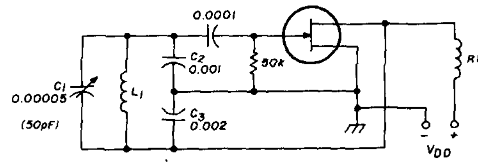

fig. 5. Colpitts shunt-fed oscillator.

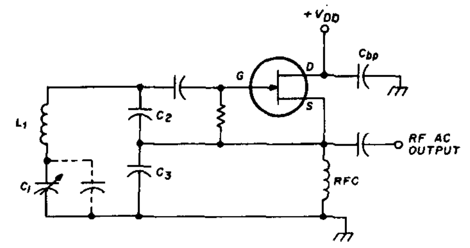

fig. 6. Clapp oscillator, a form of Colpitts.

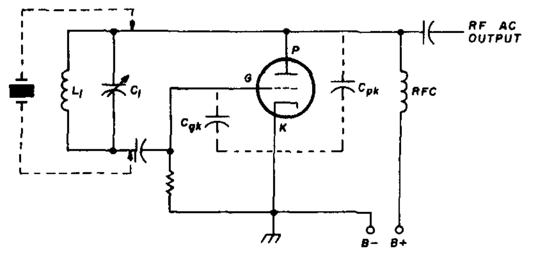

fig. 7. Ultra audion VHF and UHF oscillator becomes a Pierce high-frequency oscillator if a crystal is used as the resonant tank circuit.

the Colpitts oscillator, **fig. 6**. Such a circuit permits the tuning capacitor, now in series with L_1, to have one of its terminals grounded. This is very desirable because it makes insulated tuning shafts from panel knobs to the tuning capacitors unnecessary. Usually in this circuit only the relatively small rf ac voltage developed across C_3 (and the RFC) is used as the rf ac output. As a result, these oscillators are usually followed by a low-power rf amplifier to bring the oscillator ac up to a usable amplitude. Such a "buffer" amplifier also tends to isolate the oscillator from external circuits which might affect the oscillator's frequency. You will usually find a fixed capacitor, shown dashed, connected across C_1 to increase the strength and stabilize the output amplitude of Clapp-type oscillators.

The higher the frequency of oscillation the smaller the required capacitances (and inductances) of any oscillator circuit. For example, an oscillator used in the VHF range (30 to 300 MHz) or higher is the "ultra-audion," which was popular with vacuum tubes (and operates with FETs), **fig. 7**. Here the very small value inter-electrode plate-to-cathode and grid-to-cathode capacitances, shown dashed, act as C_2 and C_3 across the LC circuit of a Colpitts oscillator. Of more importance, a crystal, also shown dashed, can be used in place of the LC circuit, providing a simple *Pierce*-type crystal oscillator which requires no tuning coil or capacitor at all. The Pierce-type crystal oscillator is quite popular.

Note that the oscillator circuits shown are all developing rf ac. Af ac oscillator circuits would be similar but would use iron or ferrite cored inductors and relatively larger inductance and capacitance values to enable oscillations at such lower frequencies.

harmonic and overtone oscillators

If it is desired to have crystal-controlled oscillations in the 28-MHz range, the crystal for such a high frequency will be very thin and fragile. For low power circuits, such as with small transistors, crystals at this frequency may be practical. More often, lower frequency crystals are used and harmonics of their fundamental frequency of oscillation are picked off. One such circuit is shown in **fig. 8**. When the 7-MHz drain LC circuit is tuned to the frequency of the crystal (actually to a slightly higher frequency to produce the necessary feedback phasing), the crystal oscillates. The second L_2C_2 circuit might be tuned to the third harmonic of 7 MHz, or 21 MHz. However, the rf ac power output from this LC circuit will be much less than the power generated at 7 MHz. If the harmonic circuit were tuned to the fourth harmonic of 7 MHz, then 28 MHz rf ac would be the output from L_2C_2, but at a still lower power level.

The reason harmonic energy can be picked off with this circuit is that the active device is biased to such a high value (class C) that the drain current is developed as very narrow pulses widely separated from the next pulse. As a result, the pulses shock-excite the LC circuits, which may oscillate back and forth several times before the next pulse arrives. If L_2C_2 is tuned to the second, third, or fourth harmonic of the crystal frequency, the resonant circuit by its flywheel oscillations will produce very nearly sine-wave rf ac at that harmonic frequency. The harmonic output will always be an exact whole number multiple of the crystal's oscillating frequency.

While we think of crystals as having a basic fundamental vibration frequency, it is found that they may also oscillate or vibrate in an odd number of layers. That is, a 4-MHz crystal will vibrate longitudinally at 12 MHz (three times 4 MHz), or at 20 MHz (five times

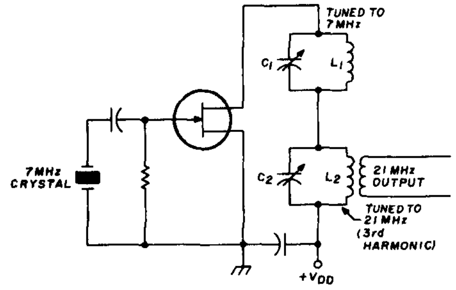

fig. 8. Harmonic output crystal oscillator.

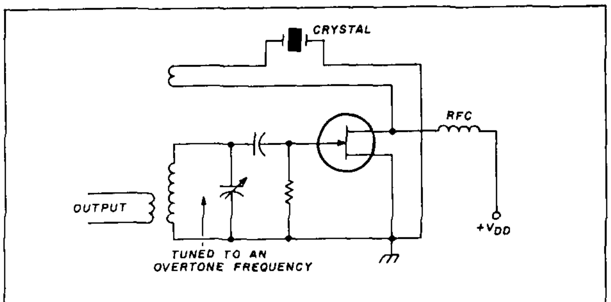

fig. 9. One form of an overtone crystal oscillator.

4 MHz), and possibly at 28 MHz (seven times 4 MHz). To make the crystal oscillate at such *overtones* the crystal might be connected in series with the tickler coil of a shunt-fed Armstrong circuit, **fig. 9**. This circuit is said to be *shunt-fed* because the crystal, a nonconductor, forces pulsating drain dc to be fed from the drain to $+V_{DD}$ through RFC instead of through the tickler. The tickler, with the crystal in series with it, can have only rf ac flowing in it. The circuit shown back in **fig. 2** is a *series-fed* oscillator, because I_D is flowing through one of its coils.

Another overtone circuit can be developed by adding a crystal in series from the FET source to the LC center-tap of the Colpitts oscillator shown in **fig. 6**. The LC circuit of the oscillator must be tuned to the overtone, not the fundamental frequency, of the crystal. Actually, the overtone frequency is near, but is never an exact multiple of, the crystal's fundamental oscillation frequency. If overtone crystals are required at a given frequency, the crystal manufacturer must know which overtone is to be used and the desired operating frequency, in order that the crystal can be ground to a correct fundamental frequency.

Another popular type of stabilized crystal oscillator, called a phase-locked loop (PLL), will be explained in a later article.

RC oscillators

There is a family of oscillators which fall into the category of *RC oscillators*, because they depend on the charging and discharging time of capacitors through resistances to determine the frequency of their oscillations. In most cases these oscillators use two cascaded (one following the other) single-ended grounded-source (-emitter, -cathode) active devices with some means of feeding back from the output of the second stage to the input of the first, as in **fig. 10**. Since both stages are grounded-source types, there is 180° phase shift through each stage, or a total of 360° (same as 0°, or in-phase) feedback by C_2 from the drain of Q_2 to the gate of Q_1. C_1 alternately charges and discharges through R_2, and C_2 alternately charges and discharges through R_1. The values of these RC pairs determine the frequency of oscillation. If C and R are both large values the time of charge and discharge is long, and the oscillation frequency is low. With small C and R pairs the oscillation frequency will be high.

The voltage-drops developed across R_1 and R_2 will be relatively slow charging and fast discharging, resulting in sawtooth-shaped ac waves available from the tops of these resistors. Q_1 and Q_2 alternately turn on and turn off as the bias values change from high values to the point where drain current just begins to flow. Since the circuit is regenerative (in-phase feedback), once drain current starts to flow the transistors switch on (to maximum I_D) almost instantaneously. As a result, voltages taken from the drain terminals will be squarewave pulses of dc caused by the rapid on-off switching of the device. If the output load is coupled through capacitors, the pulses of squarewave dc become squarewave ac cycles in the load. If R_1C_2 has a fast time constant and R_2C_1 has a slow time constant, a narrow pulse will be developed by Q_1 and a wide pulse will be produced by Q_2. Such a circuit can produce narrow pulses from Q_1 spaced relatively widely apart in time. Narrow pulses of this type can be used as triggering signals for some other circuit.

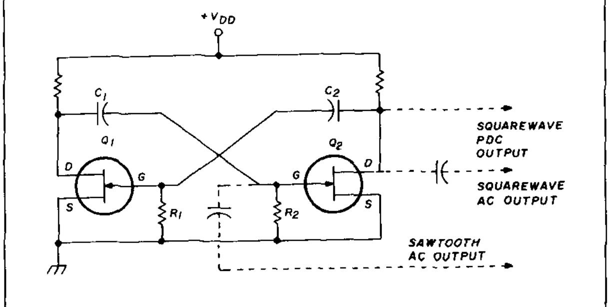

fig. 10. Multivibrator, RC, or relaxation oscillator.

FCC test topics

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

- quartz crystals, appearance, applications, symbol.

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

- oscillators, various types, applications, stability.

For more information on these subjects it is recommended that you refer to a textbook such as *Electronic Communication*, by Robert L. Shrader, McGraw-Hill Book Company, available through Ham Radio's Bookstore, and to radio handbooks.

ham radio

More Details? CHECK—OFF Page 98

the ham notebook

external microphone for the TR-2400

My new TR-2400 finally arrived, complete with earphone, charger, and battery pack. After I spent an hour playing with the buttons and learning how to use the controls, it was on the air, and the reports started coming in: "Super audio quality," "Sounds great," and "Terrific speech quality!" The 2-meter synthesized handheld made by Kenwood certainly met all my expectations.

After a few weeks of use at home, on a trip, and in the car, I realized that an external microphone would be a valuable addition. Why pick up the whole set, when only the microphone has to be used? A quick review of the instruction manual revealed that Kenwood recommended using a 2-kilohm capacitor microphone, or else a dynamic microphone with a series 0.47-1.0 μF capacitor to block dc voltage. In addition, the microphone cable must be equipped with an external 1/8-inch miniature and a 3/32-inch microminiature plug (furnished as accessories with the radio) to mate with the external microphone and standby jacks.

Looking through my collection of microphones, I found a capacitor microphone element (removed from an old cassette recorder) and two dynamic microphones, one of which had the correct mating plugs used in the same cassette player. One by one each microphone was tested, and each time the audio reports came back: "Sounds awful," or "Sounds like you're in a barrel," or "Sounds pretty good, but not as good as the internal microphone." A variety of capacitors and microphone holders were tried, but to no avail.

The next day I called Kenwood to find out if a small capacitor microphone with mating plugs was available, and was told that there was none at this time. I inquired about the internal microphone and found out it was a small Electret microphone, available as a replacement part for \$5.00 plus \$2.25 for shipping and handling. It was stocked as part no. T91-0312-05, "Condenser Microphone." I ordered one from stock, and received it by mail in a few days.

I discovered it really *was* small, about 1/4 inch (6.4 mm) in diameter! The microphone contains an internal FET amplifier and is designed to operate into a circuit that provides around 7 volts dc through a load resistance. The circuit used by Kenwood from the external microphone jack is shown in **fig. 1**; the connections to the polarized microphone terminals are shown in the insert.

I decided to mount the microphone element into my cassette microphone holder with the mating cables. An identical microphone is made by Radio Shack, part no. 33-1054 (1980 catalog, \$4.99), "Low Cost Dynamic Microphone." This microphone comes with a slide switch on the case and a microphone holder.

Carefully unsolder the microphone element. A 3/4 inch (19 mm) rubber grommet with a 1/4-inch (6.4 mm) hole mates snugly with the microphone holder, and also with the capacitor microphone element. As the grommet was too thick, I first cut down the grooved section with a razor, splitting it into two 3/4-inch (19-mm) round washers; one of the resulting washers was used. The microphone element was pressed into the hole. It makes a snug fit, so cement wasn't necessary.

Next, solder the wires carefully to the microphone element, observing polarity. The wire going to the tip of the plug is the positive connection and should be soldered to the *smaller* of the two microphone terminals (if your microphone doesn't work, try reversing these connections). The rubber grommet can now be pushed into the microphone holder so that it is flush with the end. A piece of 1/4-inch (6.4 mm) thick foam plastic (the yellow, fluffy variety) can be cut to fit over the element to reduce the effect of wind on the microphone, if it is to be used for mobile work. The foam fits snugly between the element and the screw cap cover.

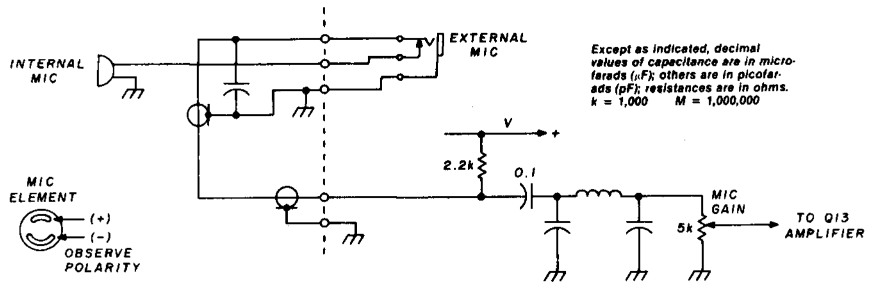

fig. 1. Circuit used by Kenwood from the external microphone jack. Connections to the polarized microphone terminals are shown in the insert.

My first tests with the microphone were, as they say, good news and bad news. The good news was that the audio was excellent — the same high quality as the internal microphone (after all, it is the *same* microphone). The bad news was that microphone gain was too high, a particular problem on one local repeater that provides speech clipping to discourage excess gain.

A check of the transceiver circuit revealed that both the internal and external microphones were controlled by the same gain control. Any adjustment of the control for the external microphone would change the gain for the internal microphone as well. A gain control was needed for the external microphone.

The circuit of **fig. 2** was constructed on a breadboard and found to work perfectly to reduce gain. The

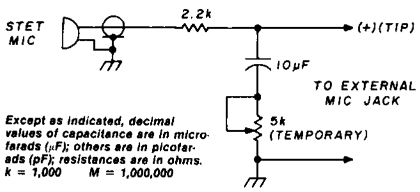

fig. 2. Attenuator circuit for reducing microphone gain.

best results were with a 2k setting of the pot, which was replaced with a 2.2k resistor. I found 1/4-watt resistors to be nice and compact. A nonpolarized 10-μF tubular electrolytic was used as the capacitor. The network was soldered together as a compact array by clipping the leads short. Connect the leads to the microphone element, and tape the bare wires with plastic tape. Another small piece of plastic foam holds the components snugly inside the microphone case without rattling.

The final results were gratifying. No one has been able to tell the difference between the internal and the external microphones — the final test of perfection! A further discussion with Kenwood indicated that the microphone elements are probably quite variable from unit to unit, so the final values of the resistance network (if needed) will have to be determined experimentally; but the results make it all worthwhile.

Herb Bresnick, WB2IFV

TI58/TI59 calculator programs

Programs are now available from *ham radio* for the following items:

antenna bearing and distance between stations

This program gives the necessary antenna pointing information and the distance between locations for any latitude/longitude coordinates on the earth. It should be of great help to DXers, and those interested in meteor scatter work.

EME elevation/azimuth

This program gives small calculators the abilities of a computer. Using information found in the current year's nautical almanac, the program prints out the elevation/azimuth information in 15-minute increments. Only a few keystrokes of input are needed to run an entire day's output of moon coordinates. This program eliminates tedious manual calculations and paperwork and should prove invaluable to moonbounce operators.

(These programs will be provided free of charge for six months by *ham radio* upon receipt of an 8½ by 11 inch envelope and $1.03 in postage. After six months, there will be a reprint charge of $2.50 — Ed.)

Brian M. Manns, K3VGX

taming set screws

The knob on the function switch of my transmitter kept getting loose on its shaft. The set screw was a slotted-head 6-32 (M 3/5) machine screw. I replaced the set screws with Allen-head units, which cured the problem.

I've worked around machinery all my life and have never had much luck with anything but Allen-head set screws.*

Orville Gulseth, W5PGG

*The same problem on a Drake R-4C receiver was cured by using Allen-head set screws. Editor.

electronic timer

Here is a handy little gadget for the ham shack. I'm long winded, so it prevents me from over-talking the local 2-meter repeaters. The time range is 1-15 minutes. It also works well as a 10-minute ID reminder for the low bands.

The LM-741 op amp is the heart of the timer. It is connected as an inverting differential comparator. The reference voltage is taken from the junction of two 10k resistors. The resultant 6.75 V is connected to the inverting input (pin 3) of the LM-741 (see **fig. 3**). The 23 mA below V_{CC} 13.8 V is the measured current through the buzzer, transistor, and LED. Thus the LED operates in its safe region with full brightness.

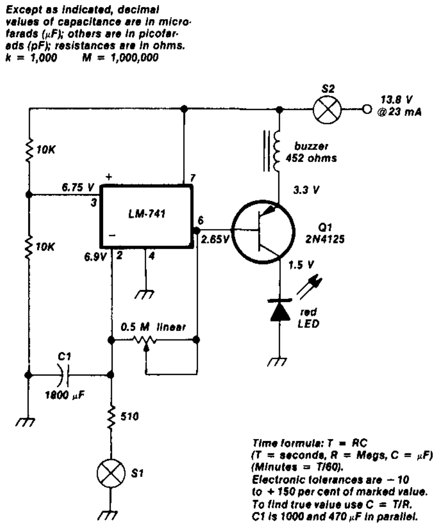

fig. 3. One to 15-minute timer. Voltages shown are with Q1 conducting. Mini-buzzer (6 - 9 V) is $1.95 at Jameco Electronics, Belmont, California 94002.

The control voltage is picked up from output pin 6 of the LM-741, passes through the 0.5-meg linear time-setting pot to pin 2. The capacitor is discharged through the 510-ohm resistor, which prevents damage to the LM-741 and the capacitor that would be caused by a dead short. Discharge time is roughly one second. S1 is a dpdt switch to activate and reset the timer.

To operate, switch S1 to **ON**. Pin 6 voltage should be just below the supply voltage and positive with respect to Q1 emitter. The transistor is reverse biased and can't conduct. Voltages are: pin 2, 0 volts, pin 3, 6.75 volts, and the transistor base the same as at pin 6. The emitter is negative with respect to base. Collector voltage is zero.

When C1 charge reaches one-half the supply voltage, the LM-741 operates and the voltage at pin 6 drops. Switching-transistor Q1 conducts, and the following voltages will be present: emitter 3.3 volts, base 2.65 volts, and collector 1.5 volts. The LED and buzzer are then activated. They are pulsed to better catch the user's attention. The transistor bias is 0.65 volt, and current is 23 mA.

Denver V. Tolle, W9EBT

S-line QSK noise

When I initially modified my Collins S-line for CW QSK, I used a circuit described by Shafer.[1] I found, however, there still existed a certain amount of hash being generated by the exciter, which was picked up by the receiver even when the final amplifiers were cut off. Although far below the level produced by the final amplifiers, it was still sufficient to be annoying and hamper weak-signal reception. The culprit was the rf amplifier, V6. Since ALC voltage is fed to the control grid of this tube during SSB operation, I felt that, rather than grid-block key this stage, a simpler method would be to apply the same treatment as the final stage had received; namely, removal of screen voltage during standby.

R-38, either 4700 ohms or 100k depending upon production model, was removed and replaced with a 56k, 1/2-watt resistor. The B-plus end was not returned to its original location; rather, it was wired to J9, one of the PA DISABLE jacks. This jack (to which the final-amplifier screens are also attached) has no voltage on it during key-up conditions when using the QSK circuit mentioned above. Thus, both the final amplifiers and the rf amplifier are cut off during receive, and absolutely no hash is audible in the receiver during operation. Keying is unaffected. See **fig. 4** for details.

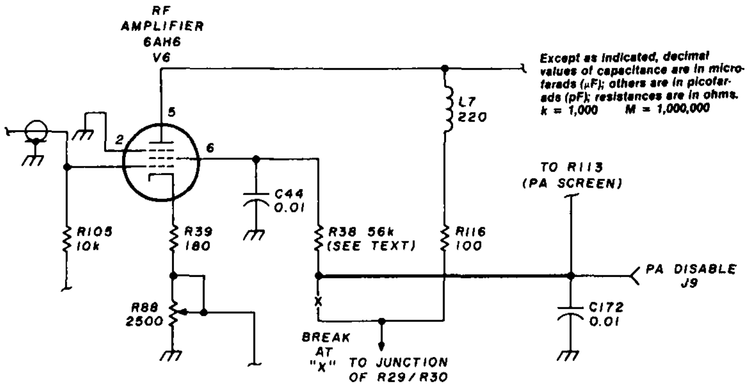

fig. 4. Rewiring R-38 in the 32S-3 eliminates hash during CW QSK operation.

reference

1. David P. Shafer, W4AX, "Cleaner Break-In With The 32S-3," *QST*, November, 1964, pages 46-47.

Paul K. Pagel, N1FB

low-frequency crystal oscillator

For years I've been collecting transistor crystal-oscillator circuits hoping to find one that would work using a 455-kHz crystal, but none would oscillate. I stumbled onto this circuit while building a BFO and am quite happy with it.

The circuit needs a little explanation. Most all crystal-oscillator circuits show a bypass capacitor between emitter and ground. I could not make this circuit oscillate when

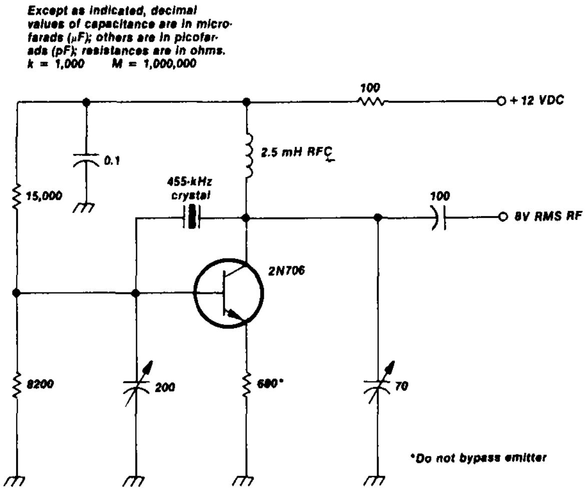

fig. 5. 455-kHz crystal oscillator.

sidetone for the Atlas 210 transceiver

One disadvantage of the Atlas 210 when operating on CW is that it has no sidetone provision. When faced with this problem, one of my Amateur friends tossed his Atlas on my bench for a solution. The following circuit is the result of the work, and has proved very satisfactory.

In **fig. 6**, Q1 and Q2 act as a simple audio oscillator and the frequency is adjusted by altering C1 to suit the operator. Q3 acts as a keying transistor simultaneously with transmitter keying.

This oscillator operates from about 6 volts, and so a simple regulator is used to keep its voltage relatively constant. The rest of the circuit is that recommended by the manufacturer for break-in CW operation. This unit was built in a small box; the keying output goes to the key jack on the Atlas, and the key plugs into the jack on the minibox.

B.E.G. Goodger, ZL2RP

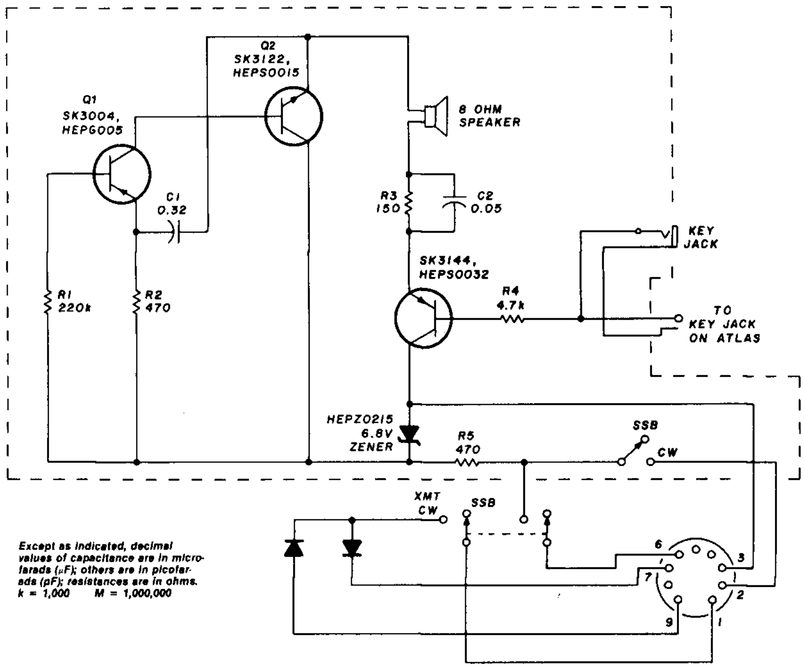

fig. 6. Modified Atlas circuit for CW sidetone with addition of connection of wire from white lead inside to pin 9.

the emitter was bypassed. Mine would not work until I put in a 2.5 mH rf choke. The next discovery I found, when using two variable capacitors, was that the capacitance from base to ground had to be larger than that shown in my collection of oscillator circuits. Also I found it necessary to increase the value of the capacitor from base to ground. Juggling the two variable capacitors (**fig. 5**) gave the most oscillator output. The oscillator puts out 8 volts rms of rf.

I used a 2N706 transistor, but others of the NPN type such as the 2N2222 should work. The crystal was a metal-can-type HC-6.* The FT-241 was not tried as I didn't have any on hand. I tried using FET MPF-102s at 455 kHz but could make none of the circuits work, although the handbooks show many low-frequency oscillators using them.

A capacitor was inserted in series with the crystal, my hope being it would vary the frequency a bit. It is also supposed to have a negative reactance to the crystal, which would be shifted into the positive-reactance region. I found the series capacitor did nothing. The oscillator worked just as well with the crystal connected directly between the base and the collector as shown in the schematic.

That's my story. If you want a detailed description of crystal oscillators, several are given below. However, I'll use this circuit for my BFOs from now on. Success at last.

bibliography

Harrison, Roger, VK2ZTB, "Survey of Crystal Oscillators," *ham radio*, March, 1976.

Nelson, Don, WB2EGZ, "Quartz Crystals: Gems for Frequency Control," *ham radio*, February, 1979.

Ed Marriner, W6XM

*Crystals for 455 and 453.5 kHz are available from John L. Winton, WD6DUS, 8062 San Meteo Drive, Buena Park, California 90620. Price is $2.50 each.

easy matching sections

How to design impedance transformers for multi-antenna arrays

In single-antenna applications, using the usual 50-ohm transmission-line system, impedance matching is no problem. However, when multiple antennas are used, the feed system becomes more complex, and impedance transformations become important.

If the antennas in question are of unknown impedance or are known to be reactive, the impedance will have to be reduced to a convenient resistive value by using stubs or other means before they can be fed in an array.[1] If stubs are used in a multi-antenna array, the phasing of the antennas should be checked to ensure that all stubs are alike and are introducing identical phase changes in each line.

In the case of commercial antennas, or those of a known resistive impedance, stubs are unnecessary. However, in dealing with unbalanced coax feed-line systems, any balanced antennas must be fed with baluns.

theory

When using multiple identical antennas with a coax feed system, the necessary impedance transformations are easily handled with 1/4-wavelength sections of rigid coax constructed to give the correct Z_0:

$$Z_0 = \sqrt{Z_{load} \times Z_{feed}} \qquad (1)$$

where Z_0 = characteristic impedance (ohms)

Z_{load} = load point impedance (ohms)

Z_{feed} = feedpoint impedance (ohms)

so that an antenna of 50 ohms attached to a 75-ohm feed system would need a 1/4-wavelength section of:

$$Z_0 = \sqrt{50 \times 75} = 61.24 \text{ ohms} \qquad (2)$$

This coax is not readily available, so it will have to be constructed.

A system developed by Marshal Williams, K5MB, and others, using a square aluminum outer conductor for matching sections is ideal for this unit, and will be used here. In this system the 1/4-wavelength section has an outer conductor of 1-inch square (OD) aluminum tube with either 1/8 inch or 1/16 inch wall thickness.

In this system, with square outer and round inner conductors, the impedance of the coax sections is given by:

$$Z_0 = 141 \log_{10} \frac{b}{a} \qquad (3)$$

where b = OD of inner conductor (inches)
a = ID of outer conductor (inches)

Solving for b in terms of Z_0:

$$b = a \log_{10}^{-1} \left[\frac{Z_0}{141} \right]$$

$$\text{or } b = a \log_{10}^{-1} \left[\frac{\sqrt{Z_{load} \times Z_{feed}}}{141} \right] \qquad (4)$$

This allows us to determine the necessary inner conductor OD for each of the outer tubing wall thicknesses. The handiest combination will be used.

As an example, consider a 25-ohm load matched to a 50-ohm feed line. The Z_0 of this section will be:

$$Z_0 = \sqrt{25 \times 50} = 35.35 \text{ ohms} \qquad (5)$$

Using 1/8-inch thick wall outer stock and this Z_0 we will need a 0.419-inch OD inner conductor. This is an unusual size for tubing, so try the same process with 1/16-inch wall (7/8-inch ID) outer stock. This combination requires a 0.492 inch inner conductor, so we can use standard 1/2-inch OD copper tubing; obviously the easiest choice.

By Jim Pruitt, KL7HIT, Box 2066, San Francisco, California 94126

With this basic construction available, let's look at practical antenna combinations. Impedance matching usually becomes a problem only in multiple antenna systems, which we will assume are composed of even numbers of coax-fed antennas with impedance of 300, 200, 75, or 50 ohms.

network details

Using two 50-ohm antennas, we then have a parallel combination presenting a 25-ohm load to the matching section. This is done by using two parallel connectors on the load end of the matching section (**fig. 1**). As we saw previously, this matching section will use 1/16-inch thick wall outer stock and 1/2-inch OD inner tubing.

Similarly four 50-ohm antennas can be handled as four parallel loads totaling a 12.5 ohm load, **fig. 2**, or as two sections back-to-back forming a 1/2 wavelength matching section, **fig. 3**, which is simply an easier way of building two 1/4-wavelength, 25-ohm to 100-ohm sections. The 100-ohm points are then paralleled to give a 50-ohm point.

Up to four loads may be used on each 1/4-wavelength section — one connector per side — so a 1/2-wavelength section can drive up to eight loads. Matching sections may be used two deep if necessary, as in **fig. 4**.

Table 1 lists the appropriate inner conductor OD for each application. The values are for 50- and 75-ohm antennas and feed systems most commonly used. Other values may be found using the same method, or the antenna may be converted to these values. The velocity of propagation in air dielectric coax such as this is virtually the same as air. Free-space calculations may be used, and the length found by:

$$\lambda/4 \; length \; (in.) = \frac{1.808 \times 10^4}{4 f_o} \quad \textbf{(6)}$$

where f_o = operating frequency (Hz).

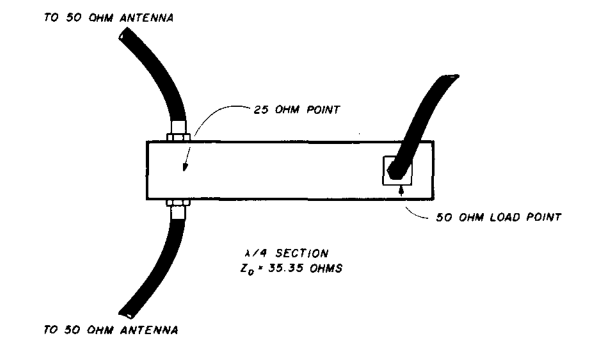

fig. 1. Load end detail with two load connectors.

The value for 145 MHz, for instance, is 31.17 inches. This is the dimension used between connector and center pins. The outer conductor square stock will be cut approximately 1/2 inch longer on each end to accommodate the connector flanges. **Fig. 5** shows the connector mounting details. If more than one matching section is used in a system, make all dimensions identical in all sections to minimize errors.

The feed point in the middle of a 1/2-wavelength section is constructed as shown in **fig. 6**. The load-end construction is identical for 1/2- or 1/4-wavelength designs.

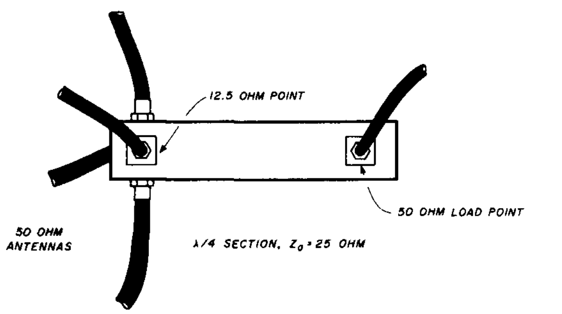

fig. 2. Load end construction showing four loads.

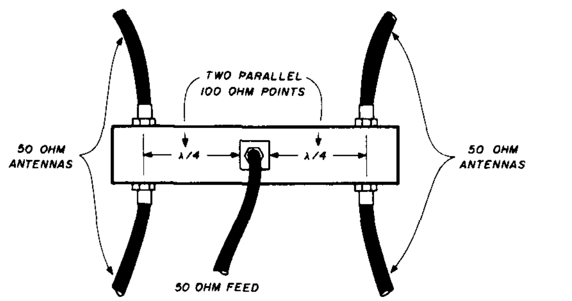

fig. 3. Detail of four load, halfwave construction.

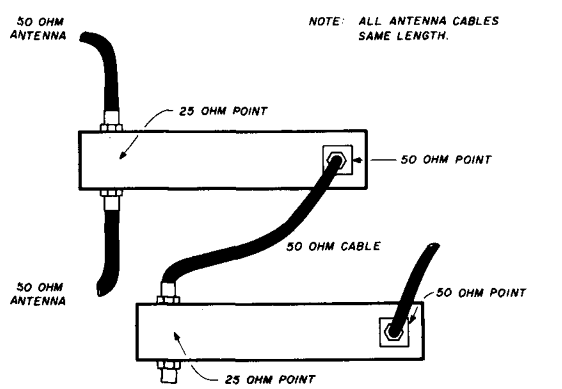

fig. 4. Network using two-deep matching sections.

examples

Now that we have the construction of the individual sections in hand, let's look at some examples. Suppose we want to design a broadside array of sixty-four antennas, with three elements each, for a total of 192 elements. All antennas are balun-fed Yagis of commercial design and present 50-ohm loads to the balun feed points.

There are several possible feed configurations involving different-value matching sections. If we use all identical matching sections, we can work with a design to connect four 50-ohm antennas to a 50-ohm system (see **fig. 7**). From **table 1** we find that 1/8-inch wall square stock and 1/2-inch OD center conductor works very well for this conversion. Using this design throughout we have a network to com-

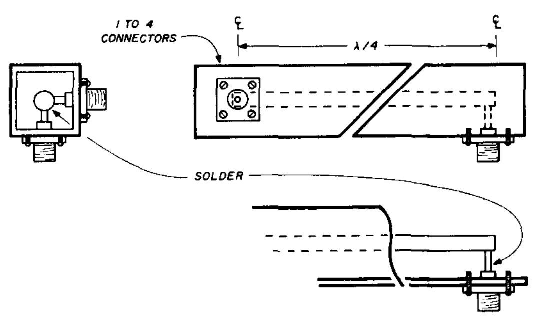

fig. 5. Detail of connector mounting.

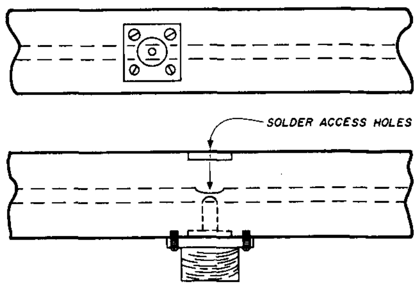

fig. 6. Halfwave feed point connector mounting.

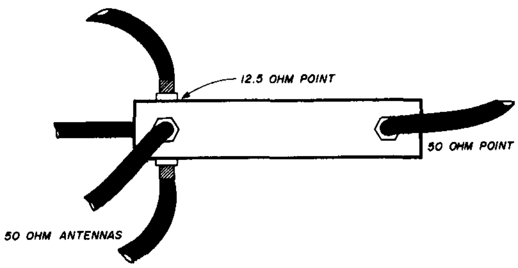

fig. 7. Sixty-four antenna array using all identical matching sections.

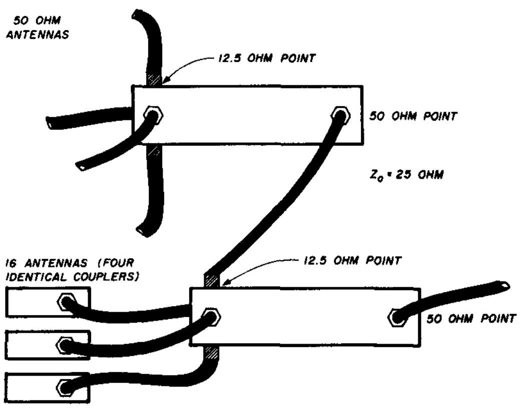

fig. 8. Sixteen 50-ohm antennas matched to a 50-ohm source.

table 1. Inner-conductor OD values for common 50- and 75-ohm antennas and feed lines.

number of loads	using 1/16-in. wall outer stock (in.)		using 1/8-in. wall outer stock (in.)	
1/4 wavelength, 50-ohm antennas to 50-ohm system:				
2	1/2	very good	27/64	
3	35/64		15/32	
4	9/16 SWR 1.04		1/2	very good
1/4 wavelength, 75-ohm antennas to 75-ohm system:				
2	3/8 SWR 1.02		5/16	very good
3	27/64		3/8	very good
4	15/32	very good	13/32	very good
1/2 wavelength, 50-ohm antennas to 50-ohm system:				
2	9/32		15/64	
4	3/8	very good	21/64	
6	7/16 SWR 1.08		3/8	very good
8	1/2	very good	27/64	
1/2 wavelength, 75-ohm antennas to 75-ohm system:				
2	13.6/64	hard to find	4/32	
4	1/4	very good	7/32	
6	5/16	very good	9/32	
8	3/8	very good	5/16	very good
1/4 wavelength, 75-ohm antennas to 50-ohm system:				
2	3/8		0.431	hard to find
3	1/2		0.421	hard to find
4	17/32	hard to find	0.455	hard to find
1/2 wavelength, 75-ohm antennas to 50-ohm system:				
2	0.213	hard to find	3/16	good
4	0.322	hard to find	0.276	hard to find
6	3/8		0.322	
8	7/16 SWR 1.18 not good		3/8 SWR 1.18	

bine 16 antennas into one group that will match a 50-ohm system (**fig. 8**). The addition of three more identical groups, each connected to a port on one last matching section, gives the final configuration of the sixty-four antennas shown in **fig. 9**. Another possibility using a combination of 1/2- and 1/4-wavelength sections in the same array is shown in **fig. 10**.

power division

In an impedance-matching section with two or more loads we, of course, also have a power division occurring. The matching section is interested only in the transformation of total net load impedance to feed line impedance. The power division among the loads is a function of their impedances. If the power to all loads is to be equal, then the load impedances must be equal. Noting that some of the matching sections have other sections as loads, we can see that all antennas must be identical in construction, as must all the similar matching sections. Dimensions must be identical for similar units, so cut all the parts at the same time to ensure uniformity.

phasing

In a large array it is necessary to get maximum power to the antennas through proper impedance management and to have it evenly divided. However, we must also make sure that the rf gets to all antennas at the same time, or in phase. Since we have

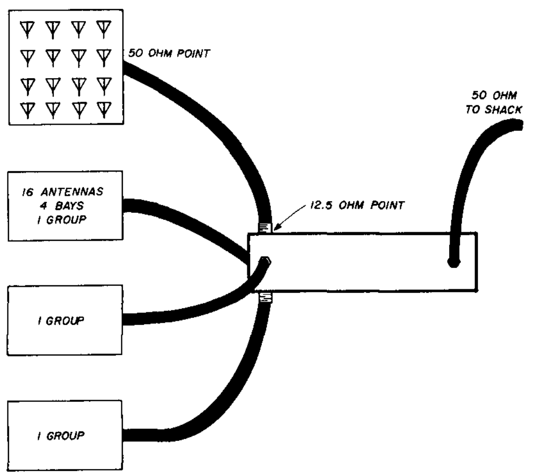

fig. 9. Four of the sixteen antenna arrays combined using one more four-port matching section.

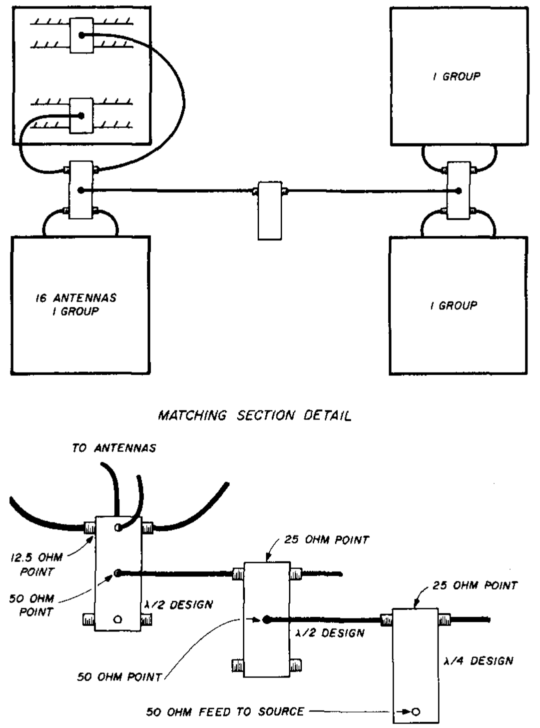

fig. 10. Same array as in fig. 9 but using another matching section combination.

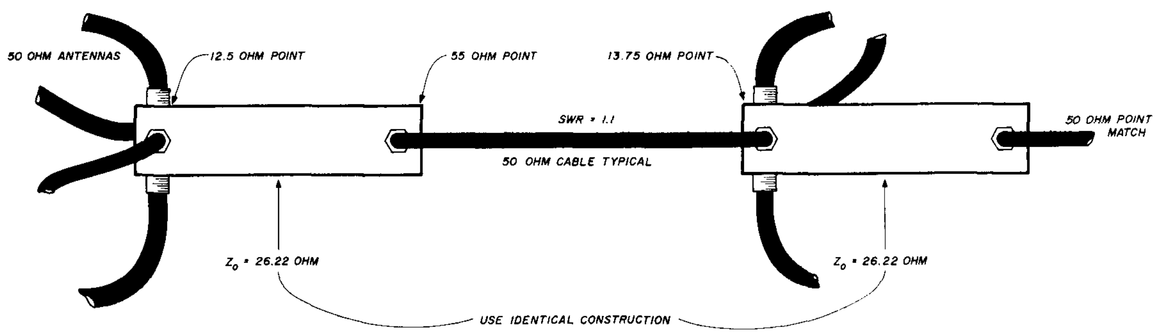

fig. 11. Two identical sections tend to correct their own construction errors.

made all the matching sections equal lengths, and they all have the same air dielectric, the delay to rf traveling through them will all be the same. A good grade of coax for all connecting cables is very important. Care must be taken to make all coax lines in the system the same length as all other lines in the same positions. That is, all coax lines from the antennas to the first matching sections must be the same length. All lines from the first matching sections to the second matching sections must be the same length, but not necessarily the same length the antenna lines were, and so on.

self-correcting features

Another benefit of identical matching sections is the self-correcting feature. If for some reason the transformation is not exactly correct, so that 50-ohm antennas are transformed to, say, 55 ohms by the first matching section, the identical second matching section will correct the situation by transforming the 55-ohm networks back down to 50 ohms to match the drive system (**fig. 11**).

power and precautions

With properly constructed matching sections, the coax portions of the network will be flat with a VSWR near 1.0. The array shown here should present a 50-ohm resistive load with a feed-line VSWR of 1.0 or very close to it.

The impedance-matching sections will carry full legal power with ease provided some basic precautions are taken. It is almost impossible to waterproof everything on these units: rivets, screws, connectors all tend to leak. The best approach is to leave the ends wide open so that the water can drain out and check occasionally for obstructions such as insect nests, leaves, or ice, depending on your location.

materials

Materials are available from several sources. One-sixteenth-inch, 1-inch square aluminum tubing is available from most hobby or building supply stores. Specifically it has been obtained from MacLanburg Duncan Co., 4041 N. Santa Fe, Oklahoma City, Oklahoma 73118. Standard copper tubing sizes are available in rigid form from a plumbing supplier. Some other tubing sizes, usually in brass, are available from large hobby shops. If this is not convenient, contact a nonferrous-metals dealer in a larger city for odd-size tubing and for the 1-inch square, 1/8-inch wall aluminum stock.

reference

1. Jim Pruitt, WB7AUL, "Matching Complex Antenna Loads to Coaxial Transmission Lines," *ham radio*, May, 1979, page 52.

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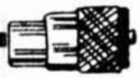

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More Details? CHECK—OFF Page 98

a speech processor
for fm transmitters

A microphone amplifier
and audio processor
for fm transmitters
using Plessey SL6043 ICs

This article describes a microphone amplifier and audio processor for fm transmitters. It uses a Plessey Semiconductors type SL6043 quad operational amplifier and consists of a high-input-impedance preamplifier (which may be omitted if a high-input impedance is not required), an amplifier, a pre-emphasis circuit, and a Sallen and Key lowpass filter.

the Plessey SL6043 IC

The SL6043 (**fig. 1**) has been especially developed for use in radio applications. The operating current of each amplifier is programmed by an external pin. Pin 8 biases amplifiers B, C, and D, and pin 16 biases amplifier A. It's thus possible to bias one amplifier at a totally different point than the others if desirable in a particular application. The SL6043 may be used in amplifiers, buffers, filters, comparators and voltage regulators.

speech processor circuit

Fig. 2 shows the circuit diagram of the speech processor. It consists of a high-input-impedance, noninverting stage with a gain of 16 dB (x6), a main amplifier with a gain of 38 dB (x80), a pre-emphasis stage with a response rising at 6 dB/octave, and a lowpass Sallen and Key filter with an 18 dB/octave rolloff above 3 kHz. The pre-emphasis stage is arranged to have symmetrical limiting so that it will also serve as a peak clipper.

The input amplifier uses operational amplifier A of the SL6043C in the noninverting mode. Its dc working voltage point is deliberately set at 0.4 Vcc rather than 0.5 Vcc, so that the electrolytic interstage coupling capacitor is correctly biased. This stage has an input impedance of about 400k and a gain of 16 dB (x6). The gain is set by R1 and R2 and may be altered by changing R2 according to

$$gain = \frac{R1 + R2}{R2} \qquad (1)$$

The gain of stage A may be varied from unity (R2 omitted) to 26 dB (x20) if R2 is reduced to 27k. This is the minimum recommended value for R2. If more gain is required, it should be added externally.

If a low-impedance dynamic microphone is used, the input amplifier is not necessary and may be omitted. In that case op-amp A may be used for some other purpose. In either case, it may be necessary to detach pin 16 from R3 (**fig. 2**) — either to power down op-amp A altogether or to power it to a higher level. If the input amplifier isn't used, the input signal is applied at point X, which should also be decoupled to ground by a 0.001-μF capacitor.

The main amplifier is a conventional inverting "see-saw" amplifier. Its gain, which is set by R4, is normally 38 dB (x80), but it may be varied between 20 dB (x10) when R4 = 2.7k and 40 dB (x100) when R4 = 27k. The input coupling capacitor sets the low-frequency rolloff of 6 dB/octave below 300 Hz.

This amplifier, and the one following it, are biased so that any large-amplitude signals are symmetrically clipped. Clipping is essential to ensure that the transmitter does not over deviate on transients. Symmetrical clipping ensures that only odd-order harmonics are present in the clipped signal (third, fifth, etc.);

By James M. Bryant, G4CLF, and **Peter E. Chadwick, G3RZP,** Plessey Semiconductors Ltd., Cheney Manor, Swindon, SN2 2QW, England

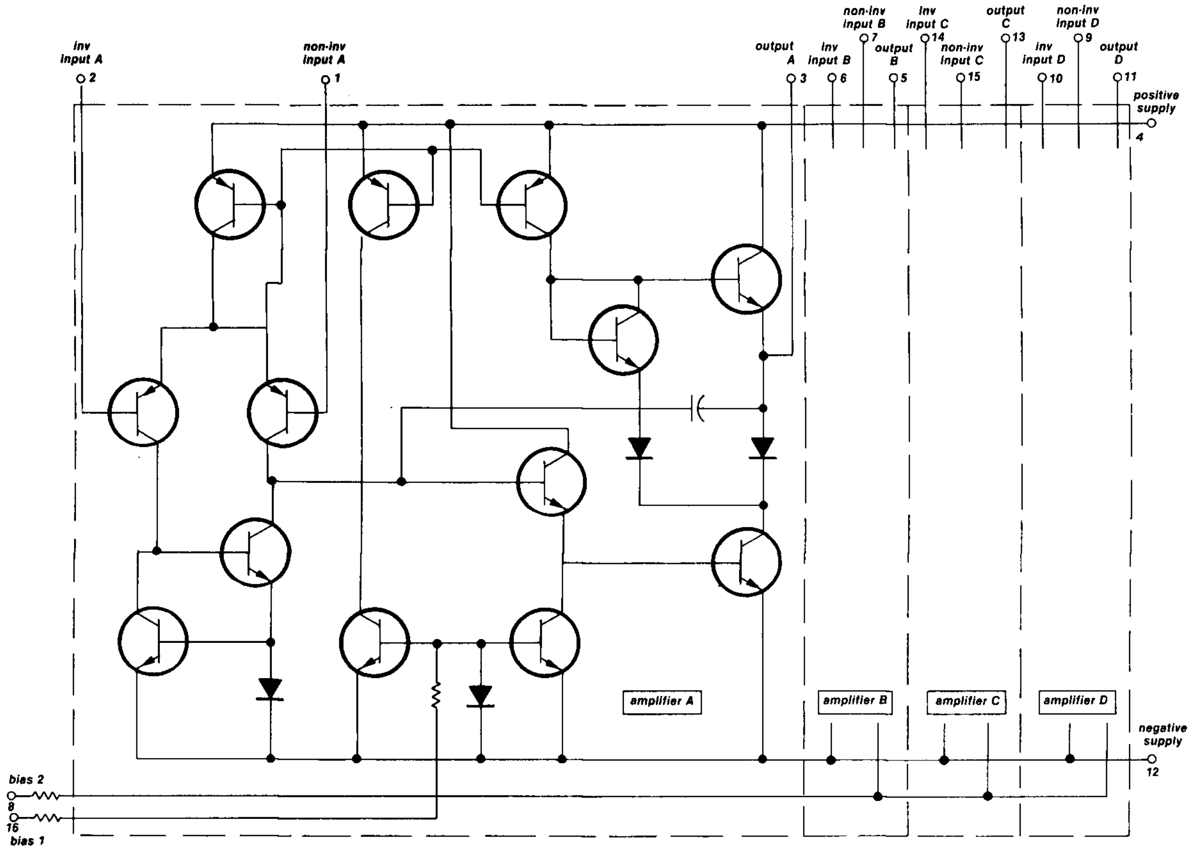
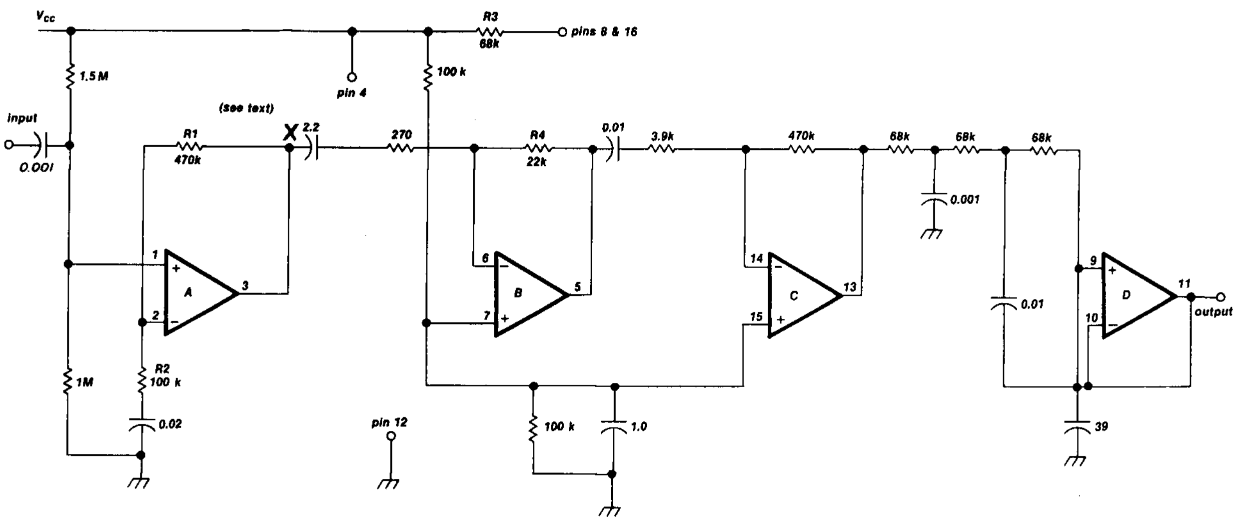


fig. 1. Circuit diagram of the SL6043C quad operational amplifier.



Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms.
k = 1,000 M = 1,000,000

fig. 2. Circuit diagram of the fm speech processor.

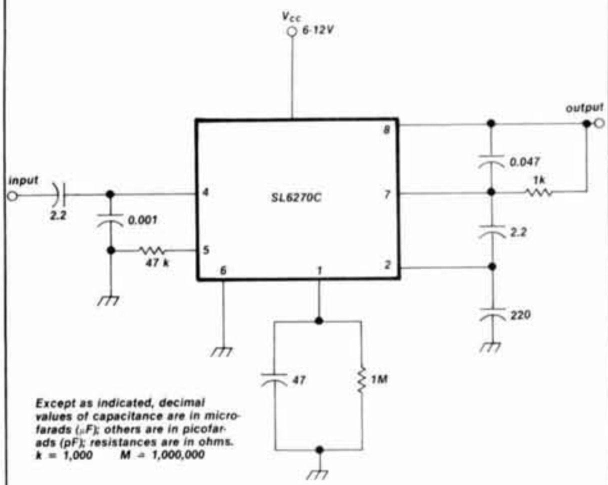


fig. 3. VOGAD using the SL6270C (may be used in place of the input stage if audio AGC is required).

they are less unpleasant and, being higher in frequency, more easily filtered than the second harmonic, which would result from asymmetrical clipping.

The third stage is another inverting see-saw amplifier; but the input half of the see-saw, consisting of 0.01 μF in series with 3.9k, is capacitive up to 4 kHz and gives a rising 6 dB/octave response up to this frequency. This stage is the one most likely to limit.

The signal from the pre-emphasis circuit goes to a third-order Sallen and Key lowpass filter, which gives an 18 dB/octave slope above 3 kHz. This filter consists of three capacitors, three resistors, and op-amp D, which is used in the unity gain, noninverting mode.

The output level from the system depends on the input level and the gain since no AGC is used (if audio AGC is required, the input amplifier should be replaced with the Plessey Semiconductors SL6270 VOGAD, used in the circuit shown in **fig. 3**, and R4, **fig. 2**, should be 5.6k). The gain of the first two stages should be set so that the output level is around 1.5-2 VRMS with normal speech into the microphone. This ensures a reasonable, but not excessive, level of clipping.

The power supply is a single +12 V unit, but this is not critical and may be varied from +6 to +24 V without any effect but a change in the clipping level. The supply should, however, be well decoupled from audio and radio-frequency energy.

No printed circuit board has been designed for this system, because it's so simple that it's likely to be used in many widely different applications. No special precautions are needed in construction except to isolate the high-impedance input from the output and, if it contains hum, to isolate the power supply.

ham radio

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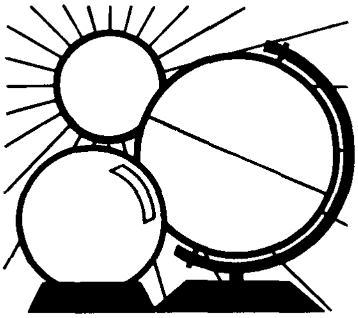


DX FORECASTER

Garth Stonehocker, K0RYW

last-minute forecast

The higher-frequency ham bands during daylight hours will offer the best DX for the first week and a half of the forecast period. Solar flare activity is expected to result in solar wind bursts of particles that disturb the magnetosphere and ionosphere. Disturbed periods are probable around the 7th, 15th, and 23rd of the month. Signals on east/west paths through high latitudes will be weak and suffer from QSB, while trans-equatorial north/south paths will be enhanced. Low-band DX should be very good all through the month, particularly trans-polar paths at twilight during geomagnetically quiet times. The moon will be full on March 9 and perigee on March 4 and 29.

In March and April spring storms bring rain to much of our country. From these storms come the year's first major thunderstorms — and thunderstorms mean noise (static). Increased noise lowers the signal-to-noise ratio in our receivers, decreasing readability. This brings to mind the old saying, If you can't hear 'em, you can't work 'em. Last year's March issue of *ham radio* went into how noise gets here and how to track it. You can schedule your DXing in between storm passages to get the best chances of hearing the weak ones.

Toward the end of March (associated with the equinox, which is on March 20 at 2256 UT), the geomagnetic field is easily disturbed. The equatorial plane of the sun lines up through space with the earth's equator, giving particles a more direct path to the earth's polar regions. Disturbances are common. DX can be from unusual locations because of the ionosphere's erratic movements. East/west paths are generally poorer; otherwise, over-the-pole DX paths are best during the equinox season.

I've mentioned beacons several times in the past. A beacon is a transmitter which generally operates full time. It is identifiable by its frequency, modulation, or call sign. By listening for the beacon you can ascertain if the band is open to that location. Beacons can be intentionally set up by Amateurs, or it's possible to eavesdrop on the transmitters of other services on frequencies adjacent to an Amateur band. Even a megahertz or two away is close enough to give you an idea of the propagation conditions on the band in question.

One group of signals that make useful beacons are the standard frequency and time stations on 2.5, 5, 10, 15, and 20 MHz. There are some twelve different countries represented, with a total of nine beacons on 2.5 MHz, eleven on 5 MHz, nine on 10 MHz, seven on 15 MHz, and two on 20 MHz. Canada and Australia broadcast three frequencies each near these.

beacons on 2.5, 5, 10, and 15 MHz

The following stations may be used as beacons on the WWV frequencies: BPM, China; JJY, Japan; WWVH, Hawaii; WWV, Colorado; MSE, England; IBF, Italy; LOL, Argentina; ZUO, South Africa; and RTA, Russia. If you've heard some peculiar sounds with the WWV signals while you've waited to check the daily solar flux and geomagnetic data at eighteen minutes after the hour, it may have been one of these other signals on the frequency "interfering." Maybe that's not so bad: after you ferret them out, you can use them for determining propagation conditions and openings.

By knowing the broadcast and modulation schedule of each station, you can tell which one is which. Here are a couple of examples: WWV is a man's voice and WWVH a woman's voice, giving the time each minute (ladies first); China identifies BPM in Morse during the one minute preceding the hour and half hour. For information on all these stations and their services consult the CCIR Working Group 7-C Draft report on 267-4 (MOD F), which may be obtained from Mr. R. Beehler, National Bureau of Standards, 325 Broadway, Boulder, Colorado 80301.

band-by-band summary

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

Ten, fifteen, and twenty meters will be full of signals from most areas of the world from morning into early evening almost every day. The openings will be shorter on the higher bands and concentrated more toward noon for the path of interest. High solar flux values and geomagnetic disturbances will favor these bands for trans-equatorial contacts. Noise effects are not too noticeable.

Forty, eighty, and one-sixty meters are the night DXer's bands. The bands open just before sunset and last just until the sun comes up on the path of interest. Except for daytime short-skip signal strengths, high solar flux values don't affect these bands much. Geomagnetic disturbances, however, which will be more evident near the equinox, cause much signal attenuation and fading on polar paths. Noise will be spasmodic and very noticeable on these lower-frequency bands.

ham radio

MARCH

WESTERN USA

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

MID USA

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

EASTERN USA

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

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

NEW products

Morse-A-Keyer

A low-cost, dependable CW keyboard is now available from Microcraft. It features an industrial quality keyboard, rugged steel case, and a 16-character first-in first-out buffer which allows you to type slightly

ahead of the text being sent. Also included are an internal speaker, sidetone monitor, and buffer full LED.

Speed range is 5 to 45 WPM standard, but can be easily increased by changing one resistor. A reed relay is used to key your transmitter and to provide isolation between the keyboard and associated equipment.

The Morse-A-Keyer is available as a partial kit, complete kit, or factory wired and tested. The partial kit consists of a PC board, construction manual and board parts. The builder must supply an ASCII coded keyboard, 5 volts at 120 mA supply and miscellaneous hardware. Cost is $69.95 plus $3.00 shipping and handling. The complete kit sells for $159.95 plus $5.00 shipping and handling and the factory wired model for $205.00 plus $5.00 for shipping and handling. Write Microcraft Corporation, P.O. Box 513, Thiensville, Wisconsin 53092.

trailered towers

Trailer-mounted antenna towers can be erected by a single person in record time. From the time the trailer

was parked, to the full extension of the Telex/Hy-Gain tower, only 15 minutes had passed. These self-supporting, crank-up steel towers are easily trailered even by passenger cars. The trailer towers are exceptionally well suited to microwave tower surveys, their construction or repair, for site evaluation of two-way radio repeaters, for emergency or security field communications for remote a-m, fm or TV broadcasts at special occasions such as large outdoor concerts, fairs or sports events, or can be used as temporary light-support systems.

Towers are mounted on the trailer by a method which requires only one winch to tilt and erect the tower to its full height. Single-axle trailers, complete with legal running lights, accommodate medium to heavy-duty towers to 52 feet (15.85 m). Two axle heavy-duty trailers with towers to 70 feet (21.3 m) are also available. Antenna rotators, winch motors, and other accessories are optional.

For full information contact Clyde Blyleven, Hy-Gain, Division of Telex Communications, Inc., 8601 N.E. Highway Six, Lincoln, Nebraska 68505.

440-MHz synthesized handheld

Encomm, Inc., announces the addition of the ST-7/T 440-MHz synthesized handheld transceiver for use in the 440-449.995 MHz band to the Santec line of handheld radios.

This compact UHF package has a nominal 3 watts output from the transmitter and incorporates all 16-tone DTMF tones and optional synthesized CTCSS encoder capability. The high power level is backed up by the ability to switch to either one watt or as low as 50 milliwatts for battery saving applications.

The styling of the ST-7/T is quite similar to that of the popular Santec HT-1200 2-meter unit. All of the external accessories for the 2-meter unit are compatible with the ST-7/T. Both the receiver and transmitter cover the full band of 440 fm to provide true universal compatibility with the ARRL band plan for 440 MHz. Offset of the transmitter from the dialed receiver frequency is accomplished at the flick of a three-position switch, which provides for direct operation on the same frequency and up or down 5 MHz for the standard repeater offset. Another switch feature is the immediate access to the national calling frequency of 446.000 MHz (SPX) by actuating a single slide switch. The ST-7/T features a micro-thumbwheel frequency

selector switch to provide positive readout and control of the CMOS PLL synthesizer plus a metalized center body to provide better antenna efficiency. The antenna is a full 1/4-wave flex antenna which mounts on the BNC connector.

For more information, contact Encomm, Inc., 2000 Avenue G, Suite 800, Plano, Texas 75074, or telephone (214) 423-0024.

COMM-X antennas

"COMM-X," "Communications Extender," series of antennas presently includes two models. The model CX-144 has a frequency of 144-148 MHz and is 52 inches in length; the model CX-220 is 35 inches long and has a frequency of 220-225 MHz.

Both feature adjustable whips designed to allow field tuning for optimum VSWR, typically 1.5:1 or less at resonance, and typical gain of 3 dB over a 1/4-wave standard. In addition, two stainless steel set screws secure the heavy-duty whips to provide "double-locked" protection. The ferrule is attached with adhesive and also mechanically staked to ensure integrity.

The "COMM-X" is rated at 200 watts and is made of quality materials, including 17-7 taper ground stainless steel whip, 16-gauge copper matching coil, and standard 3/8-24 chrome-plated brass base. This combination provides excellent wear resistance for long-lasting service.

Valor Enterprises, Inc., is located in West Milton, Ohio. Additional information may be obtained by writing or calling (513) 698-4194; outside Ohio call toll free: (800) 543-2197.

vlf converters

Palomar Engineers is introducing two new converters for the 10-500 kHz band. They add to shortwave receivers reception of weather, ship-to-shore CW traffic, RTTY, WWVB, navigation beacons, 1750-meter no-license band, and European low-frequency broadcast stations.

Model VLF-A converts to 3510-4000 kHz for use with ham-band-only

receivers and transceivers. This gives optimum reception, since receiver noise figure is best on 80 meters.

Model VLF-S converts to 4010-4500 kHz for general coverage shortwave receivers. With digital readout the last three digits read frequency directly.

The new converters feature antenna bypass when turned off, LED power indicator, and low-current 9-volt dc operation. They are housed in attractive brushed aluminum and black vinyl cabinets.

The new converters sell for $79.95. For further information write Palomar Engineers, 1924-F W. Mission Rd., Escondido, California 92025.

portable RTTY/CW terminal

HAL Communications Corporation announces the new CWR685A Telereader portable RTTY/CW terminal. Featuring compact size and 12-Vdc operation, the CRW685A is just the thing for the traveling RTTY Amateur. A green phosphor 5-inch display is built into the small 12-3/4 × 11 × 5 inch main cabinet, as is an RTTY modem for three shifts, both high and low tones. The keyboard is separate and connects with a 3-foot cord to the main unit. Advanced features such as programmable HERE IS messages, type-ahead transmit buffer, and automatic transmit/receive control are included with the Telereader.

NEW products

The CWR685A can easily be slipped into a suitcase for a ham-holiday outing. In the home shack, the Telereader consumes little space and can be connected to an external monitor and parallel ASCII printer for even more versatility. For more information, contact HAL Communications Corporation, Box 365, Urbana, Illinois 61801.

handheld synthesized scanner

Electra Company has announced a breakthrough in scanning radios with their new Bearcat® 100 handheld portable, which they will manufacture here in the U.S. Fully synthesized, it requires no crystals. *Compressed into a 3 × 7 × 1¼ inch case* is more scanning power than in many base or mobile units. The unit has a full 16 channels with extended frequency coverage. Power consumption is kept extremely low by using a liquid crystal display and several low-power integrated circuits which are new to the industry.

The Bearcat 100 produces audio power output of 500 milliwatts and a hefty one full watt when used in conjunction with the accessory ac adapter included in the package. The unit has patented Track Tuning, selectivity of better than 50 dB down, and sensitivity of less than a microvolt on all bands and all channels.

The unit operates on six AA batteries and has a battery-low LED indicator to signal when to recharge. A special internal circuit protects against overcharging while also preventing excess drain on the batteries. The unit's wide frequency coverage includes all public service bands (low, high, UHF, and T bands), both 2-meter and 70-centimeter Amateur bands, plus military and federal land mobile frequencies. The unit has direct channel access and a built in automatic scan delay.

The package includes a sturdy carrying case, earphone, battery charge/ac adapter and has a suggested retail price of $449.95. Complete details are available from Bearcat scanner suppliers, or by writing to Electra Company, 300 East County Line Road, Cumberland, Indiana 46229.

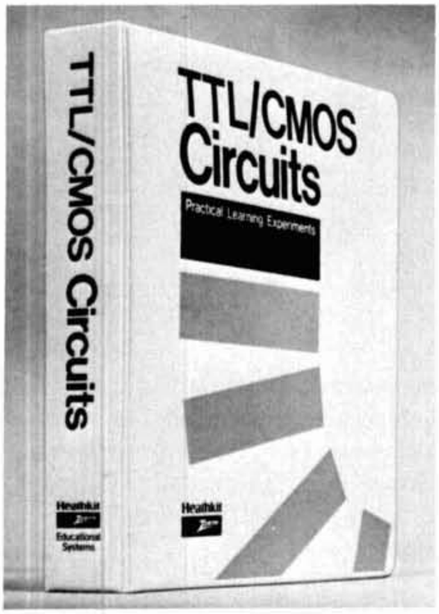
2-meter fm transceiver

Trio-Kenwood has just introduced a new 2-meter fm mobile transceiver, the model TR-7730. The compact TR-7730 has an rf output power of 25 watts, with HI/LO power switch, five memories, memory scan, automatic band scan, up/down manual scan on the microphone, four-digit LED frequency display, S/rf bar meter, ± 600 kHz offset switch, and LED indicators for BUSY, ON-AIR, and REPEATER.

Optional accessories include the MC-46 sixteen-button autopatch microphone, SP-40 remote speaker, and KPS-7 power supply for fixed station operation. For additional information, contact Trio-Kenwood Communications, P.O. Box 7065, Compton, California 90224.

course in TTL and CMOS

A new "hardware-oriented" course in TTL and CMOS circuits is being offered by Heathkit/Zenith Educational Systems. Designed for the electronics student, experimenter, Radio Amateur, or computer enthusiast, these concise circuit descriptions are ideal for the person who wants to learn by doing.



A hardware-oriented course designed to give hands-on experience, the TTL and CMOS Circuits Course is composed of a series of circuit files arranged in a logical progression. Each file provides the student with a description of the particular circuit and its operation, a circuit schematic, and modifications that can be performed on the basic circuit.

Text reading is condensed and the course places emphasis on actual circuit construction. Examples of the circuits the student will build (components are included) are seven-segment digital displays, flip-flops, clock generators, data selector distributors, and comparators.

For more details on the EH-702 TTL and CMOS Circuits Course, see the latest 104-page Heathkit Catalog. For a free copy write Heath Company, Dept. 350-165, Benton Harbor, Michigan 49022.

multi-purpose rf wattmeters

Bird Electronic Corporation's line of RF Power Analyst™ directional wattmeters has been expanded by the addition of seven new models. These microprocessor-based digital THRULINE® wattmeters are available now as rack-mounted as well as portable instruments, with built-in or external coax line sections, and with measurement parameters geared to fm, a-m, SSB/DSB, CW, TV or 2-way communications signals.

In addition to bi-directional power from 0.5 to 2300 MHz and from 100 milliwatts to 250 kW, the new series of RF Power Analyst™ instruments measure VSWR, return loss, percent of modulation, dBm and peak envelope power functions. A min/max memory of any displayed quantity makes equipment adjustments simpler than with an analog device.

Detailed specifications in bulletin PA4382-87/1. Price $500-$850, Plug-in Elements $46-$100. Delivery 4-6 weeks ARO. Contact Bird Electronic Corporation, 30303 Aurora Road, Cleveland (Solon), Ohio 44139.

200-watt CAP transceiver

The 200-watt solid-state Civil Air Patrol transceiver, Ten-Tec Model CAP 100, has eight crystal controlled channels (two user-selected 4-MHz channels for primary and alternate frequencies plus the National Emer-

NEW products

gency Frequency, two CAP channels on 7 MHz, and the 11.9, 14.9, and 20.8 MHz CAP channels) all built-in. Other features include automatic sideband selection, four-pole crystal ladder filter (2.7:1 shape factor, 6/50 dB), built-in squelch, S/SWR meter, adjustable threshold ALC and drive, clean audio, high-stability oscillators, built-in speaker, built-in phone patch jacks, linear T/R control relay, counter output jack, and 13-volt dc circuitry.

Options include eight-pole plug-in filter, power supply, microphone, noise blanker, mobile mount, mobile circuit breaker, speech processor, and antenna tuner. Styling is in rich bronze with contrasting nomenclature for easy reading. The "clamshell" type aluminum case in dark finish features full shielding, tilt-up bail, and compact size: 5 × 11-3/8 × 12-1/8 inches.

The unit, a basic high-frequency SSB transceiver, can be adapted to domestic and foreign commercial applications as well. Model 100 is priced at $595 with all crystals included. For full information, write Ten-Tec, Inc., Highway 411 East, Seiverville, Tennessee 37862, or telephone (615) 453-7172.

10 kHz-30 MHz tuner

This advanced Signa/Match frequency-selective tuner from Grove Enterprises is designed to optimize impedance matching between any antenna and any receiver on any frequency between 10 kHz and 30 MHz. It will reduce, and in many cases remove, receiver intermodulation, images and front-end overload. Background noise is reduced. Vlf signals you never dreamed were there come roaring in loud and clear.

Front-panel switches allow instant selection between two antennas and between two receivers (or two antenna inputs to one receiver). Matched rotary switches permit the listener to peak signal strength of the frequency of interest, while a main tuning dial provides sharp resolution of the final signal.

The Signa/Match works best with 50-100 foot wire antennas or center-fed dipole antennas. Signa/Match requires no power source. Installation is between your antenna input line and receiver. Signa/Match comes com-

plete with instruction manual and all interconnecting cables. For further information and free catalog, contact Grove Enterprises, Inc., Dept. D, Brasstown, North Carolina 28902.

MBA™ reader only

AEA, Inc., announces a new reader for Morse, Baudot, and ASCII operation. The MBA-RO (reader only) is a state-of-the-art device using a 32-character vacuum fluorescent alphanumeric display. The 32-character

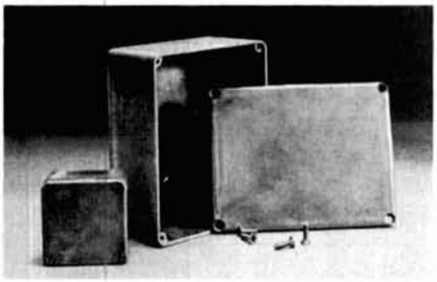
display allows for up to five words to be displayed at one time. This extended display is especially useful during high speed copy.

The equipment features include speed capabilities of up to 99 WPM for CW copy, 60, 67, 75, and 100 WPM for Baudot, and ASCII at 110 and hand-typed 300 baud. The MBA incorporates automatic speed tracking, ensuring no loss of copy due to rapid speed changes in signal reception. The MBA required a 12-Vdc external power supply, making it ideally suitable for portable, mobile, or fixed operation. The MBA is compact in size and can be used with a hand key, bug, or electronic keyer.

For more information, contact Advanced Electronic Applications, Inc., P.O. Box 2160, Bldg. O&P — 2006-196th SW, Lynnwood, Washington 98036, or telephone (206) 775-7373.

diecast boxes

Hammond has introduced a new line of improved diecast aluminum alloy boxes. Good rf shielding makes smaller sizes excellent for rf connectors. The countersunk lid has an interlocking flange and the box is drilled and tapped for screws provided.



The boxes have an attractive ground and tumbled finish which may be painted if required. Quantity discounts provided when ground and tumbled surface not required. These boxes are available at all Hammond distributors or we'll send a free catalog on request. Contact Hammond Manufacturing Company, 1690 Walden Avenue, Buffalo, New York 14225.

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More Details? CHECK—OFF Page 98

QSL ECONOMY: 1000 for $13. SASE for samples. W4TG, Box F, Gray, GA 31032.

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AMP-LETTER: Devoted to designing, building, and operating Amateur Radio Amplifiers. Sample $2.00. AMP-LETTER, RR2 Box 39A, Thompsonville, IL 62890.

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WOLF, SHERMAN W., Author of FM Digest. Anyone know his present address? Please contact me. K4CHE, 104 Brookfield Drive, Dover, DE 19901.

HAM RADIO FANATICS! You need the W5YI Report — Twice monthly award-winning insider newsletter. 24 issues — $18.00. Sample issue SASE (2 stamps). W5YI, Box #10101-H, Dallas, Texas 75207.

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CONNECTICUT'S Ham Store — Rogus Electronics, 250 Meriden-Waterbury Turnpike, (Rt. 66) Southington. (203) 621-2252.

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TELONIC SPI-64 Sweep generator, Heath TC-1 manuals/schematics needed. Purchase or photocopy. WA4VZQ, 4740 Edens View Road, Kingsport, TN 37664.

WANTED: Pre-1950 TV sets and old TV Guides. Jeff Kadet, W3CRH, Box 90-HR, Rockville, MD 20850. (301) 654-1876.

NEW REPEATER SITE? Intermod studies done by computer. Specify maximum on-site receiver bandwidth, receiver I.F. frequencies (if known) all on-site transmit and receive frequencies, and specify maximum harmonic multiplier of interest. Charges: $1.50/frequency plus $5.00/harmonic multiplier. Lee Barrett, K7NM, Box 488, Havre, Montana 59501.

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

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SB-102, SB-600, PS, CW filter. MINT honest. Original owner. K5PA, 12412 Mossybark, Austin, TX 78750. (512) 258-4959. $390.

ROHN TOWERS — Wholesale direct to users — All products available. Write or call for price list. Also we are wholesale distributors for Antenna Specialists and Regency FM radios. Hill Radio, P.O. Box 1405, 2503 GE Rd., Bloomington, IL 61701. (309) 663-2141.

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OVERPRINTED — 1981 Fox-Tango Club Newsletters. Sixty loose-leaf pages packed with modifications and information on Yaesu rigs. Only $6 while they last. Also a few 1980 sets at $5. (Overseas add $3 each, airmail.) N4ML, Box 15944, W. Palm Beach, FL 33406.

WANTED: MS connectors (new or used), synchros, military equipment and parts. Send list, Bill Williams, P.O. 7057, Norfolk, Virginia 23509.

SATELLITE TELEVISION: Information on building or buying your earth station. Six pages of what's needed, where to get it, etc. $4.00 to Satellite Television, RD #3, Oxford, NY 13830. Parabolic antenna construction book also available. Send SASE for details.

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

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More Details? CHECK—OFF Page 98

MICROWAVE CONVERTERS, decoders. Catalog 20¢. G.W. Electronics, P.O. Box 688, Greenwood, Indiana 46142.

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

2 METER EME NEWSLETTER. For 2 meter moonbounce enthusiasts. SASE for free monthly publication. WB7DTI, 426 N.E. 156th, Seattle, WA 98155.

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ACTIVITIES

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CALIFORNIA: Orange County Hamfest, March 6 & 7, Orange County Fairgrounds, Costa Mesa. Admission: $2.50 per person; children under 12 free. Auction, DX and CW contests; speakers; children's games; magic show. Western chicken barbeque Saturday, $5.95 pp. Talk in on 147.69, out on 147.09. For information write: Cataline Amateur Repeater Association, P.O. Box 2197, Westminster, CA 92683.

PLAYBOY CLUB: Plan ahead now to attend the ARRL Hudson Division Convention, October 30-31, 1982, at the Playboy Club, Great Gorge, McAfee, NJ. For info send SASE to HARC, Box 528, Englewood, NJ 07631.

CONNECTICUT: The Hartford County Amateur Radio Association's annual auction of used equipment and "stuff", March 11, 7:30 PM, Veterans Memorial, Sunset Ridge Drive, East Hartford. Refreshments served.

FLORIDA: The Playground Amateur Radio Club's 12th annual Swapfest, Saturday, March 20, 8 AM to 4 PM, and Sunday, March 21, 8 AM to 3 PM, Okaloosa County Fairgrounds, Fort Walton Beach. All inquiries, reservations, etc: PARC, c/o Joe Giangrosso, 304 Chickasaw Circle, Fort Walton Beach, FL 32548.

ILLINOIS: The Civil Air Patrol's second annual Spring Hamfest, Saturday, March 20, Lake County Fairgrounds, US 45 & IL 120, Grayslake. Donation: $2.00; tables, $3.00. Reservations and info: SASE Captain Rehm, 637 Emerald St., Mundelein, IL 60060.

INDIANA: The Randolph Amateur Radio Association's third annual Hamfest, Sunday, March 14, 8 AM to 5 PM. Tickets: $2.00 advance; $3.00 door. Guaranteed reservations by advance payment only. R.A.R.A., P.O. Box 203, Winchester, IN 47394 or W9VJX (317) 584-9361. Talk in on 147.90-30.

LOUISIANA: The 22nd annual Lafayette Amateur Radio Hamfest, sponsored by the Acadiana Amateur Radio Association, Saturday, March 13 and Sunday, March 14, Evangeline Downs Racetrack Club House, off Hwy. 167, 5 miles north of Lafayette. For information: AARA, P.O. Box 51174, Lafayette, LA 70505.

MARYLAND: The Baltimore Amateur Radio Club's Greater Baltimore Hamboree and Computerfest, Sunday, March 28, Maryland State Fairgrounds Exhibition Complex, Timonium. Indoor flea market, outdoor tailgating, Amateur radio, personal computer, small business computer displays. Cash grand prizes, hourly door prizes, food service, free parking. Doors open 8 AM. Admission: $3.00. Talk in on 34/94 and 07/67. For information, table reservations: G.B.H. & C., P.O. Box 95, Timonium, MD 21093. (310) 561-1282. For recorded announcement: (301) HAM-TALK.

MASSACHUSETTS: The Framingham Amateur Radio Association's 6th annual Spring Flea Market, the largest Ham flea market in New England, Sunday, April 4. Doors open 10 AM. Admission $2.00. Sellers $8/table (prior to

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March 27; $10/table after that). Talk in on 75/15 and 52 direct. Radio equipment, computer gear, food, bargains. Contact Ron Egalka, K1YHM, 3 Driscoll Drive, Framingham, MA 01701. (617) 877-4520.

MICHIGAN: The Southern Michigan ARS and Calhoun County Repeater Association's 21st annual Michigan Crossroads Hamfest, March 20, Marshall High School, Marshall. Doors open 7 AM for exhibitors; 8 AM for buyers/lookers. Refreshments available. Talk in on 07/67 and 52. For information: SMARS, P.O. Box 934, Battle Creek, MI 49016 or call Earl Goodrich (616) 781-3554.

MINNESOTA: The Rochester Amateur Radio Club and the Rochester Repeater Society's Hamfest, Saturday, April 3, John Adams Junior High School, 1525 N.W. 31 Street, Rochester. Doors open 8:30 AM. Large indoor flea market, prize raffles, refreshments. Talk in on 146.22/82. For further information: RARC, c/o WB0YEE, 2253 Nordic Ct. N.W., Rochester, MN 55901.

MISSOURI: A.R.C.H. '82, sponsored by the Gateway Amateur Radio Association, March 27 and 28, Chase Park-Plaza Hotel, St. Louis. Amateur Radio and computer hobbyists. Giant indoor flea market, major exhibitors/dealers; workshops and forums. Saturday evening banquet, ladies' activities. Thousands of $$$ in prizes. Advance tickets $3.00. Gateway ARA, P.O. Box 8432, St. Louis, MO 63132. (314) 361-4965.

MISSOURI: The PHD Amateur Radio Association's 13th annual Northwest Missouri Hamfest and the 1982 Missouri State ARRL Convention, Saturday and Sunday, April 3 and 4, Trade Mart Building at Downtown Kansas City Airport. Over $3500 in prizes. Doors open 10 to 5:30 both days. Forums, ARRL, DX, contest, technical antenna, YL, XYL. Saturday nite banquet at world famous Gold Buffet. Guest speakers: Ellen White, W1YL, DX editor of QST; Marge Tenney, WB1FSN, Convention Coordinator, ARRL; Paul Grauer, W0FIR, ARRL Midwest Director. Registration $4.00. Banquet tickets $10.25. Talk in 146.34/.94. For information/preregistration: PHD Amateur Radio Association, P.O. Box 11, Liberty, MO 64068-0011. (816) 781-7313 or (816) 452-9321.

MISSOURI: The Jefferson Barracks Amateur Radio Club's annual auction and Hamfest, March 12. NEW location, Carondelet Sunday Morning Athletic Club, South St. Louis. For information: Jefferson Barracks ARC, K0ZFK.

NEBRASKA: The 3900 Club and the Sooland Repeater Association's 6th annual Hamboree, Friday, March 19 and Saturday, March 20, Marina Inn, South Sioux City. Doors open Friday noon and Saturday 9 AM. Technical programs, ARRL forum, special Novice meeting, two CW contests, displays of latest equipment. Prize drawings all day Saturday and at banquet. Special exhibits by ARRL, QSL Bureau, Handi-Hams, 3900 Club and Sooland Repeater Association. Special programs for the ladies all day Saturday. Saturday evening at 5 PM entertainment by the North High School Jazz Band followed by banquet at 6. For table reservation contact: Al Smith, W0PEX, 3529 Douglas St., Sioux City, IA 51104. Advance tickets and motel reservations: Jerry Smith, W0DUN, Box 14, Akron, IA 51101. For further information: Dick Pitner, W0FZO, 2931 Pierce St., Sioux City, IA 51104 or Glen Holder, K0TFT, RR 1, Hinton, IA 51024.

NEW JERSEY: The Delaware Valley Radio Association's annual flea market, Sunday, March 28, 8 AM to 4 PM, New Jersey National Guard 112th field artillery armory, Eggerts Crossing Road, Lawrence Township. Advance registration $2.50, $3.00 door. Indoor/outdoor flea market, door prizes, raffles, refreshments, FCC exams. Sellers bring own tables. Talk in on 146.52 and 146.07-.67. For further information: D.V.R.A., P.O. Box 7024, West Trenton, NJ 08628.

NEW JERSEY: The Chestnut Ridge Radio Club's Ham Radio Flea Market, Saturday, March 20, Education Building, Saddle River Reformed Church, East Saddle River Road and Weiss Road, Upper Saddle River. Tables: $10.00 for first; $5.00 each additional. Tailgating: $5.00. Food and soda. Free admission. Contact: Jack Meagher, W2EHD, (201) 768-8360. Neil Abitabilo, WA2EZN, (201) 767-3575.

NORTH CAROLINA: The Raleigh Amateur Radio Society's 10th annual Hamfest, April 18, 8 AM, Crabtree Valley Mall, US 70 West, Raleigh. First prize: Kenwood TS830S HF transceiver OR Icom IC251A 2m transceiver; second prize: Icom 25A 2m transceiver and many more prizes. Expanded covered flea market, special interest meetings, nearby motels and restaurants. Talk in W4DW 146.04/146.64; K4ITL 146.28/146.88. For information/reservations: RARS Hamfest, P.O. Box 17124, Raleigh, NC 27619.

OHIO: The Toledo Mobile Radio Association's 27th annual Auction and Hamfest, Sunday, March 21, Lucas County Recreation Center, Key Street, Maumee. 8 AM to 5 PM. Auction starts at 10 AM. Tickets $2.00 advance; $3.00 door. Flea market tables available, electronics and ham gear only. Refreshments, door prizes and big raffle. Prizes include Kenwood TS-130S w/power supply; Kenwood TS-2500 Handy Talkie, Icom IC-2AT Handie Talkie and much more. Special ladies' programs. Area repeaters are 146.01/61, 19/79, 34/94, 147.87/27 and 975/375. Talk in on 146.52/52. For more info: J. Honisko, KB8YD, 1733 Parkway Drive N., Maumee, Ohio 43537.

OHIO: The 4th annual Lake County Hamfest, Sunday, March 28, 8 AM to 4 PM, Madison High School, Madison. Admission: $2.50 advance; $3.50 gate. Food, prizes. Main prizes: Kenwood TR9000 2m transceiver; Kenwood TR2500 HH 2m transceiver; Mirage B108 2m amplifier. Hourly door-prize drawings. Talk in on 147.81/21. For details call: (216) 953-9784 or write: Lake County Hamfest Committee, 5704 Middle Ridge, Madison, Ohio 44057.

PENNSYLVANIA: The Conemaugh Valley Amateur Radio Club's fifth annual Hamfest, March 28, Sandy Bottom Sportsman's Club, Seward, ten miles NW of Johnstown. 8 AM to 4 PM. Refreshments available. Good prizes. Check in on 146.34/94 repeater. For information: Conemaugh Valley ARC, 2829 Bedford Street, Johnstown, PA 15904.

PENNSYLVANIA: The Eight annual Northwestern Pennsylvania Hamfest, May 1, Crawford County Fairgrounds, Meadville. Gates open 8 AM. Bring your own tables. $5 per table to display inside, $2 per car space outside. $3 admission, children under 12 free. Refreshments. Commercial displays welcome. Talk in 04/64, 81/21, 63/03. Details: C.A.R.S., P.O. Box 653, Meadville, PA 16335. Attn: Hamfest Committee.

PENNSYLVANIA: Tradefest '82 sponsored by the Penn Wireless Association, Sunday, March 7, National Guard Armory, Southampton Road and Roosevelt Blvd., Langhorne. General admission $3. Bring own tables; power connections $3.00. Prizes, refreshments, rest areas, displays and surprises. Talk-in on 146.115/715 and .52. Contact: Mark J. Pierson, KB3NE, P.O. Box 734, Langhorne, PA 19047.

NEW JERSEY: Annual Flemington Hamfest Saturday, April 3 from 8:30 to 3:30 at the Hunterdon Central High School Field House. 20,000 square feet of heated indoor area. Gigantic flea market, 200 tables, major manufacturers, and more. Bring the XYL, kids and friends. Flemington is located between NYC and Philadelphia at the intersection of routes 202 and 31 just 10 miles south of I-78, and is a tourist area. Talk-in 146.52, 147.375, 147.015, 224.12 and 224.54 MHz. Admission $3.00 donation. For reservations or information call 201-788-4080 or write Cherryville Repeater Association c/o W2FCW, Box 76, Farview Dr., Annandale, NJ 08801.

KNOXVILLE, TENNESSEE: See World's Fair while attending 1982 Knoxville Hamfest and ARRL Delta Division Convention, Memorial Day weekend, May 22-23. DX, computer and technical forums; air-conditioned exhibit area; and large indoor/outdoor flea market make this Tennessee's largest Hamfest. More information? (dealers, tickets, reservations) N4BAQ, 5833 Clinton Hwy., Suite 203, Knoxville, Tenn. 37912.

WEST VIRGINIA: Attention Dealers! Wheeling WV Hamfest, July 25. White Palace, Wheeling Park. Attendance from 3 states, 1000 car parking. Reserve space. Contact: TSRAC, Box 240, RD 2, Adena, OH 43901.

WISCONSIN: The Madison Area Repeater Association's tenth annual Swapfest, Sunday, April 4, Dane County Exposition Center Forum Building, Madison. Doors open 8 AM for sellers; 9 AM for public. Admission $2.50 advance, $3.00 door. Tables $4.00 ea. advance/$5.00 ea. door. Door prizes; all-you-can-eat pancake breakfast and Bar-B-Q lunch available. Talk in on WR9ABT, 146.16/.76. For reservations/information: M.A.R.A., P. O. Box 3403, Madison, WI 53704 or Clyde Downing, W9HSY, P.O. Box 3403, Madison, WI 53704. (608) 222-1035.

NEW HAMPSHIRE: The Interstate Repeater Society's annual Hamfest and Flea Market, Saturday, March 13, Merrimack Hilton Hotel, Merrimack. 9 AM to 4 PM. Tables available at $10.00. Admission: $1.00. Prizes during day. Dinner dance with live music and entertainment. Talk-in on 146.25/85 and 146.52. Further information: Ken Soares, N1BAD, P.O. Box 94, Nashua, NH 03061 or on 25/85.

OPERATING EVENTS

"Things to do..."

MARCH 20: YL ISSB QSO Party. 0001 GMT, March 20 to 2359 GMT, March 21 (CW). 0001 GMT, April 24 to 2359 GMT, April 25 (Phone). Send logs, summary sheets, complete YLISSB QSO Party applications to: K0RDJ or KA0ALX.

MARCH 21: Wisconsin QSO Party. 1800 Z, March 21 to 0200 Z, March 22. (8 hours) CW and phone. Frequencies: CW: 3570, 7070, 14070 kHz. Phone: 3990, 7290, 14290 kHz. Logs, prior to May 1, to: Wisconsin QSO Party, c/o West Allis Radio Amateur Club, P.O. Box 1072, Milwaukee, WI 53201.

MARCH 28: A Special Event Station, W3FT, commemorating the annual Baltimore Amateur Radio Club's 1982 Hamboree and Computerfest. This station will be operated by the members of the Catonsville Community College ARS from the Maryland State Fairgrounds, Timonium, from 1200 to 2100 UTC. Frequencies: Phone — 7.275, 14.290, 21.365, 28.550 ± QRM. CW — 7.110, 21.120, 28.120 ± QRM. A certificate will be issued to Amateurs contacting W3FT upon receipt of QSL card and 40¢ U.S. postage. Foreign remit 2 IRCs. QSL via KA3GSN or KA3ENU, '82 Callbook.

MARCH 13. The 1982 Virginia State QSO Party sponsored by the Sterling Park Amateur Radio Club. 1800Z, Saturday, March 13 until 0200Z, Monday, March 15. 3 categories: Fixed/portable, single transmitter; fixed/portable, multitransmitter and mobile. Exchange QSO number, QTH (county for VA stations, state, province or country for others.) Suggested frequencies: Phone — 3930, 7230, 21375, 28575. CW: 60 kHz from low end and Novice bands. Plaque to high VA score and certificates to other high scores. Mail logs no later than April 15, 1982, to: A. Ray Massie, K3RZR, Rt. 1, Box 115E, Dunnsville, VA 22454. SASE for results.

MARCH 27: Ramapo Mountain Amateur Radio Club's UHF/VHF QSO Party. 1600 Hrs (local) Saturday, March 27 to 2400 Hrs (local) Sunday, March 28. 1982 contest rules considerably different from previous two contests. For log/entry forms SASE: RMARC, P.O. Box 364, Oakland, NJ 07436.

APRIL 7: DX YL to North American YL. All licensed women operators throughout the world invited to participate. CW starts Wednesday, April 7, 1800 UTC; ends Thursday, April 8, 1800 UTC. Phone starts Wednesday, April 14, 1800 UTC; ends Thursday, April 15, 1800 UTC. DX YLs call "CQ North American YL". N.A. YLs call "CQ DX YL". All bands may be used. No cross band operation. Nets, repeaters, OM contacts do not count. Please send logs prior to April 29, 1982, to: YLRL Vice President Sandra Heyn, WA6WZN, 962 Cheyenne Street, Costa Mesa, CA 92626.

APRIL 17: QRP AMATEUR RADIO CLUB International SSB QSO Party. 1200 UTC Saturday, April 17 to 2400 UTC Sunday, April 18. Operate max. 24 hours. Call CQ QRP. Suggested frequencies: 1810, 3985, 7285, 14285, 21385, 28885 and/or 50385 kHz ± interference clearance. VHF/UHF direct — no repeaters. Send logs and scoring to: QRP ARCI Contest Chairman, William Dickerson, WA2JOC, 352 Crampton Drive, Monroe, MI 48161.

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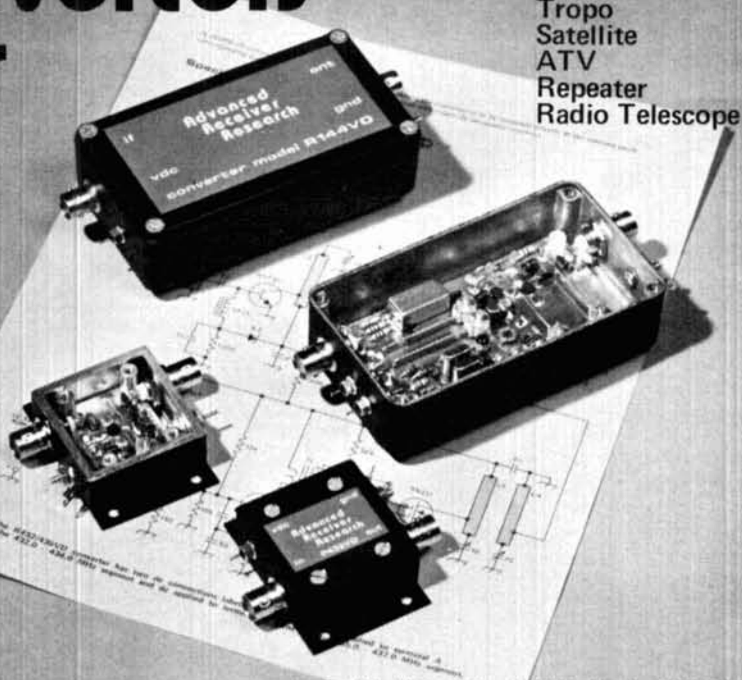

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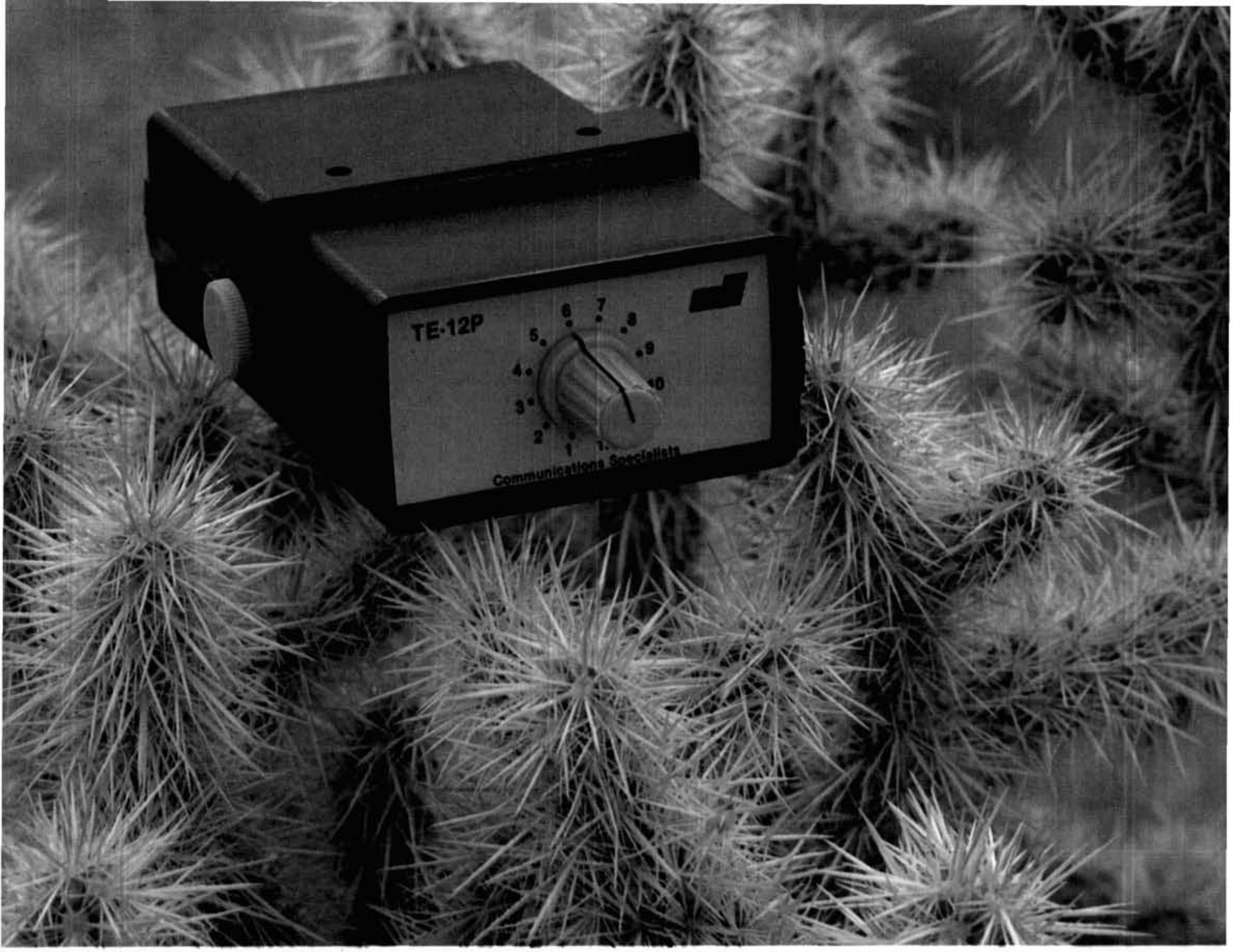

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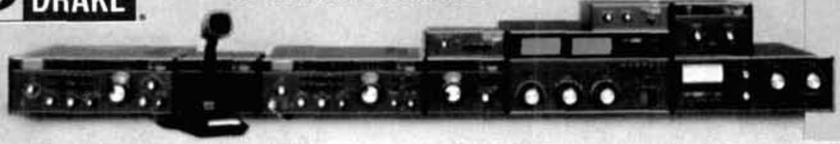
• **FREQUENCY FLEXIBILITY.** The TR7A / R7A combination offers the operator, particularly the DX'er or Contester, frequency control agility not available in any other system. The "Twins" offer the only system capable of no-compromise DSR (Dual Simultaneous Receive). Most transceivers allow some external receiver control, but the "Twins" provide instant transfer of transmit frequency control to the R7A VFO. The operator can listen to either or both receiver's audio, and instantly determine his transmitting frequency by appropriate use of the TR7A's RCT control (Receiver Controlled Transmit). DSR is implemented by mixing the two audio signals in the R7A

• **ALTERNATE ANTENNA CAPABILITY.** The R7A's Antenna Power Splitter enhances the DSR feature by allowing the use of an additional antenna (ALTERNATE) besides the MAIN antenna connected to the TR7A (the transmitting antenna). All possible splits between the two antennas and the two system receivers are possible.

Specifications, availability and prices subject to change without notice or obligation.

DRAKE

See your Drake dealer or write for additional information.



COMING SOON: New RV75 Synthesized VFO Compatible with TR5 and 7-Line Xcvrs/Rcvrs

• **Frequency Synthesized** for crystal-controlled stability • **VRTO (Variable Rate Tuning Oscillator*)** adjusts tuning rate as function of tuning speed. • **Resolution to 10 Hz** • **Three programmable fixed frequencies** for MARS, etc. • **Split or Transceive** operation with main transceiver PTO or RV75

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* Patent pending