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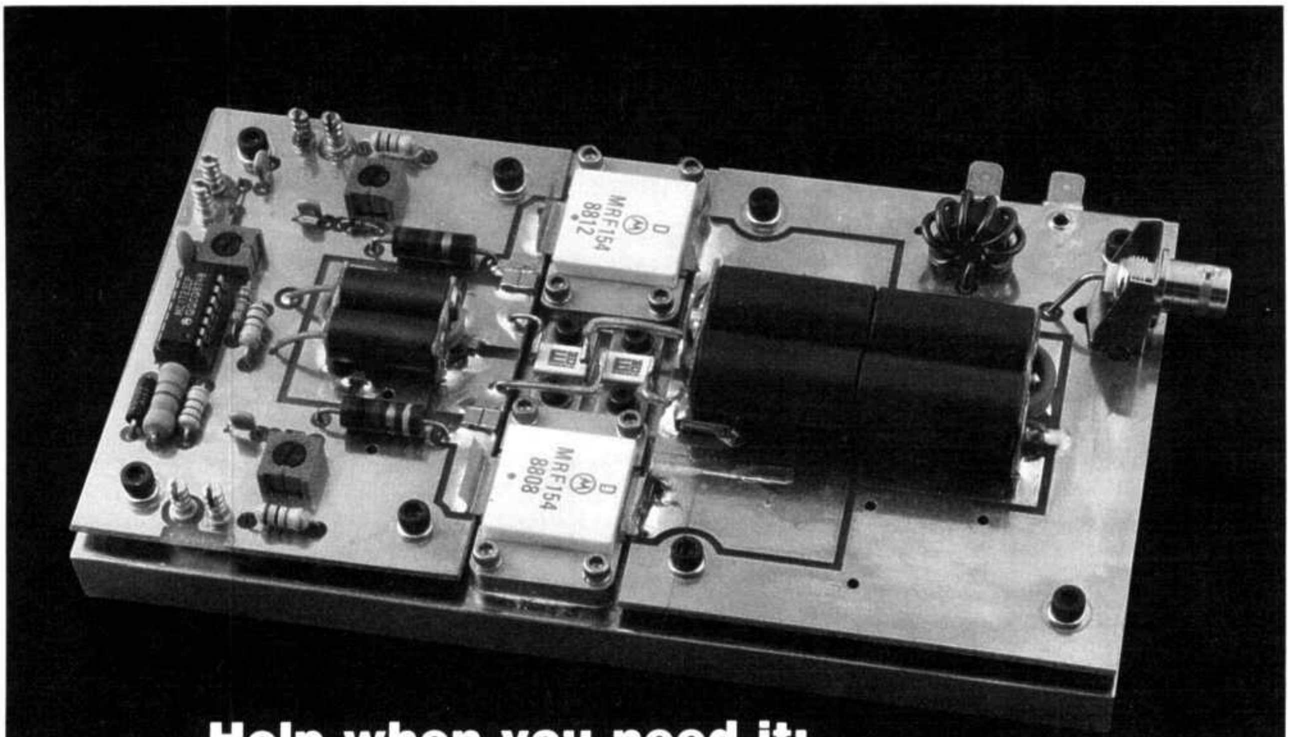
ARRL Experimenters' Exchange

JULY 1990



Help when you need it: a 1-kW solid-state HF linear amplifier

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American Radio Relay League
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The American Radio Relay League, Inc, is a noncommercial association of radio amateurs, organized for the promotion of interest in Amateur Radio communication and experimentation, for the establishment of networks to provide communications in the event of disasters or other emergencies, for the advancement of the radio art and of the public welfare, for the representation of the radio amateur in legislative matters, and for the maintenance of fraternalism and a high standard of conduct.

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Purposes of *QEX*:

1) provide a medium for the exchange of ideas and information between Amateur Radio experimenters
2) document advanced technical work in the Amateur Radio field
3) support efforts to advance the state of the Amateur Radio art.

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

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

Any opinions expressed in *QEX* are those of the authors, not necessarily those of the editor or the League. While we attempt to ensure that all articles are technically valid, authors are expected to defend their own material. Products mentioned in the text are included for your information; no endorsement is implied. The information is believed to be correct, but readers are cautioned to verify availability of the product before sending money to the vendor.

Empirically Speaking . . .

Digital Committee Meets

The ARRL Committee on Amateur Radio Digital Communication met in Frederick, Maryland on June 16. Briefly, the committee reviewed the League's petition RM-7248, which was withdrawn for reasons explained in June *QST* "It Seems to Us . . ." The existing STA will permit a continuation of SKIPNET operation until January 7, 1991. Following that date, it appears that the FCC will give favorable consideration to another extension to permit a consensus to develop on whether to permit automatic control of digital communications and, if so, under what provisions in the rules.

The Digital Committee reviewed its previous plans for a Version 2.1 of the AX.25 packet-radio link-layer protocol. At its previous meeting in Colorado Springs, the committee favored a number of minor modifications to Version 2.0, which included priority acknowledgement, a novel address-extension feature for call signs exceeding 6 characters, and other fixes for perceived "bugs" reported by implementers and users. At this meeting, the committee decided to delete the address-extension feature from Version 2.1 and complete the new protocol specification by August. While not a pressing problem at the moment, extensible or dynamic-length addresses are needed in future protocols to accommodate amateur call signs with prefixes and suffixes. The goal is to have a protocol specification to review at the committee's next meeting, to run it by the implementors for a final look and publish Version 2.1 before the end of 1990.

The committee continued its previous conversations on development of a major replacement for AX.25 Version 2.1 some day. This could take the form of a Version 3.0 or a new suite of protocols, each tailored to a transmission mode: HF, VHF/microwave, satellite and meteor scatter. Part of the key to faster data rates is taking advantage of off-the-shelf protocol chips to handle the framing. Further study of HDLC, Ethernet and T-1 chips is needed. The committee encourages developers to give consideration to international (as opposed to North American-only) speeds, such as 64 and 2048 kbit/s for future systems.

The committee turned to AMTOR, which is undergoing some interesting evolutionary changes. Paul Newland, AD7I, reported that W1AW has fully implemented AMTEX, the Amateur Radio version of NAVTEX, which permits selective reception of messages. The International Radio Consultative Committee (CCIR) has published a protocol for adaptive ARQ in which 9 characters are sent together instead of the normal 3. The ARQ9 mode produces a 20% improvement in throughput. A letter was sent to AMTOR system developers asking their input on possible adoption of ARQ9 as an option in future AMTOR systems. The response, thus far, has been positive, although there remain a few questions to be resolved.

In response to a request from Eric Gustafson, N7CL, the committee discussed the possibility of establishing a standard TNC-radio interface. Ideas on such a standard are solicited. The plan is to develop a "strawman" standard for circulation to those who indicate an interest.

There was some discussion of future systems, including DREAMNET. The basic idea is that amateurs should be thinking of what systems we would like to have 10-15 years from now to take advantage of emerging technologies. Many improvements are technically feasible now but require further refinement and economical manufacturing to make them flourish. The lingering problem is still affordable plug-and-play RF equipment for the microwave bands; the digital part seems easier.

The committee was pleased to see the initiative taken with CLOVERLEAF, described in this issue, and encourages further development of this system.

The next meeting of the Digital Committee will be September 23, 1990, in London, Ontario, following the 9th Computer Networking Conference, held jointly by ARRL and CRRL the day before. It is an open meeting to which observers are welcome. If you wish to have any matter considered by the committee, please send a letter to Chairman, Digital Committee, ARRL HQ, 225 Main St, Newington, CT 06111.—*W4RI*

A Compact 1-kW 2-50 MHz Solid-State Linear Amplifier

By H. O. Granberg, K7ES/OH2ZE
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Motorola, Inc
Phoenix, AZ 85062

Solid-state high-power linear amplifiers are becoming more and more popular in the field of ham radio as the prices of HF power transistors continue to fall. 250-W devices are now available for almost half the price they were selling for a few years ago. RF power FETs are still more expensive, but eventually their prices will also fall, although not as fast since they are still novelty items and the manufacturing yields are low due to ESD problems and requirement for cleaner facilities for wafer processing.

General

It is much easier to design wideband power amplifiers with FETs than bipolar transistors mainly due to their higher input impedances at least up to VHF. Their input impedance also varies less with frequency than that of bipolar devices and changes in the output load line are reflected back to the input to a lesser degree because of the much lower value of feedback capacitance (collector to base vs drain to gate). Practically all RF power FETs on the market today are of the enhancement MOS type, meaning that positive voltage at the gate in respect to the source is required to turn the device on.

The 1-kW amplifier described here would be difficult, if not impossible, to design to cover four and a half octaves with comparable performance using inexpensive bipolar transistors. In addition, a series of power splitters and combiners would be required to reach high power levels. Biasing to class AB linear operation is also much simpler with FETs since the gate does not draw any dc current, whereas a current equal to I_C(peak)/h_{FE} must be supplied to the base of a bipolar device. One example of this and the splitter-combiner complexity is presented in the Application Note AN-758 by Motorola, Inc.

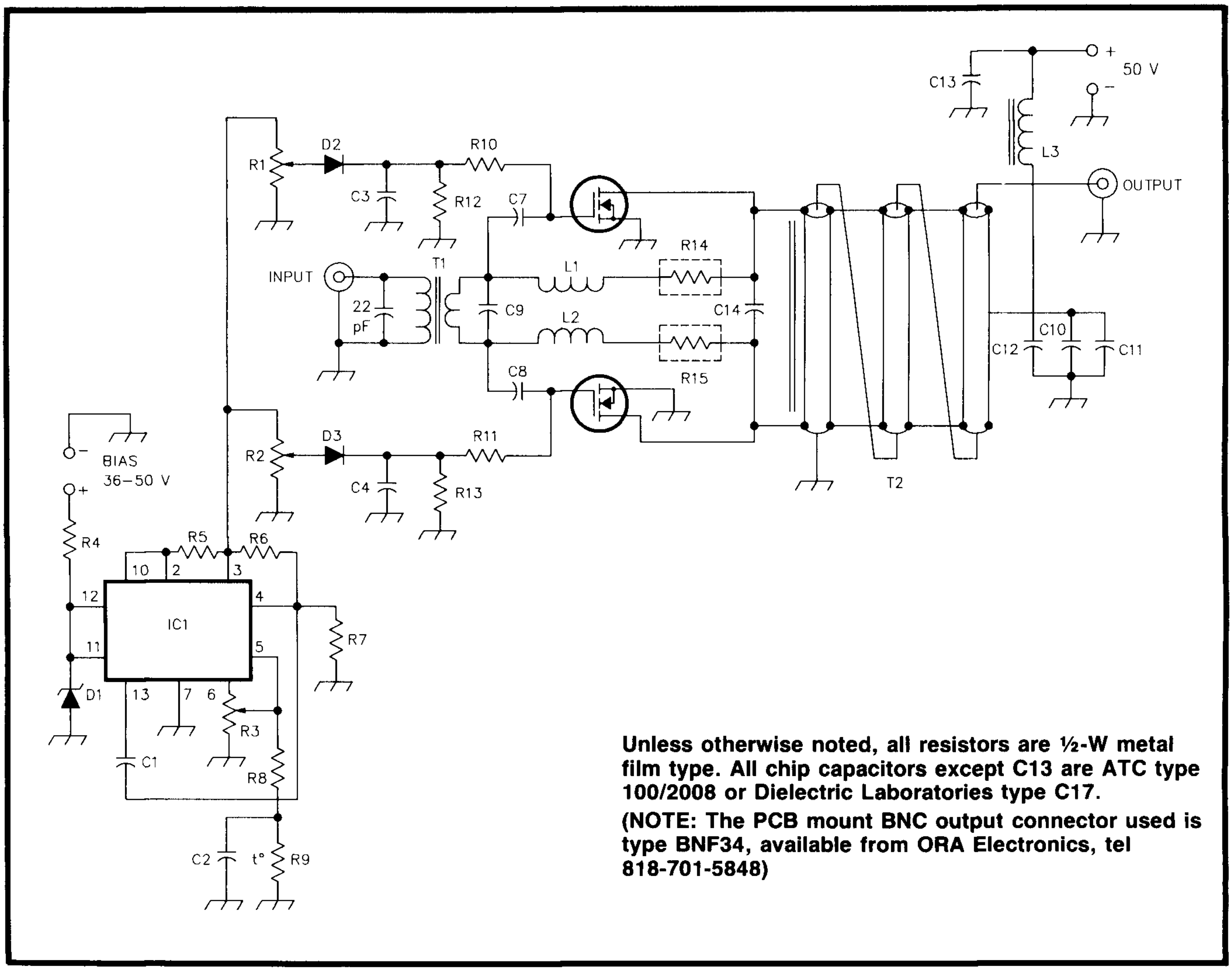
This article features a state of the art extremely compact design using a pair of FETs rated for 600 W of power output each. It would be capable of a power output of 1.2 kW as a push-pull circuit, but with the output matching employed, which is optimized at around 800 W, the unit starts saturating at around 1 kW at a 50-V dc supply, resulting in high IM distortion. Similarly at a 40-V supply, it would be usable up to 800 W. The type output matching transformer employed allows only integers as 1:4, 1:9. 1:16, etc. The 1:16 impedance ratio transformer would make the output matching optimized at 1400 W, which would result in a poor efficiency at 1200 W and lower power levels. The only way to compensate for this would be to adjust the supply voltage accordingly, in this case 45-46 V. However, the 1:16 ratio transformer of this type is physically much more difficult to fabricate than the lower ratio ones, and may not be available in the commercial market.

The Bias Regulator

The gate bias regulator (IC1 in Fig 1) allows the main supply voltage to be varied or the use of an unregulated supply while keeping the gate bias voltages and the FET idle currents constant. Since the maximum operating voltage of the regulator IC is only 40 V, a Zener diode (D1) is employed to keep it at a safe level. The regulator supply terminals are separated from the main power supply permitting the use of a separate bias supply if desired. There is also an option for a thermistor connection to stabilize the idle currents against temperature changes. The thermistor should be in a physical contact preferably with a mounting flange of one of the FETs. The gate voltages are individually adjustable (R1, R2) making gate threshold voltage matching of the devices unnecessary. In case of a device failure, such as a drain-gate short, D2 and D3 block the full supply voltage from being fed back to destroy the regulator. R10, R11 and C3, C4 are merely RC filters to protect the regulator from possibly strong RF fields. To set the idle currents, R1 and R2 must be adjusted to minimum. R3 is then adjusted for a regulator output voltage of about double the FET gate threshold voltages (IC1, pin 3). The current is monitored at the main supply voltage point while adjusting R1 for a desired idle current, typically 800 mA-1.0 A. R2 is then advanced until the current is doubled, resulting in equal idle currents for both devices. After this procedure, the settings of R1 through R3 should remain until one or both FETs must be replaced.

The RF Path

The amplifier is designed to operate into the industry standard 50-ohm input and output interface. The impedance matching to the low impedance levels of the



Unless otherwise noted, all resistors are ½-W metal film type. All chip capacitors except C13 are ATC type 100/2008 or Dielectric Laboratories type C17.

(NOTE: The PCB mount BNC output connector used is type BNF34, available from ORA Electronics, tel 818-701-5848)

Fig 1—Circuit Diagram—2 to 50 MHz Amplifier

2-50 MHz Amplifier Components List

- **R1,R2—1 kΩ single-turn Trimpots**
- **R3—10 kΩ single-turn Trimpot**
- **R4—470 Ω, 2 watts**
- **R5—10 Ω**
- **R6,R12,R13—2 kΩ**
- **R7—10 kΩ**
- **R8—Exact value depends on thermistor R9 used (typically 5-10 kΩ)**
- **R9—Thermistor, Keystone RL1009-5820-97-D1 or equivalent**
- **R10,R11—100 Ω, 1 W carbon**
- **R14,R15—EMC Technology model 5308 or KDI Pyrofilm PPR 870-150-3 power resistors, 25 Ω**
- **D1—1N5357A or equivalent**
- **D2,D3—1N4148 or equivalent**
- **IC1—MC1723 (723) voltage regulator**
- **C1—1000-pF ceramic disc capacitor**
- **C2,C3,C4—0.1-μF ceramic disc capacitor**
- **C5—0.01-μF ceramic chip capacitor**
- **C6,C12—0.1-μF ceramic chip capacitor**
- **C7,C8—Two 2200-pF ceramic chip capacitors in parallel each**
- **C9—820-pF ceramic chip capacitor**
- **C10,C11—1000-pF ceramic chip capacitor**
- **C13—0.47-μF ceramic chip capacitor or two smaller values in parallel**
- **C14—Unencapsulated mica, 500 V. Two 1000-pF units is series, mounted under T2.**
- **L1,L2—15 ηH, connecting wires to R14 and R15, 1.5 cm each #20 AWG**
- **L3—10 μH, 10 turns #12 AWG enameled wire on Fair-Rite Products Corp ferrite toroid #5961000401 or equivalent**
- **T1,T2—9:1 and 1:9 impedance ration RF transformers, types RF800-3 and RF2067-3 R, respectively (RF Power Systems, 3038 E Corrine Dr, Phoenix, AZ 85032)**

FETs is accomplished with broadband RF transformers. Both the input transformer (T1) and the output transformer (T2) are of the so-called conventional type in contrast to transmission line transformers.[1,3,4] Both employ only one turn in the low impedance winding. T2 is far more critical than T1 because it determines the efficiency and the high frequency end gain characteristics, plus it must be able to handle a large amount of RF power. For increased bandwidth characteristics, its low impedance, one turn winding consists of three

[1]Notes appear on page 8.

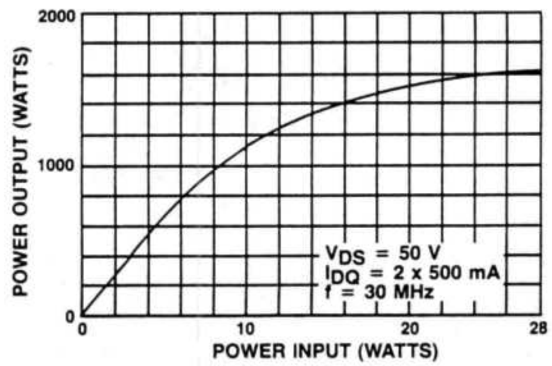


FIGURE 2 — POWER OUTPUT VERSUS POWER INPUT

Fig 2

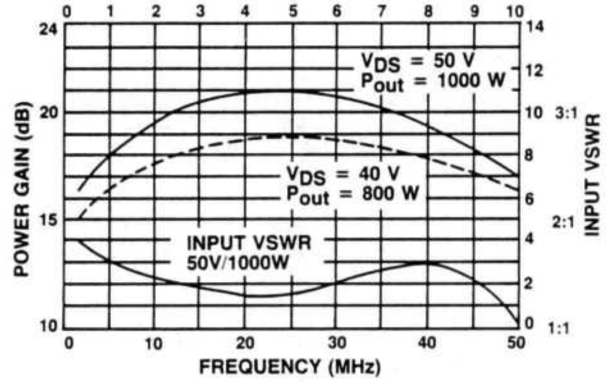


FIGURE 3 — POWER GAIN AND INPUT VSWR VERSUS FREQUENCY

Fig 3

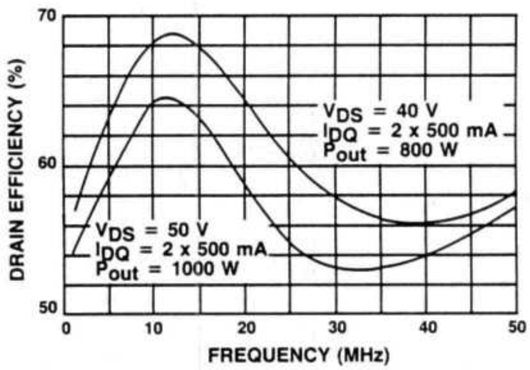


FIGURE 4 — DRAIN EFFICIENCY VERSUS FREQUENCY

Fig 4

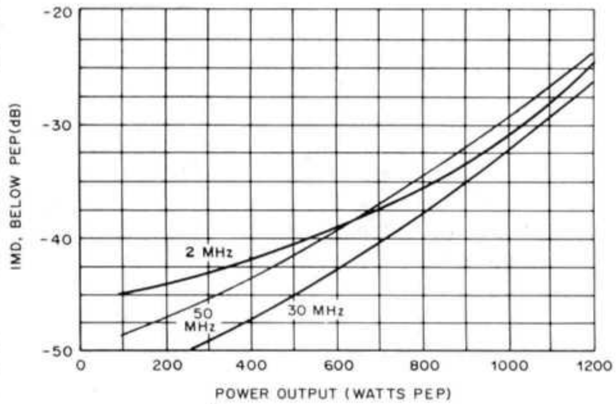
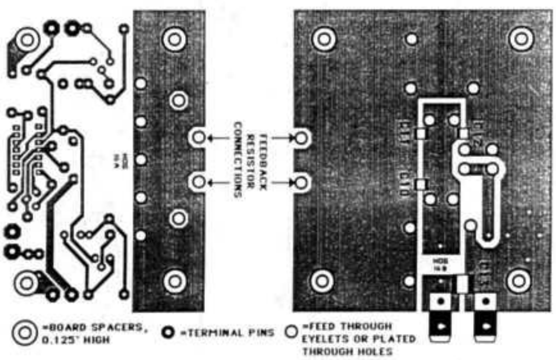
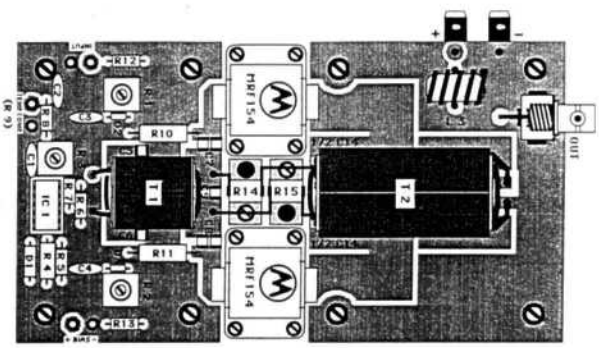


Fig 5



COMPONENT LAYOUT — BOTTOM SIDE

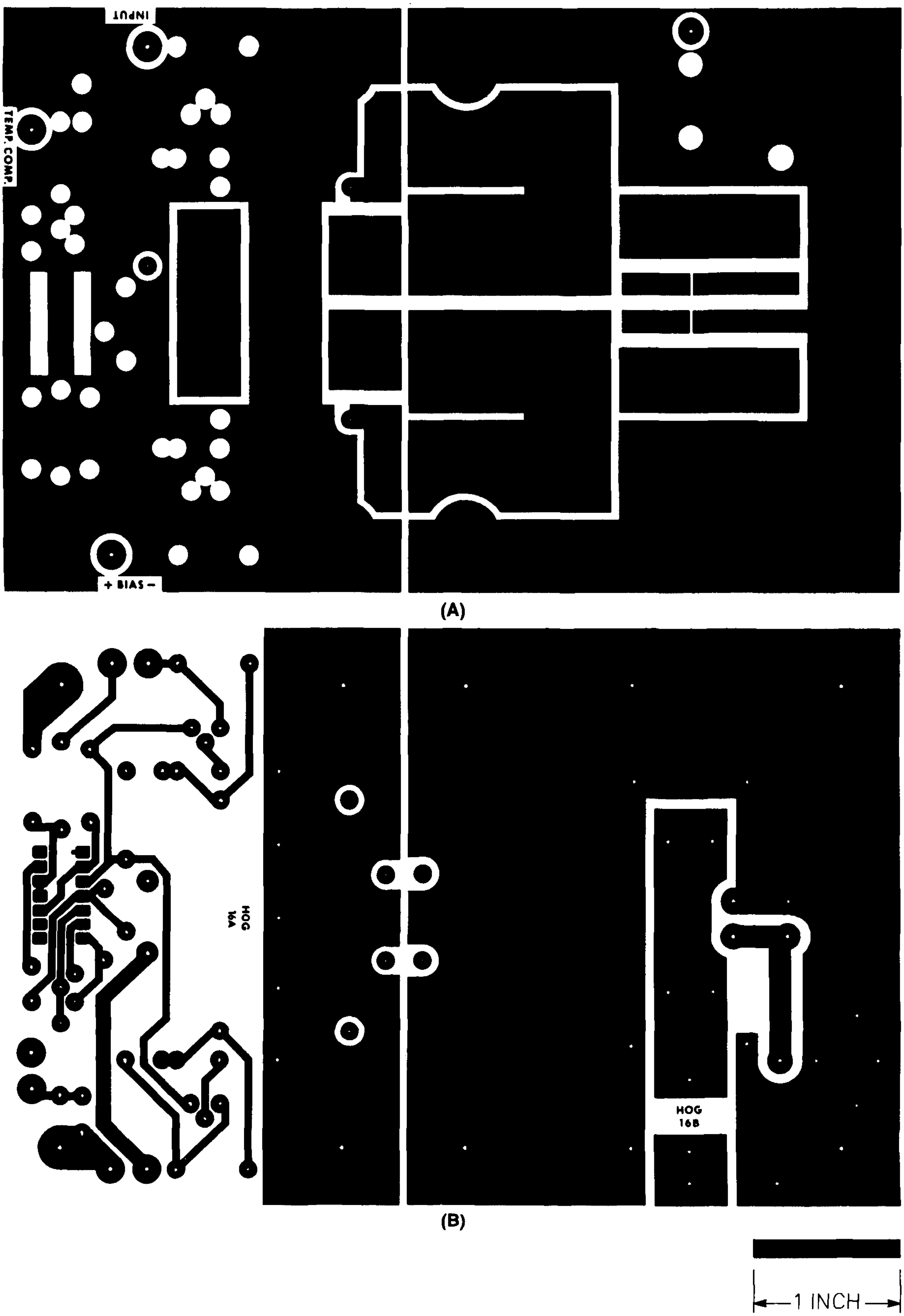
Fig 6



COMPONENT LAYOUT — TOP SIDE

Fig 7

paralleled 10-ohm coaxial cables, resulting in a tight and controllable coupling between the primary and secondary. According to formulas given in Reference 2, approximately twice the present 4.7 cm² ferrite cross sectional area would be required in order for the core not to saturate with the calculated 127 gauss flux density. The saturation mainly occurs at the lowest frequencies, in this case at 2-3 MHz. Unfortunately most ferrite manufacturers do not give information on saturation flux densities that applies to applications such as this. However, it is known that high permeability ferrites, in general, saturate easier than low permeability materials. Thus, the lowest permeability material should be selected that will satisfy the minimum inductive



Figs 8A and 8B—Circuit Board—Top Side and Bottom Side reactance requirement at the lowest frequency of operation. The formula to calculate this is $NX_L = 2R_{S(L)}$, where: X_L = inductive reactance for one turn, N = number of turns, $R_{S(L)}$ = source or load impedance. Low permeability material is also less lossy at high frequencies, resulting in less heat generated in the transformer. T1, which must handle only 8-12 W of power, is made of higher permeability ferrite. This makes it possible to make the unit physically small as well. In T1, the secondary consists of metal tubes (see Ref 1), where three turns of the primary wire is threaded through. Metal tubes are also used in T2, but only to hold the structure mechanically together.

At high-power levels generated with solid-state devices, which operate at relatively low voltages, the impedance levels automatically become low. This creates a problem for finding passive components, especially capacitors to handle the high RF currents involved. In vacuum tube circuits a similar problem exists, but in the form of high voltages. In this design, C14 gets the roughest treatment. It must be able to carry RF currents in excess of 10 amperes at the higher frequencies, although the voltage across it is only 75 V rms. At first, several good quality ceramic chip capacitors were tried in parallel, but temperature excursions caused them to crack resulting in RF arcs that burned the circuit board in the area as well. Finally, two unencapsulated mica capacitors (brand names such as Unelco, Underwood, Standex, Elmenco and Semco) were soldered in series by attaching the terminal tabs together, making it a symmetrical structure. Since each is double the total value required and with double the number of plates, this increases the RF current carrying capability and provides a larger area to be soldered to the board metal foil to make the cooling more efficient. The low impedance winding terminals are then soldered to the tops of the capacitor metal casings, leaving the effective capacitance across the winding. For further fine tuning, an Arco (Elmenco) #469 or Sprague #GM-40900 compression mica trimmer can be soldered to the front-top terminals of the transformer. Slot openings in the metal foil (Fig 7) located on each side of the output transformer, next to the drain terminals, were provided to increase the series inductance for certain high-frequency narrow-band applications. This tunes out some of the FET output capacitance, resulting in increased efficiency. At lower frequencies (below 80 MHz) however, they only add to the IR loss and should be shorted. The location of C9 is also critical and should be placed approximately as shown in Fig 7. This will affect the input VSWR at frequencies above 30 MHz.

Bypass capacitors C10 through C12 must also be of good quality. The center tap of T2 should be free of RF if the circuit is balanced. This may not always be the case, in which case these capacitors will aid this function. L3 and C13 form an additional filter, ensuring that no RF energy is being fed back to the power supply. Switch-mode power supplies especially are sensitive against RF and may actually get damaged from it.

Negative feedback is provided through the networks L1-R14 and L2-R15. Its purpose is to produce a relatively flat power gain versus frequency response. It also improves the input return loss and helps to stabilize the amplifier at low frequencies, where the power gain would be 25-30 dB without it. The feedback is at its minimum at the high frequency end and at maximum at low frequencies, where most power is dissipated in R14 and R15. This power is roughly the difference in power input without the feedback between 2 and 50 MHz assuming a constant power output (in this case 25-30 W). A simple formula for calculating the feedback resistor values as well as their dissipation ratings is given in Reference 5. Reference 5 also includes information on physical construction of RF transformers such as used here.

Thermal Aspects

Assuming a 50% worst case efficiency for the unit, each FET dissipates 500 W of heat in an area of 1 × 1.5 inch. It is imperative that the transistors are mounted on the surface of a material with low thermal resistance such as copper. This is called a heat spreader as it is then attached to a heat sink made of material with poorer thermal resistance. It should extend about one inch beyond the edges of the FET mounting flanges at least on three sides. It is even more practical to make the heat spreader as large or larger than the amplifier itself. This would allow all circuit-board spacers to be an equal height of 0.125 inch. The thickness of the heat spreader should be a minimum of 0.375 inch. The heat spreader is then separately attached to the actual heat sink, which can be a 12-inch length of Wakefield Engineering type 4559 extrusion or equivalent[6]. Heat sink compound must be applied to all thermal interfaces and the recommended transistor mounting procedure should be followed, including the screw torque. Fig 9 shows the amplifier mounted to the heat spreader. Although the heat sink is not shown, one must be used for continuous operation and for test periods longer than a couple of minutes. For continuous operation, two 5-inch muffin fans under the heat sink will suffice. They will keep the device case temperature at below 80°C, and the die temperature, which equals to device thermal resistance × power dissipation + case temperature = 0.13 × 500 + 80, at less than 145°C, which is well below the 200-degree maximum recommended value. We must realize that the 500-watt dissipation is only valid when the unit is operated into a 50-ohm load. Under mismatched conditions, depending on the phase angle, the dissipated power may be lower or higher than this value.

Performance

Some of the amplifier performance characteristics are shown in Figs 2 through 5. Although at 30 MHz and above all harmonics are 25 dB or more below the fundamental, an output filter is required to comply with

FCC regulations. However, it can be a simpler one than required for the low frequencies, where the third harmonic may be only attenuated 12-15 dB. In push-pull amplifiers, the even harmonics are not usually a problem since they are attenuated by the balanced operation of the circuit. Information on high power low-pass filters for applications as this can be found in Reference 7. These filters are automatically relay switched with BCD code available in most modern transceivers.

References

The circuit boards and other components for this design are available from Communication Concepts, Inc, 508 Millstone Drive, Xenia, OH 45385, tel 513-429-3811/220-9677.

[1]Motorola, Inc, Semiconductor Sector Application Notes AN-749 and AN-1035.

[2]Hilbers, A.H., "Design of HF Wideband Power Transformers," Amperex (Philips) Application Laboratory Report ECO6907 and ECO7213.

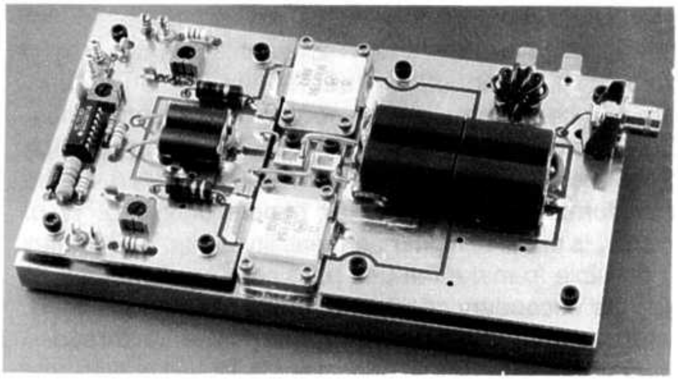


Fig 9—Amplifier Mounted to the Heat Spreader

[3]Blocksome, Roderick K., "Practical Wideband RF Power Transformers, Combiners and Splitters," *Proceedings of RF Expo*, February 1986.

Bits

OSCAR Seminar

The Tandem Radio Amateur Club and Project OSCAR, Inc, invites everyone interested in Amateur Radio satellites (OSCAR) to attend the OSCAR Seminar which will be held on September 29 and 30, 1990. With so much information available and so many subjects to be covered, the entire weekend will be devoted to OSCAR! Speakers will cover all aspects of OSCAR from basic information necessary to get started, right up to advanced topics for the experienced OSCAR user. Computers will be available to demonstrate OSCAR software. Displays showing some of the equipment used by OSCAR users will also be available. Whether you are interested in RS satellites on 10 meters, worldwide DX available on OSCAR-13, telemetry sent from DOVE and other MICROSATs, or you just have many questions about OSCAR, this seminar is a must for you to attend.

Some of the subjects that will be covered include:

Understanding Keplarian Elements
How Operate MICROSATS and FO-20 Successfully
OSCAR—a Basic Tutorial about Using the Satellite
How to Use the S Satellites
Present Status and Future Plans for OSCAR
Preamplifers and How to use Them Properly
Successful Mode L Operating
An Open Forum Question and Answer Session
Successful Omni Antennas for MICROSATs
How Noise Figure Relates to Successful OSCAR Operation

The following topics may be added pending a speaker:

Understanding OSCAR Telemetry
Successful Mode S Operations
AMSAT-NA Forum

Preregistration is required so that adequate seating and supplies will be available. The funds raised will cover the minimal expenses to hold the seminar. All excess money raised will be allocated towards the building of future Amateur Radio satellites.

The seminar will be held right off highway 280 in Cupertino, CA. Motels, restaurants, and shopping are all close by. On Saturday evening, there will be time for informal discussions with those you want to learn more information from.

Registration fee for the seminar is $15.00 per person. This includes a copy of the papers published for the seminar. For complete registration forms and details of the seminar, send a business size, self-addressed, stamped envelope (SASE) to: **OSCAR Seminar, Project OSCAR, PO Box 1136, Los Altos, CA 94023-1136**. Here is the best opportunity to ask all the questions you ever had about any OSCAR!

The "Cloverleaf" Performance-Oriented HF Data Communication System

By Raymond C. Petit, W7GHM
PO Box 51
Oak Harbor, WA 98277

News Item: In March of 1990, AKØX and W7GHM conducted a series of on-the-air tests of a new HF data communication system design over the 1500-mile path between Boulder, Colorado, and Oak Harbor, Washington. On five different days, and on the 80, 40, 30, and 15-meter bands, Ed sent text from Isaiah 55 to Ray, W7GHM, at higher speeds than any other data mode was capable in the same band conditions, and Ed's "Cloverleaf" signal was so compact that twenty of them could have been packed, without mutual interference, into the same 2-kHz space now used by one packet channel. On 15 meters, Ray was printing data at 75 bit/s free of errors. On 30 and 40 meters, during a time when the packet link between AKØX and W7GHM was nothing but retries, Ray got 50 bit/s from the Clover link. (The design limit of AMTOR is 33.) On 80 meters, when it was necessary to repeat single letters several times on CW to be understood, the Clover link delivered 15 bit/s, free of errors.

During a second series of tests by Willard, N7JTQ, and Ray, W7GHM, a one-way Clover link delivered throughput-per-bandwidth performance from about 50 to over 1000 times better than HF packet in the severe multipath environment of a night-time 50-mile path on 80 meters.

The first test began at 10 PM on April 29. The Clover link transferred data at 37 bit/s on a sustained basis without losing or garbling any data. Willard and Ray were unable to establish a packet link because the TNCs retried out making connect requests.

The second test began at 9 PM on April 30, 1990. The Clover link delivered 75 bit/s with one in ten of the data blocks lost. (The two-way Clover protocol will provide for retransmission of lost blocks without requiring retransmission of blocks already correctly received.) Shortly after 10 PM, a file transfer on packet was aborted after a few minutes by a link failure. The average data rate was 0.7 bit/s. A second attempt produced a nearly identical result. The Clover one-way link then delivered 117 blocks of data at 50 bit/s, losing only two blocks.

On May 2 at 7 PM the third test was conducted. The conditions were much more stable, and a 2 kbyte file transfer on packet averaged about 31 bit/s. Afterwards, the Clover link delivered 75 bit/s. At about 8 PM, another packet file transfer averaged about 17 bit/s and it was followed by a Clover data transfer at 50 bit/s.

In the final series of tests on May 31, Logan, KL7EKI, sent the entire test message at 95 bit/s from Wasilla, Alaska, in ideal 20-meter conditions. His 9-watt signal was received 2000 miles away without a single error requiring correction. In late evening on 30 meters, when Logan and Ray's packet link was immobilized, Logan sent Clover data at 15 bits/s and 15 lines of text were received before the first uncorrectable error occurred.

The performance "figure of merit" was obtained by dividing the number of correctly received bits per second by the spacing (in hertz) required to guarantee that two signals of the same type do not cause mutual interference, even if one is 60 dB stronger than the other. For a Clover signal, this spacing is 100 Hz. Packet and AMTOR require at least 20 times this space.

Introduction

"Cloverleaf" is the name I have given to a modulation and coding scheme which offers very worthwhile improvements over HF packet, AMTOR, and even CW. The specification for this system will be a gift to the Amateur community. Here are its main performance features:

1. It is exquisitely compact in bandwidth. For practical purposes a Clover signal is entirely contained in a channel only 100 Hz wide. Clover signals are designed for channel spacing of 100 Hz; they need no guard bands. The actual channel width of the Clover receiver is this same 100 Hz. A Clover signal in the neighbor channel will not cause interference even if it is 60 dB stronger than the signal to which the receiver is tuned. A network of 10 Clover links can be maintained without mutual interference in a 1-kHz band. Each channel is a "clear channel": no collisions, no "splatter," and no key clicks come from the other users, even if they are much stronger.

2. A Clover link communicates data at the highest speed the RF propagation path permits. As the band conditions change the system adapts to them automatically. Under the best conditions, it operates at above 100 correct data bits per second delivered to the user. Under the worst conditions, conditions in which even CW data rates approach zero, a Clover link can communicate a few bits per second.

3. The Clover design uses Reed-Solomon error-control coding to correct errors in transmission, rather than rejecting a block of data on account of the errors. The coding is set such that it will recover blocks which have as many as 10% of their data symbols lost. If too many errors occur, the receiving station obtains a retransmission from the sender. It is never necessary to retransmit a block of data which has been received successfully on account of errors in previous blocks.

4. The data link is completely transparent to the data user. No restriction exists on the alphabets or data sequences. There are no illegal data codes. Input is accepted as a sequence of bytes and delivered to the output of the link in the same format. Programs using a Clover link are

totally free to define their data in the ways best suited to their needs.

5. The Clover system requires and takes advantage of the extreme frequency precision and stability of its transceivers. It also requires accurate knowledge of time. The transceivers obtain both the frequency and time information automatically from observations of WWV (for Western Hemisphere applications). A Clover channel can be centered 50 Hz from a band edge with confidence.

Overview of the Design Specification

The Cloverleaf system uses channels 100 Hz wide with their edges at multiples of 100 Hz. The Cloverleaf modulator generates 25 pulses per second in blocks which vary in length from 3 seconds to about 30 seconds. The pulses are very carefully shaped in amplitude such that they produce no sidelobes in frequency. The demodulator has dynamic range high enough to guarantee that adjacent Cloverleaf signals do not interfere with each other even if one is 60 dB stronger than the other.

For the higher speed modes, the data is transferred via the difference in the phase and amplitude of the successive pulses. Depending on the stability of the radio channel, each pulse conveys from 1 to 6 bits of data using from two to sixteen distinct phase levels and up to four amplitude levels. When the channel conditions are too poor to support the "phase" modes, the data is sent in interleaved binary pulse-position modulation to make possible, by signal averaging, the recovery of data at low speed when the signal is below the noise level.

The data is encoded into Reed-Solomon error-correcting codes which permit the receiver to recover all the data in a block—most of the time—despite the inevitable sudden losses of signal due to multipath effects and noise. The number of phase levels and the Reed-Solomon code block size used are adjusted automatically according to the channel conditions such that loss of blocks at the receiver is kept to about 10% of the blocks.

The Original Cloverleaf System

In May, 1988, I ran a simulation which satisfied me that the system described here was feasible. On June 19, 1988, I conducted an on-the-air test of a breadboard Cloverleaf modem with W7HHU on 80 meters, and it confirmed my expectations. The remainder of 1988 was spent in developing the operating system software for a 6809-based demodulator and primitive error-control coder. On January 7, 1989, AKØX successfully sent me test patterns on 15 meters from Boulder, Colorado. I spent the first half of 1989 developing an automatic synchronizing protocol and a very flexible Reed-Solomon encoder and decoder. In May, 80-meter tests with W7ZEG at a time of intense solar activity showed that there are times when nothing gets through! I spent the second half of 1989 working on the hardware for the second version.

The original breadboard version has separate transmitter and receiver modules. Both are implemented with 6809 processor boards and hand-wired expansion boards, and the software provides one-way data transfer only, for the present. The transmitter generates the pulses in software as a succession of 16-bit data words and presents them to a 16-bit D/A converter and filter. The output of the converter/filter is centered at 500 Hz and sounds like a rapid, smooth and steady hooting.

The receiver downconverts its audio input to a pair of baseband channels in quadrature, passes both signals through a 10-pole linear-phase active low-pass filter, then through digitally gain-controlled dc amplifiers, and finally to 8-bit A/D converters. With this arrangement, AGC range is about 90 dB, but distortion in the audio output stage of the radio makes only about 60 dB of it usable. The audio signal used for the downconversion is synthesized in 0.1-hertz steps and the receiver software can continually adjust the frequency over a small range to maintain zero beat.

The receiver software includes an analyzing routine which can distinguish between normal background noise and this noise with a weak carrier present. The synchronizing protocol first presents a steady carrier. This "wakes up" the demodulator which the tunes itself to zero beat. Then a stream of phase-reversing pulses establishes "framing" of pulses. This is followed by blocks of 9 pulses with inter-block gaps of one pulse length. With these blocks the receiver obtains "byte synchronization." Then follows information about the modulation and coding formats in the upcoming data blocks, and a "countdown" anticipating the first block of communication data. An enormous amount of redundancy is used in this process to ensure that the synchronizing data is correctly received even under marginal conditions.

The data, text from Isaiah 55, is sent in Reed-Solomon coded blocks in the selected format. At the end of each block is a gap of one pulse length. The receiver measures the power level in this gap and the signal power level to estimate received signal-to-noise ratio. It also measures the phase jitter in the received signal and the number of errors it was required to correct in the Reed-Solomon decoder. All this information is used to keep a running estimate of the channel capacity. In a two-way protocol yet to be implemented this information would be used to request updates in the modulation and coding format employed by the remote station. The time and frequency discipline maintained by the protocol will shorten the process of establishing a connection to a few seconds.

The Second-Generation Transceivers

A pair of Clover transceivers is in development. These units will provide means for extended evaluation of this design as a practical alternative to packet under conditions requiring the highest levels of performance. Waveform generation, channel filtering and demodulation will be handled by a Motorola DSP56001 digital signal processing chip with 16-bit A/D and D/A converters. Data coding and the two-way protocol will be managed by a 6809 chip. All the system clocks are phase locked to a single master reference oscillator which is checked against WWV automatically to obtain both frequency and time synchronization. The RF portion of the transceivers feature an ultra-low noise frequency-synthesized local oscillator system which will provide reliable (and required) frequency accuracy to within a fraction of a hertz. The IF crystal filters are 1 kHz wide, permitting observation and perhaps operation on 10 Clover channels simultaneously. The linear RF power amplifiers will deliver 20 watts. An RS-232 serial port will provide the data link to the host application and computer.

INTERVIEW: Questions and Answers

Question: Why have you chosen to use PSK instead of the universally accepted narrow-band FSK?
Answer: The modulation scheme here can't really be called PSK as that term is used in amateur applications. PSK, like FSK, is supposed to be a constant-amplitude modulation method. To rapidly change the phase of a carrier is to generate enormous out-of-band radiation, and that is precisely what I wanted to avoid. FSK is better in this respect, and that is one reason it makes sense to use it on HF. But it is even better not to change the phase at all when the carrier level is nonzero. This modulator never shifts the phase of a carrier or a pulse, but generates separate smoothly amplitude contoured pulses, each of them appearing at a new phase angle as required by the data being sent. This concept is not at all new, as any communication-systems engineer can attest. But it has not been used on HF before to my knowledge, at least in the ham bands. In fact, it would have been illegal until just recently!

Question: So a lot of the motivation for this design was to make a data signal which was just as compact as possible, right?
Answer: Yes. A lot of people during the eighties worked hard on this problem and their work has now been canonized in the engineering textbooks. They were usually thinking of how to make high-speed microwave data links more efficient, but the same principles apply for low-speed systems, too.

Question: Why do you regard this extreme spectrum compactness to be so important?
Answer: What would you give for a tenfold increase in the size of the CW and data portions of every ham band? Imagine the tiny 30-meter band being expanded to the size of the entire 80-meter band! What a thought! The Clover design will accomplish the same effect, not by expanding the space, but by allowing us to pack ourselves ten times closer than we do now without mutual interference. And the specification for this system puts real meaning to the idea of "no interference." A Clover signal 60 dB stronger than the one you are listening to and only 100 Hz away won't degrade your copy. How far away must such a signal be now in any of our data modes to get the same protection? What this all amounts to is simply making better use of existing resources.

Question: Are you sure that phase-encoded data methods will work on HF? After all, a lot of people have done a lot of work, and they always have ended up using FSK.
Answer: Yes, very true. All the classic work which gave us what we have now, as far as modulation methods are concerned, was done before microprocessors existed. And before chips which were designed specifically for digital signal processing. And before ultra-stable HF radios were practical and inexpensive enough for the home builder. It's time for a reevaluation of the conventional reasoning on this subject.

Question: But what about the fundamental problem of multipath, selective fading, and Doppler shifts? Phase data is certainly going to be lost, no matter how sophisticated the hardware.
Answer: Yes. A great deal of my work with the original Clover machine was devoted to on-the-air observation. One of the neat things the Clover demodulator permits me to do is to watch the phase of any HF signal I could tune to with my ICOM 735. I began by extended observations of the 10-MHz carrier of WWV in Boulder, Colorado, about 1500 miles from here. I wrote a program which could track the carrier on a long term basis while I observed the short-term phase behavior by watching a dot move around in a circle on the scope. I also wrote a program which could display the phase spectrum of the signal on my computer screen. An another program could count the number of bit errors which would be caused by these phase shifts. There were times when WWV's phase really jumped around, but much of the time it was very stable.

Then I listened, with the same setup, to many different foreign broadcast stations. I soon discovered that some had very unstable carriers! Some were using frequency synthesizers which had residual low-frequency phase modulation in their outputs. (That was detectable because their carrier amplitude was quite constant but their phase went jiggling around wildly—phase variations caused by propagation are always accompanied by amplitude variations.) I observed many amateur CW signals and I could distinguish the transmitters using keyed oscillators from the ones using unkeyed oscillators. This all gave me a feel for what to expect.

The textbooks broadly agreed that the multipath dispersion on moderate-distance HF channels is almost always under 4 milliseconds. The degrading effect of this dispersion is reduced if the pulse duration is much greater than that figure. At bandwidths I was considering, selective fading doesn't exist; when fading occurs, virtually the entire signal fades in unison. I decided to use a 40 millisecond pulse duration, 25 pulses per second, and chose four phase levels. This would put out 50 bit/s. After a lot of analysis and experimenting with computerized Fourier analysis of signal waveforms, I found a shape that was compact with no sidelobes and was practical to generate. I built the receiving filter to match it and verified that I could recover the clock and data information from the signal after it emerged from that filter. Now to avoid errors at 25 bit/s and four phase levels in the modulation, the propagation-induced phase error during one bit intervals cannot exceed one-eighth of a cycle in 40 milliseconds, which amounts to an instantaneous frequency deviation of plus or minus just above 3 hertz. At times of intense solar activity or over some very long paths I saw that figure exceeded: I saw phase scattering which I knew would make Clover signals unreadable. But I also saw signals which were so well behaved that I decided it was worthwhile to make the modulator go to as high as 16 phase levels and to make the number of levels adjustable to get as high a throughput as the channel permitted. So I wrote a program which could appraise the phase spectrum and recommend what format would get me the best data speed at acceptable error rates.

Concurrently with all this was the question of error checking. One of the things that really got me going on this was a statement I read in one of my textbooks to the effect that while in VHF or microwave channels the improvement due to error-control coding was at most a few dB, over HF channels the improvement could be spectacular. This really whetted my appetite! So I decided to implement a Reed-Solomon coding system, a task which took me many, many months, because I knew nothing about the math of these kind of things. My first coder operated on data blocks of 15 4-bit symbols, a block length of 60 bits. I soon discovered that a whole family of RS code block lengths would be needed in order to cope with the widely varying conditions I observed. In due course, I found out how to match the coder to the conditions.

The on-the-air tests verified my expectations. It was really beautiful to see data coming through "solid copy" even though the signal regularly dropped out or was obliterated for a moment by noise! When conditions were poor, we just hunkered down and got the data through at a slower rate. When conditions were good, we went faster! Under nearly perfect conditions it delivered 95 bit/s. If the data is coded in 5-level Baudot, we're talking about 18 characters per second. No one I know can type that fast! By comparison, AMTOR gives you about 7 Baudot characters per second maximum by design. A packet HF BBS under ideal conditions on a 200-mile path on 80-meter daytime ground-wave conditions averaged about 10 ASCII characters per second on one occasion while sending me long messages. That was exceptional.

Question: What about the weak-signal performance?
Answer: A 10-dB signal-to-noise ratio at the receiver is perfectly adequate for data modes, but most of the time on HF we operate way, way above that level! When Ed, AKØX, and I began the 15-meter test, he was coming in something like S-8. It was way too strong. I asked him to reduce his power to as low as he could get it. I was still copying him fine when his power was so low he could not see any indication on his RF output meter! Clover, like AMTOR, works really good when the signal is weak. In the biphase mode, it can read signals which I can barely hear in the noise.

Question: How about two or more Clover signals on the same channel?
Answer: A carrier or other Clover signal 20 dB below the one you want to hear will begin to slow things down if, without it, the system is running at top speed. One of the rules the transceivers will follow is not to transmit any channel on which another Clover signal is readable. There will never be any need to, at least for a long, long time!

Question: It appears that you are turning your back on the TDMA scheme used by packet in favor of FDM...
Answer: Yes. Everyone knows the AX.25 protocol is really best for higher-speed work at VHF and above. Bandwidths are wide and amateur data sources, so far, are very slow in comparison. It makes good sense to "time share" a channel since any given QSO needs only a fraction of the available channel time to pass data. On HF, we don't have the bandwidth (except on 10 meters) for things like 1200 bauds on voice band FM. And wideband high-speed data modes just can't take the beating from HF propagation. So I say, instead of forcing 20 stations to coexist on one voice channel, give each one a clear channel in that same space. No collisions, no QRM! And if it really comes to push and shove, within each of these channels it is possible to establish a discipline in time, like the way CW or voice nets operate, even if the stations aren't talking to each other.

The Version 2 Transceiver

Question: Have you considered multitone modulation formats?
Answer: Yes, quite a bit, and on several occasions. My IF filters on the Version 2 system are 1 kHz wide, centered at a point 2.5 kHz below the BFO. The DSP chip can easily generate more than one tone. But unless the linear amplifier intermod products are kept down, those products will interfere with signals in the nearby channels. Several times I pondered that some good power FETs are specified at −50 dB third-order products in class A operation at about 50 watts. That's not bad. This is a promising area.

Question: Will the Version 2 transceivers be capable of operating on the other data modes?
Answer: The heart of the transceiver is a Motorola DSP56001 digital signal processing chip. A 6809 handles everything else. The transceivers should be able to do anything. For the present, I'll stick to Clover formats, but the hardware of the transceivers is very "general purpose," and I'd invite any enterprising programmers to make this matching jump through whatever loops they please.

Question: What about the RF hardware for these transceivers? The frequency synthesizers look a bit complicated for a home builder.
Answer: These transceivers are designed for just one purpose: high-performance HF data communication. They have no extras, no bells and whistles. The RF paths are incredibly simple in comparison to your typical commercial rig. It is single conversion, and the IF frequency, 18 MHz minus 2.5 kHz, works with the 20-30 MHz synthesizer to provide coverage from about 2 to 12 MHz. They were designed with frequency precision and stability as a primary goal. The IF amplifier has no AGC, but instead is designed for high dynamic range. The DSP engine gets its data from a 16-bit A/D converter—that provides 90 dB range—and all the channel filtering is done in software.

More than half of the circuitry is in the frequency synthesizer. It is a multiloop design which will provide one-tenth hertz steps over its entire 10-MHz range. Four of the five circuit boards of the synthesizer are identical. Most of the parts for the transceiver were obtained from a well-known mail-order house in the Midwest (USA). The crystal filter is made from inexpensive microprocessor clock crystals. The linear amplifiers are straight out of a Motorola application note. I think any experienced home builder could do it fine.

Question: It still looks pretty expensive, out of amateur range...
Answer: Yes it is, but in ten years one of these transceivers will be possible to build at very attractive prices. My versions are synthesized for flexibility, but in the applications I see for these things, a single-frequency crystal-controlled version at half the cost makes good sense. And just watch the prices for DSP chips fall as they are more widely used!

Question: Where do you see this system fitting into the whole of amateur data communication?
Answer: My experience with Coherent CW says that I shouldn't expect something like this to gain wide acceptance quickly. AMTOR showed what could be done when someone was designing specifically for the conditions we get on HF. Packet is gaining a wide following in spite of its performance on HF. I see that some people are thinking about making incremental improvements to HF packet: It's needed and all to the good. But at some point, a whole new approach has to be taken. It's like the conversion from am voice to single sideband back in the 50s.

I expect that the Cloverleaf system will find its best use in the lower-frequency HF bands where it is well suited to the formation of regional networks covering areas the size of Western Europe. Link-level protocols are being worked out, but networking software is a project awaiting a taker. I doubt if Clover will replace packet, but it will provide a high-performance alternative. Getting twice the throughput in one-twentieth the bandwidth at some point just has to make sense!

Question: Your introduction indicated that you intended to give this whole system to the amateur community. Haven't you considered patenting this thing and making a commercial enterprise of it?
Answer: Yes, I've thought about it a lot. Back in 1972, I made a commercial enterprise out of a fun project and I survived for about 3 years. I'm a very small budget operation, your proverbial garage outfit. Getting a patent costs more than my entire annual budget, it takes several years, no protection exists until you have it, and then in order to protect it you have to spend hundreds of thousands and all your emotional energy in the courts. I don't want to live that way. It's more important to me that the machine gets used, that practical Clover networks get established, and that we all get to enjoy its advantages. I expect to have diagrams, circuit boards, and parts kits for home builders pretty soon. I expect that eventually some companies will start making these things. I plan to be one of them.

Correspondence

Comments on 13 cm

Thanks for the pep talk on the 13-cm band in Geoff Krauss' VHF+ Technology column (December 1989). Most of the equipment referred to in the column has been described in the literature, so I was disappointed that a list of references was not included. Rather than complain about it, I made one up. It is certainly incomplete, and I apologize to all the missing authors; but it is better than nothing. Most of these articles are still available; all of the Proceedings are currently available at half price from Amateur Electronic Supply in Milwaukee, WI (tel 800-558-0411).

A few more comments on 13 cm:

1. It is amazing how well a few milliwatts of SSB, a small dish or loop Yagi, and a reasonable noise figure works at 13 cm from a hill top. VUCC can easily be worked with 500 mW, a loop Yagi or two foot dish on a small camera tripod and an MSA 0685 receive preamp.

2. Duplex stations, as shown in Fig 1 in the VHF+ column, were useful ten years ago, but are now obsolete and should not be promoted for any amateur microwave band. We now have weak signal calling frequencies at 2304.1, 3456.1, 5760.1 and 10368.1 MHz. Duplex operation in the '90s serves only to increase the score of the multiop contest station at the expense of other microwave activity. New equipment should be capable of working on the calling frequencies!

3. A significant feature of the more recent transverter and preamp designs is "no tuning." No tuning is made possible by the use of modern, broadband 50-ohm devices, modern band-pass filter designs, and well-characterized discrete microwave GaAsFETs. No-tuning designs work at least as well as their tuned ancestors, especially when the temperature, voltage or drive level changes. A significant advantage of no-tuning designs is that active devices are field replaceable.

My favorite 13-cm story is about Mark Korrich, WB8TGY. A few years back, Mark decided to work some serious VHF. Rather than pick one of the more common bands like 2 m, he choose 13 cm to start with. He connected up the SSB Electronics transverter and homebrew loop Yagi with no difficulty, and soon worked VUCC by running grids around Lake Superior. After gaining some experience on 13 cm, he figured it was time to get on some other bands; so he started working on 1296. I talked to him soon after his first 1296 contact, and he remarked, "Boy, signals sure don't get out as well on the lower frequencies, do they!"—*Rick Campbell, KK7B, Route 1, Box 195, Chassell, MI 49916*

Para 2—The semi-duplex station (which is not full duplex, as it will not continuously receive when keying during transmit) was intended to show an early-1980s rig; the basic thrust of the column was *to the newer transverters, but. . . the semi-duplex rig may, under certain circumstances, be cheaper and easier, and may be more useful in some experimental situations. Bottom line: Let the VHF+er consider both, and choose the more appropriate, as long as you get on the band!*

Para 3—While "no tune" design is great for converters and transverters, the range of variations still found in devices for low-noise preamplifiers indicates that some tuning capability remains desirable (for input noise match, device current and/or voltage) if best performance is to be obtained.—Geoff Krauss, WA2GFP

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Pseudo-Sync Clarification

I would like to clarify a couple of points in my May 1990 *QEX* article, "Pseudo-Sync: A Terminal Program for Mode B AMTOR, Part II." While these may seem to be minor points, they are crucial to gaining a clear understanding of how Pseudo-Sync works.

The shifting of data from the mailbox into the proper SAB occurs when the sample counter reaches seven. When correcting for a time displacement, this is not after seven samples have been taken for the mailbox. In the example cited where the sampler fills the mailbox beginning with bit two, the sample counter begins at two, also. Therefore, the sampler takes only six samples. The seventh sample, needed for a complete SAB, is already present in bit one. This sample, obtained for the previous SAB, may introduce an error. However, the voter renders the error, if it exists, insignificant.

The article erroneously stressed that bit zero and bit eight are always wasted. This is true only in relation to a particular SAB. For current versions of the program (1.4 or greater) the eighth bit does not exist. It automatically ends up as bit one of the following SAB when a data shift occurs.—*Jerry W. Egleston, Sr, WA0SVG, 2813 Baker Road, Independence, MO 64057*

Coherent CW Group

A short while ago the editor of *QEX* kindly printed a note from me announcing the formation of a Coherent CW Group. So far we have recruited about fifty members of which several should shortly be on the air using this mode.

I feel that wider publicity may help and would be much obliged if you could afford a little space for this letter. No subscriptions are being asked from members outside the United Kingdom, though help with postage is always appreciated. We have a list of available information and issue a short Newsletter about every two months.

Anyone interested is invited to contact *Peter Lumb, G3IRM, at 2 Briarwood Avenue, Bury, St. Edmunds, Suffolk IP33 3QF, England.*

Components

By Mark Forbes, KC9C
PO Box 445
Rocklin, CA 95677

The response to obtaining a quantity order of LM1211 chips was remarkable. By the time you read this, I should have contacted you regarding pricing and delivery. I hope some of you generate articles from your experiments.

Designing Circuits With LEDs

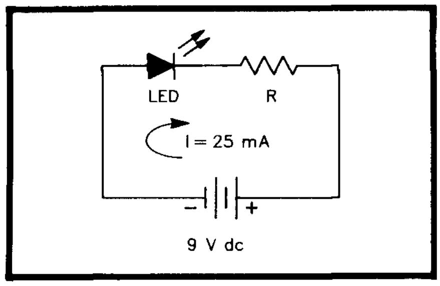
Last column, I explained the use of voltage regulators. Another component that I've received a number of questions about is the LED—the Light Emitting Diode. Since LEDs are indeed diodes, they conduct only in one direction. Unlike silicon or germanium diodes, when LEDs conduct, the semiconductor material is excited and emits electrons in the form of light. Simply stated, that's how they work.

As you may know, a diode has a constant forward-voltage drop which is dictated by the semiconductor material from which the diode is made. For germanium, the voltage drop is about 0.2 V dc; for silicon, it's about 0.7 V dc. LEDs have a forward voltage drop of about 1.5 V dc. This is essential information when designing an LED into a circuit.

In Fig 1, I've designed a very simply circuit using an LED. In this circuit, the LED lights if the power (battery) is connected. In addition to the forward voltage drop, diodes also have a maximum forward current-carrying capability. This varies somewhat from LED-to-LED, but most can carry up to about 30-40 mA, and will light with as little as around 5 mA. Thus, if you connect an LED across a battery without limiting the current flow you'll get a very bright light for a very brief time... and the LED burns out.

The current is limited with a series resistor, shown in the figure. Since we know the battery voltage and the voltage drop across the LED, all we have to do is subtract the LED voltage drop to determine the voltage that the resistor will drop. In the circuit depicted, the battery voltage is 9 volts; subtracting the 1.5-V dc LED drop leaves 7.5 volts across the resistor. Now, it's a simple calculation using Ohm's Law to find the value of the resistor necessary to limit our current. For this circuit, I chose 25 mA (which will produce a fairly bright light), and solved Ohm's Law: 7.5 V dc/0.025 A = 300 ohms. The closest standard value 10% resistor is 330 ohms, which is what I used.

Fig 1—
LED Circuit



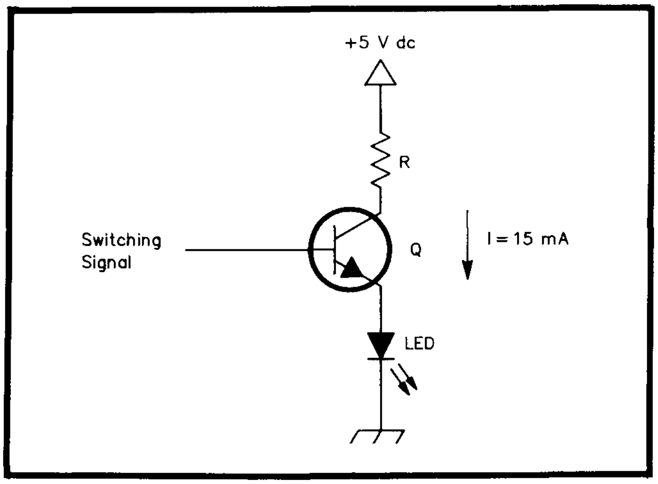


Fig 2—LED turned on and off by an NPN transistor

Fig 2 shows a circuit with a transistor switch to turn the LED on and off. When using a silicon transistor as a switch, it is operated in its saturated region, and the voltage drop from the collector-to-emitter when turned on is 0.2 volts. For this circuit, we just solve the Ohm's Law in the same way, but subtracting both the transistor and LED voltage drop (1.5 + 0.2 = 1.7 V dc). For this circuit, with a 5-V dc power supply and 15 mA the equation becomes: 3.3 V dc/0.015 A = 220 ohms, which happens to be a standard value.

You can see that incorporating LEDs into your circuits is quite simple. For most low-voltage circuits (5 to 15 V dc) a resistor in the neighborhood of 220 to 460 ohms is about right. LEDs come in several colors, including red, yellow, orange, and green. There is also a bidirectional LED that lights in one color for one polarity, a different color for the opposite polarity, and mixes the two to form a third color when ac is applied.

TriQuint TQ9121

Wes Hayward, W7ZOI, sent me a data sheet on TriQuint's newest low-noise amplifier chip. The TQ9121 operates between 1.2 and 1.6 GHz. Although it was primarily designed to be used in Global Positioning Service receivers, it obviously covers the 1.2-GHz amateur band quite well.

The TQ9121 is capable of 16-dB gain with a noise figure of only 1.25 dB. External parts count is minimized by virtue of internal self-bias circuitry and the input and output dc-blocking capacitors. What really makes this an interesting amplifier is that it operates from a single

5-V dc power supply, and draws only 17 mA. Thus, it will work very well in battery-operated receivers.

The part sells for $60 in single units, and TriQuint will sell single units to amateurs! If you'd like more information or would like to buy one of these, contact Wes at TriQuint Semiconductor, PO Box 4935, Group 700, Beaverton, OR 97076.

Micro Linear Programmable Sinewave Generator

The ML2035 and ML2036 from Micro Linear Corp are digitally programmable sine-wave generators. The sine-wave frequency is programmable from 0 to 50 kHz. The reference clock for the devices can be either an external digital clock (eg, from a microprocessor) or from an external crystal oscillator. No external components (other than the crystal oscillator, if used) are necessary!

The block diagram of the ML2036 appears in Fig 3. The ML2035 is basically identical, except it doesn't have the CLK outputs, external gain control, or the inhibit input. The sine-wave frequency is loaded into the 16-bit shift register, latched, and the part begins making perfect sinusoids at the programmed frequency. To change frequency, just load up a new value.

These are primarily intended for use with microprocessors, but a discrete digital frequency loader could easily be built. Obvious applications include programmable audio-frequency generators for testing and modems. The generator can be stepped between two highly stable frequencies for FSK operation. One interesting application could be using a PC to load the sine-wave frequency through its serial port, making a very small and inexpensive audio generator. The frequency stability of the parts is ± 0.75 Hz, so even radio-frequency applications are possible. These could make a low-frequency local oscillator for a superheterodyne receiver.

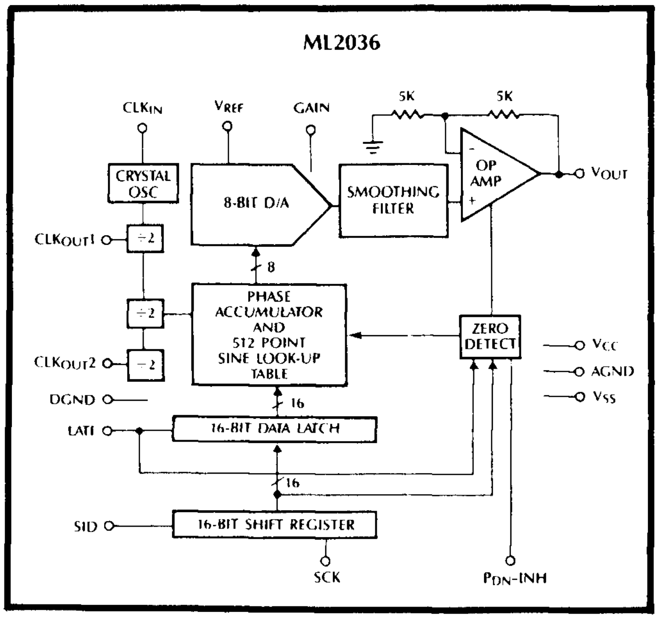


Fig 3—ML2036 programmable sine-wave generator block diagram

The parts are brand new, but should be on distributor shelves by the time this appears. Price for small quantities (1-24) is $9.55 for the ML2035 and $10.00 for the ML2036. For more information, contact Micro Linear at 2092 Concourse Drive, San Jose, CA 95131, phone 408-433-5200. If you can't find a local distributor, try contacting Pioneer Technical Products in San Jose, CA, phone 408-954-9100.

Bits

9th Computer Networking Conference

The joint CRRL/ARRL 9th Computer Networking Conference will be held on September 22, 1990, in London, Ontario, Canada. Topics are expected to include HF packet investigations, packet satellites, network development, hardware protocols, software, packet services and future systems.

The conference will take place at the London Regional Art Gallery and Museum. Registration is $20 (US) or $25 (Canadian) and includes a copy of the conference proceedings and a catered hot luncheon. Special room rates have been negotiated with the Radisson Hotel in London Centre.

If you're planning on presenting a paper at the conference, there's still time. The deadline for receipt of camera-ready papers is August 6. Contact Lori Weinberg at ARRL HQ for an Author Package.

For more details on this year's CRRL/ARRL 9th Computer Networking Conference, contact: Harry MacLean, VE3GRO, 500 Riverside Drive, London, Ontario, N6H 2R7 Canada, or; Lori Weinberg at ARRL HQ.

Conducted by: Stan Horzepa, WA1LOU
75 Kreger Drive
Wolcott, CT 06716-2702

WO-18 CCD CAMERA IRIS SETTINGS EXPERIMENTS

For the past several weeks, WEBERSAT-OSCAR-18 (WO-18) has been sending three to four pictures daily from outer space. This continuous stream of imaging data has been part of an ongoing experiment by the students at Weber State University to characterize the amount of natural light which enters the CCD camera for the various iris settings. The goal of this experiment is to find the proper settings for the camera iris for a particular light level in order to improve the overall picture quality.

With the integration of the on-board Earth sensors in the current software, the occurrence of overexposed pictures or totally dark pictures taken when WO-18 isn't pointing at Earth is no longer a problem. Chris Williams, WA3PSD, says that the painstaking task of manually setting the iris from the ground and observing the results will help software engineers in the future as they continue to understand the CCD camera operation. "The early days of random picture taking are gone," according to WA3PSD.

There are 256 possible iris settings which ground controllers can command. A "zero" setting completely closes the iris and a "255" setting opens it wide. The result of this experiment will be a look-up table in WO-18's software which will say "for this light level, use this iris setting." For those wishing to take part in this experiment, WeberWare version 1.0 is currently available from the AMSAT Software Exchange. Contact the Exchange at 301-589-6062 for further information.

from AMSAT

NORTH EAST DIGITAL ASSOCIATION FILLING A NEED

The North East Digital Association (NEDA) was formed to support packet-radio networking in the northeast. The association's main purpose is to maintain a reliable inter/intra-state packet network that is useful to Amateur Radio operators for emergencies, education and the fun of the hobby. Currently, NEDA's network extends throughout central New England and New York State.

NEDA is a member-supported organization. Members are those hams who feel that the cause of packet-radio networking is worth funding. The goals of NEDA are to form and maintain a reliable and consistent long-distance packet-radio network, to educate Amateur Radio operators as to effective methods of long-distance packet-radio network construction and operation (NEDA creates and distributes documentation; their 20-page introduction package is an instruction manual for using the network), to provide equipment for sites required to implement redundancy in the major backbones, to provide a common ground for different organizations that are doing long-distance packet-radio networking in the hopes of sharing resources (to achieve NEDA's goal of redundancy with minimum wasted effort).

New NEDA members receive a 20-page information package which includes basics of networking, network maps, instruction manual, who to contact, what it takes to make a node and information on NEDA's node configuration policy. After each quarterly Board of Directors meeting, NEDA sends a copy of the quarterly letter to voting members, supporting members, and clubs that are members. The quarterly includes the latest maps, Treasurer's report, Board of Director's meeting minutes and articles.

NEDA members may send an SASE at any time for copies of the current maps. NEDA maintains eight maps: a user port map and backbone maps for each of NEDA's divisions (Finger Lakes, Hudson, Massachusetts and New Hampshire). NEDA is also committed to generating documents on subjects related to network design and management. These are announced in the quarterly when they are available.

For information on supporting NEDA, send an SASE to PO Box 563, Manchester, NH 03105-0563.

from North East Digital Association

G8BPQ PCNODE VERSION 3.57 AVAILABLE

Version 3.57 of G8BPQ PCNode is now available and includes "multi-KISS," a protocol for operating multiple KISS TNCs on one serial port, improvements in the PK-232 host mode interface for AA4RE BB, an internal KISS interface for TCP/IP applications and several bug fixes. The software may be downloaded from CompuServe's™ HamNet as a self-extracting LHARC archived file called BPQ357.EXE.

MACINTOSH TCP/IP VERSION 2.0 READY

Version 2.0 of the Apple Macintosh TCP/IP software is now available with a number of enhancements, support for the new features found in the PC versions (including NOS) and bug fixes. The software may be downloaded via Internet using 'anonymous ftp' from apple.com, in the directory 'pub/ham-radio' or from the N6OYU landline BBS at 408-253-1309 (1200 to 9600 baud). You may also send a $5 donation to Doug Thom, N6OYU, (c/o Thetherless Access Ltd, 1405 Graywood Dr, San Jose, CA 95129-4778) to obtain a diskette containing the software.

from Doug Thom, N6OYU

C-64 TERMINAL PROGRAM FOR BLIND HAMS

Jerry Johnson, KØQQS, wrote Packet Reader Program, a packet-radio terminal program for his blind friend, John Bloom, KØGCY, that uses a Commodore

C-64 computer and Votrax Vo-Talker voice synthesizer. The software causes the synthesizer to read each letter or word as it is typed and to read packets as they are received. Received packets are buffered so that they can be repeated as needed. The program also uses the C-64's disk storage capabilities. For information on how to obtain a copy of the program, send an SASE to John Bloom, KØGCY, 1312 North Union, Fergus Falls, MN 56537.

from John Bloom, KØGCY

A NEW SERVICE, THE CALL SIGN SERVER

After I did a few keyboard-to-keyboard connections and PBBS log-ins, one of the problems I found with packet-radio communications was what else does it do for me. I can send mail to all those people out in packet-radio land that I do not know, and I can watch messages fly by that don't interest me. What was missing was a true user application. I thought, there has to be something we can do for the packet-radio community.

One afternoon, I was logged into Internet (a worldwide computer network) and saw a message that a group of people were putting a project together to acquire a copy of the Amateur Radio call-sign data base from the FCC. Great! I could put together a service whereby people could contact my packet-radio station and look up a call sign. This could be an interesting service and, if successful, provide something useful to the community. Since I knew one of the people involved in getting the data, I contacted him and got a copy of the data base.

As it turned out, the actual data file is 108 Mbytes in size and contains over 435,000 call signs. Unfortunately, it contains only US call signs, but that's a great start. In addition to the call sign, each record of the file has the mailing and station addresses, the class of license, previous call sign, renewal/process/expiration dates, and even the person's birthdate! Now all I had to do was figure out how to provide access to this data from my packet-radio station, how to store this huge data base file, and how to tell people about it.

I was working on another project, porting the KA9Q TCP/IP package to the Macintosh computer, when several people asked the same question, "What are we going to do with TCP/IP?" It is certainly a neat system, but without applications to use it, it suffered the same old problem. Then the light flashed! How about interfacing the call-sign data base to one of the TCP/IP servers. . . like the finger server?

The finger server is a utility built-in to the TCP/IP package that allows a remote station to query your station for basic information. "Great idea," said Dewayne Hendricks, WA8DZP, the programmer who did all the work, and in a few days he had written the initial code to access the call-sign data file. It took several more weeks of debugging and testing, but finally we had an extension to the finger command. Below is an example of how this all works (bold characters are typed by the user).

net> **finger %wa8dzp@n6oyu**
SYN sent
Established
[N6OYU]
Name: DEWAYNE L. HENDRICKS
License: WA8DZP
License Class: E
Mail address: 43730 VISTA DEL MAR, FREMONT, CA
    94539-0000
Station address: 43730 VISTA DEL MAR, FREMONT, CA
Effective date: May. 17, 1988
Expiration date: May 17, 1998
Previous Callsign:
Previous Class: A
Birthdate: Oct. 11, 1949
Process date: May. 17, 1988
Close wait
Last ACK
Closed (Normal)

Note the use of the %callsign@n60yu syntax in this command. The typical finger command looks like this:

net> **finger doug@n6oyu**

This will look for a text file named "doug" on the system diskette and copy its contents to the TNC. With the call-sign server extension, we added the % to tell the finger server to look up the following call sign in the data base and return that information to the TNC.

As it turns out, TCP/IP allows the use of another command to query information provided with the finger command. This involves using the telnet command (telnet is the command used for keyboard-to-keyboard communications with another TCP/IP station). This gets fairly complicated, but suffice to say, it works. Below is another example of using the telnet command to get the same information.

net> **telnet n6oyu 79**
SYN sent
Established
[N6ØYU.norcal.ampr.org]
%ka9q
Name: PHILIP R. KARN JR
License: KA9Q
License Class: E
Mail address: 25B HILLCREST RD, WARREN, NJ
    07060-0000
Station address: 25B HILLCREST RD, WARREN, NJ
Effective date: Sep. 27, 1988
Expiration date: Sep. 27, 1998
Previous Callsign:
Previous Class:
Birthdate: Oct. 4, 1956
Process date: Sep. 27, 1986
Close wait
Last ACK
Closed (Normal)

In the above example, **79** tells the telnet server to forward the request to the finger server, which in this case is the

%ka9q on the next line. The server processes the request as before.

This was all fine, but what about all the rest of the packet-radio users that do not have the TCP/IP package up and running? Well, TCP/IP will support AX.25 connections and provides a mailbox function. So, Dewayne also wrote some code to extend the mailbox function to permit inquiries of the data base. The addition of the inquire command to the mailbox code now provides AX.25 connections access to the data base. Below is a sample of the process.

Connect N6ØYU
Conn pending
Connected
<carriage return>
[NET-$]
Welcome to the N6ØYU.norcal.ampr.org TCP/IP Mailbox
(C)hat (I)nquire (S)end (B)ye
I K6LLK
Name: JOHN D. CRONIN JR.
License: K6LLK
License Class: E
Mail address: 1543 FORDHAM CT, MOUNTAIN VIEW, CA 94040-0000
Station address: 1543 FORDHAM CT, MOUNTAIN VIEW, CA
Effective date: Dec. 9, 1986
Expiration date: Dec. 9, 1996
Previous Call Sign:
Previous Class:
Birthdate: Jan 1, 1944
Process date: Dec. 9, 1986
(C)hat (I)nquire (S)end (B)ye
B
Disconnected

Now all packet-radio users have access to the call-sign server via several different mechanisms. Since bringing up the server, there have been over 3500 accesses over a six-month period. The service proved especially useful during the last Field Day exercises with several hundred requests during the weekend. An additional observation is to see what each new user does with the server. First, almost without exception, everyone looks up their own call sign! Then they look up their friends.

What is all this running on? The data base file is on a 300-Mbyte hard disk drive which is connected to a Macintosh Plus computer running Apple's AppleShare file-server software. The radio is a Yaesu FT-211RH connected to an AEA PK-232 TNC and another Macintosh Plus computer running the Macintosh version of the KA9Q TCP/IP package. The two computers are connected together via LocalTalk (Apple's networking system). My Macintosh II color system and a LaserWriter IINTX printer also share the network.

The future holds many changes for the service. The first will be a more current data file. Next, we plan on changing the method of access. As it stands currently, the only way to get call-sign information is to directly connect to my station via either AX.25 or TCP/IP. What we plan on is similar to the White Pages lookup system that is available now in the PBBS network. You will be able to send a message to the system with whatever means you have and the system will send a reply message with the call-sign information you requested. Now back to the coding.

One last note. You can connect to my station on the TCP/IP frequency of 145.75 MHz.

by Douglas Thom, N6OYU
from *Downlink*

CONNECTIONLESS MAIL PROTOCOL AND MORE

It seems to me that the main use of our network is for the transfer of items of general interest (bulletins), first, and personal mail, second. Now this may seem a bit strange particularly when one could put a reasonable case that there are more personal messages generated than bulletins (I do not go along with this, but am willing to be convinced). The trouble is that personal mail has an origin and one destination, bulletins have an origin by N destinations where N is at least every PBBS in the country!

The majority of traffic is the sending of bulletins to every PBBS, ie, over and over again. This leads people, who think in terms of telephone lines, to say we must rationalize, we must stratify, more channels, more bands, etc. Can you not see the beauty of one channel with many stations listening, in other words, use the broadcast nature of our medium. Why must we always think in terms of telephone lines? We are not on the telephone, we are not in a one-to-one, origin-to-destination situation. We can broadcast. Think about it.

Anyway, after a year or so saying I really must do something about it and writing the specification outlined below, I have also started writing a simple terminal program/conferencing system/PMS/PBBS (I haven't quite worked out what it will be yet). One of this program's features is that it listens to the channel and tries to generate messages out of the many copies of a bulletin that are sent. It turns out that it receives between 50 and 90% of all the messages that pass by it on any particular pass through depending on who is sending what to whom locally. This means that there are four local sub-PBBSs and also the original feeds to our local NTS station that I can get 95% or more of my bulletins directly from without actually being connected at any time.

I must say at this point that I don't necessarily believe that we need only one channel. Trunking should occur elsewhere, but I do believe that we should start thinking about what we are using, its nature and use the properties of our medium to the full. I also say that it may be that we could use far less equipment to achieve our goals if we do not go down the "professional's route." One could also ask what would be the point of emulating a known solution? I thought we were in this hobby to invent new and better ways and means. Why else are we tolerated in the busiest and most commercially valuable portions of the spectrum?

What I have done so far, which is merely some fancy pattern matching on monitored BPQ data, is not perfect. It gets it right 99.98% of the time and, as such, is not suitable other than for a leaf PBBS or PMS system. I have designed a UI protocol which could give 100% data integrity while still retaining the flavor of the broadcasting mechanism. I outline it below.

UI Frame Connectionless Mail Protocol Specification Version 1.00

The aim of this protocol is to utilize the broadcast nature of the radio medium to minimize the amount of air time it seems to take to distribute the mail. This system is not meant to replace all of the current system of connections from one mailbox to another, but to optimize the distribution in a local area within range of a powerful node or other powerful repeating transmitter.

This specification is based on earlier work of mine and G8UFQ (now, sadly, deceased).

The basis on which this protocol is devised is as follows:

1. Radio is a broadcast medium, a packet (particularly if it is sent by a powerful and/or well-sited transmitter) can potentially be heard by a large number of receivers.

2. The nature of the TNC, FM radio and CSMA environment is such that if a station can be heard loudly, then all other stations will tend to shut up until a suitable pause appears, at which point, they all tend to jump in.

3. The loudest station usually controls the flow traffic in a given area, thus any other station that uses that loud station usually gets more traffic through more quickly than if they go direct while the loud station is transmitting.

4. If we sent UI framed packets via the loudest station, they will be heard by many people (witness all the complaints about long beacon texts via several repeaters). If those packets can be uniquely identified as part of a particular message and also which part, then a basis of a simple connectionless mail protocol exists that more fully uses the broadcast nature of radio as outlined in (1) above.

5. The concept of acknowledging each packet correctly received is, I believe, inappropriate for a congested FM CSMA channel such as the ones we are using. Research has shown (ZMODEM protocol) that it is more efficient to say what you have not received. Further, because we are sending bulletins which are by their nature to be broadcasted, if the stations listening send their requests for the bits they missed, there will be overlaps such that any requests trampled on could be issued by another station anyway.

6. A bulletin is broadcast. This protocol is a means of broadcasting; the data therefore fits the protocol more nearly than the current method being employed. Individual mail probably fits the existing model quite well and would therefore continue to use the current system as would normal station-to-station conversation.

7. I believe it to be more efficient, overall, to send a complete message via a strong station and then wait for requests for retries of individual parts. In other words, to have a window size of infinity (or the size of the message). Further, because of the long delays between the TNC noticing a clear channel and the transmission actually being heard at full power, it will probably be necessary to send the first packet of a string twice or maybe three times because of the likelihood of its being trampled on by other stations [the main reason why the AX.25 fixed window size of >1 has been shown to be worse than simple window sizes of 1 (KA9Q)]. I propose to overcome this problem by using selective reject rather than the current system of "start again from the beginning even though I did in fact hear your last three of that window of four." This will be used in the style of the ZMODEM protocol detailed in (5) above. Because we will probably be repeating, we will need to send packets at reasonable intervals (say 0.5 seconds) in order for the repeater to receive and onward transmit it, this parameter must be tunable to allow for local conditions.

Some Details

AX.25 allows up to seven packets to be sent at a time in one gobbit of packets. Therefore, it will be necessary to send a gobbit of 1 to 7 packets, possibly with the first one repeated as it almost certainly will not be heard on a busy channel. Experiments will have to be conducted to find the optimum number of packets to send in a gobbit, taking into account direct broadcast or via a repeater.

Each packet should contain the following info:

- 1-byte Signature (suggest "~") to indicate to the software that this packet may be of interest
- 1-byte Flag to determine the type of packet.
  M for mail
  H for the mail header (from, to, subject, etc)
  E for end of message
  R for repeat request
  A for I am active request (could cause mail to be sent to you)
- 14-byte BID. A standard bid, eg, 12345_GB7TLH, some unique message ID, all messages (even mail) have some implicit bid of this form, but it need not be like that above. Anything unique would do. Left justified, excess padded with spaces.
- 5-byte Offset. The offset of this packet within this message. This is used differently in types H and E.
- 200-byte Data. This, of course, contains the data.

Contents of Data Portion

H - It is suggested that this is of fairly standard form, ie, SB ALL @ GBR < G1TLH xxxxxxxxxxxxxxxxxxxxxxx where the offset in the header is the size of the message and xxxxxxx is the title. All portions contain the BID.

M - The actual data portion of the message split up into 200-byte chunks. The offset incrementing 200 bytes (or whatever) for each packet. The length of the message and, thus, that of the last packet is arbitrary.

E - Indicates end of message. It has the length of the message in the offset position. It may be useful to have a CRC16 checksum in hex (4 bytes) in the data portion (then again it is probably overkill).

R - Request for more data, in the form address/length. These are free format pairs (starting with the offset position as the first address), eg, 000128/200, 600/200, 1200/400. Each pair is separated by a comma and the last one is followed by a full stop (which could be left out).

A -This is sent by a THL style box when switched on to say here I am, anything interesting?

Addressing Issues

The unproto mail address needs some definition. In order to recognize a packet coming in as being relevant, it must pass certain tests.

1. It must be a UI frame.
2. It must contain the signature character "~" in the first byte of the information part of the frame.
3. The mail broadcasts need to be identified as such and so an unproto address of $$MAIL is suggested. Replies could contain this address for general work, but if a significant number of packets with a particular originating call sign are received, it is better to use an unproto address of that originating call sign such that only that station replies to requests for more data. This should go some way to preventing race conditions when two or more originating stations have the same BID and start replying.

The receiving station will need to be discriminating about who it uses to poll for requests and, if it gets packets from other stations with the required information, it must discard them, but possibly remember the call signs in case of failure with the original station.

A Sample Conversation

GB7TLH>NP2>$$MAIL <UI C>:
~H12345_GB7VLS 01200SB ALL @ GBR < G9ABC
FRED BOGGS IS LICENSED

No reply - wait say 5-7 seconds

GB7TLH>NP2>$$MAIL <UI C>:
~H12345_GB7VLS 01200SB ALL @ GBR < G9ABC
FRED BOGGS IS LICENSED

No reply - wait say 5-7 seconds

GB7TLH>NP2>$$MAIL <UI C>:
~H12345_GB7VLS 01200SB ALL @ GBR < G9ABC
FRED BOGGS IS LICENSED

This is repeated 3 to 5 times

G4RQN>GB7TLH <UI C>
~R12345_GB7VLS 00000/1200

This indicates that you wish the whole lot to be sent. This may be sent three times at one-second intervals, but could perhaps be sent up to 10 times as it constitutes "retries."

I also may receive

GB7RWN>NP2>GB7TLH <UI C>:
~R12345_GB7VLS 00000/1200

and

GB7LDI>NP2>GB7TLH
~R12345_GB7VLS 00000/1200

So I send

GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 00000xxxxxxxxyyyyyyyy etc etc
GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 00200aaaabbbbbbccccccdddd etc etc
GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 00400eeeeeeeeffffffffggggg etc etc
GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 00600hhhhhhhhiiiiiiiijjjjjj etc etc
GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 00800kkkkkkkkllllllllmmmmmm etc etc
GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 01000nnnnnnnnoooooopppppp etc etc
GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 01200qqqqqqqqrrrrrrsssssss etc etc
GB7TLH>NP2>$$MAIL <UI C>
~E12345_GB7VLS 01200

I then might receive

G4RQN>GB7TLH <UI C>
~R12345_GB7VLS 00400/200,1000/200
GB7RWN>NP2>GB7TLH> <UI C>
~H12345_GB7VLS 00200/400
GB7LDI>NP2>GB7TLH <UI C>
~H12345_GB7VLS 00000/0,1000/200

This means that the need to resend packets 200, 400 and 100 and also 00000/0 is special. The station either has not heard the header or has woken up in the middle of this exchange and wants to catch up. 00000/0 will cause resending the header packet. It may be worth sending it at the start of an exchange in the first transmission of the message as a "noise" packet that causes the channel to be "grabbed" for this exchange.

So I send

GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 00000xxxxxxxxyyyyyyyy etc etc
GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 00200aaaabbbbbbccccccdddd etc etc
GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 00400eeeeeeeeffffffffggggg etc etc
GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 01000nnnnnnnnoooooopppppp etc etc
GB7TLH>NP2>$$MAIL <UI C>
GB7TLH>NP2>$$MAIL <UI C>:
~H12345_GB7VLS 01200SB ALL @ GBR < G9ABC
FRED BOGGS IS LICENSED

As you will note, these need not be in any particular order, thus, should be slotted in the appropriate place.

I may then receive

G4RQN>GB7TLH <UI C>
~R12345_GB7VLS 00400/200,1000/200

Because there is only one packet to be sent, I send it twice to make sure.

GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 00400eeeeeeeeffffffffggggg etc etc
GB7TLH>NP2>$$MAIL <UI C>
~H12345_GB7VLS 00400eeeeeeeeffffffffggggg etc etc

I now wait 5 to 7 seconds to see if there are any more. If not, I continue with the next one or shut up if there are no more.

Now there is a potential problem here in that I might receive a delayed request for a packet from the previous message. Two strategies might be used to cope with this. Either note the request and ignore it for the time being or keep the previous message file open and satisfy the request among the rest of the current message. If the first method is used, the current message is run out and the packet(s) from the previous message are then sent.

The reader will note that now three stations have obtained the six-packet bulletin at a cost of 11 information packets from the originating station including retries. The actual level of retries is probably optimistic, but even on a dead, quiet channel, you would require 18 packets to be sent to do the same job without retries.

I think it likely that each originating station will have a list of people it is prepared to satisfy requests from to cope with lift conditions, but it may be possible to have a two-tier system in which a distant or unknown station can receive service, but only if a reasonable number of packets seem to be getting through, eg, locals may be allowed 10 retries but unknown stations only 3. After all, if conditions are that good they should be utilized.

This is preliminary, any comments, suggestions, etc would be gratefully received.

by Derek Koopman, G1TLH
from *Connect International* via Hank Greeb, N8XX

GATEWAY CONTRIBUTIONS

Submissions for publication in *Gateway* are welcome. You may submit material via the US mail or electronically, via CompuServe to user ID *70645,247* or via Internet to *70645.247*@compuserve.com. Via telephone, your editor can be reached on evenings and weekends at 203-879-1348 and he can switch a modem on line to receive text at 300, 1200 or 2400 bit/s. (Personal messages may be sent to your *Gateway* editor via packet radio to WA1LOU @ N1DCS or IP address 44.88.0.14.)

The deadline for each installment of *Gateway* is the tenth day of the month preceding the issue date of *QEX*.

Bits

Call for Papers: AMSAT-NA Space Symposium

Those wanting to present papers at the AMSAT-NA Space symposium are requested to send summaries to the AMSAT-NA office at 850 Sligo Avenue, Suite #600, Silver Spring, MD 20910, by **July 15, 1990**. Those selected for presentation will be notified by August 1, 1990. Final texts will be due in electronic form, either E-mail or floppy disc, by September 1, 1990. Reproducible figures and photographs will be due at the same time.

In order to have a successful meeting, quality papers must be presented. This announcement is to solicit appropriate papers. The AMSAT-NA Space Symposium is intended to feature talks on the latest in technology in both the manned and unmanned aspects of the Amateur Space Program. Talks on MICROSAT utilization are particularly invited. The session Sunday morning will feature presentations aimed at beginning satellite users and those who wish to try their hand with the RS birds, AO-13 and the MICROSATS.

The AMSAT-NA Space Symposium and Annual Meeting will be held October 19-21, 1990, at the Johnson Space Center (JSC) in Houston, Texas. Coming, as it does, during a year in which two Shuttle missions are scheduled to carry licensed amateurs, this should be an exciting site for the meeting. With the added attraction of the Center's extensive museum and fascinating tours available, attendance could easily break all records.

AMSAT-NA Space Symposium

AMSAT has announced that the 1990 AMSAT Space Symposium will be held at the NASA Johnson Space Center Visitor's Center near Houston, Texas. The date for the weekend meeting will be October 19-21 and will be hosted by the Johnson Space Center Amateur Radio Club (W5RRR).

Registration will open on Friday afternoon, and tours of the Center will be made available throughout the entire weekend. Tours will include areas such as Mission Control, the Shuttle Mock-up facility as well as the "Zero-G" Tank, a massive swimming pool used to train mission specialists for Shuttle EVAs (rubber rafts and water wings are not allowed).

The Symposium will take place on Saturday in the Visitor Center's Main Auditorium. Feature talks include: aspects of amateur space communication and related subjects, MICROSAT operations and the results of the SAREX STS-35 Shuttle Mission, as well as details of planned SAREX operations on STS-37.

The day will conclude with "AMSAT attitude-adjustment hour"—a Texas-style barbecue—and the AMSAT Annual Meeting. Sunday's program will consist of a series of talks emphasizing how the average ham can use the various amateur satellites—expecially the newer MICROSATS.

Accommodations at a low-priced "convention rate" have been secured at the King's Inn adjacent to JSC. For more information on this year's Symposium, send an SASE to: AMSAT, 850 Sligo Avenue, Silver Spring, MD 20910, or call the AMSAT office at: 301-589-6062.