QEX 52

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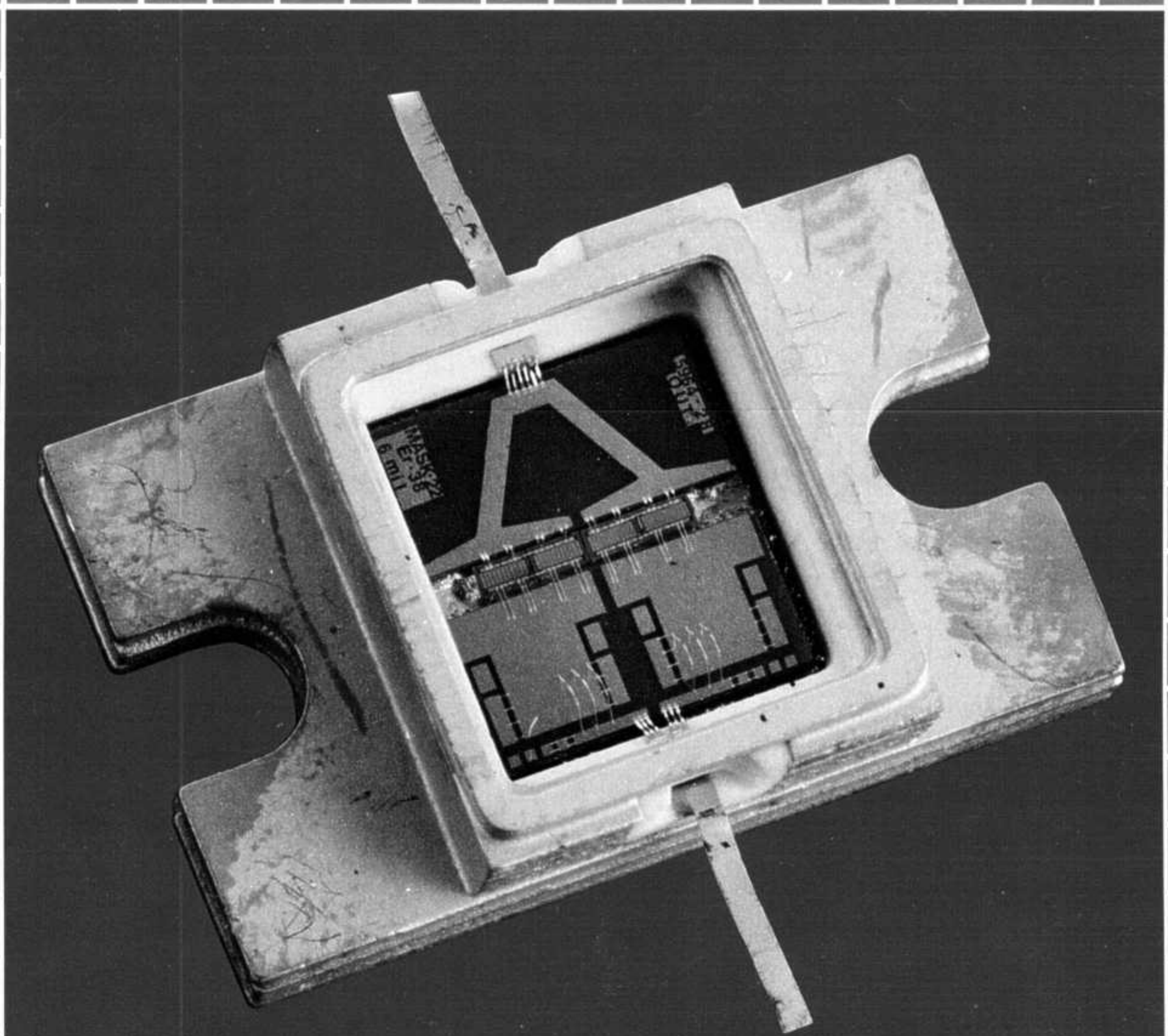
The ARRL Experimenter's Exchange



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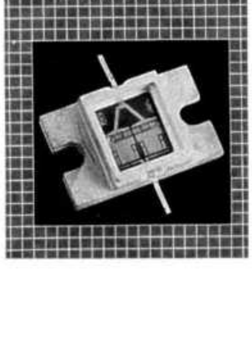

ABOUT THE COVER

A close up look at a power GaAsFET for the 5.9- to 6.4-GHz band. The device has input matching and output combining. It operates in the 3- to 5-W range and uses four separate chips. More information on transistor chips can be found on p 10. (photo courtesy of Microwave Semiconductor Corp)

THE AMERICAN RADIO RELAY LEAGUE, INC

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.

ARRL is an incorporated association without capital stock chartered under the laws of the State of Connecticut, and is an exempt organization under Section 501(c)(3) of the Internal Revenue Code of 1954. Its affairs are governed by a Board of Directors, whose voting members are elected every two years by the general membership. The officers are elected or appointed by the Directors. The League is noncommercial, and no one who could gain financially from the shaping of its affairs is eligible for membership on its Board.

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A bona fide interest in Amateur Radio is the only essential qualification of membership; an Amateur Radio license is not a prerequisite, although full voting membership is granted only to licensed amateurs in the US and Canada.

Purposes of *QEX*:

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

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

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

Empirically Speaking...

Amplitude-Compandored Single Sideband—Priming the Pump

Amplitude-compandored single sideband (ACSSB) holds some of the answers to increasing the number of voice signals that can be accommodated in the radio spectrum. The land-mobile communications services see it as a way of fitting more channels into crowded bands. The satellite-communications industry understands that ACSSB allows them not only to conserve precious spectrum, but to do so with conservative power budgets. Proposers of new radio services, such as in-flight radiotelephones, realize that if they want to get frequency space they better curb their appetites for bandwidth. The jury is still out on how firm a foothold ACSSB will achieve in the communications industry because of investment in other technologies and many competing forces.

In the Amateur Radio Service, ACSSB is still in early stages of experimentation. *QEX* has been beating the ACSSB drum for some time, as recently as the April 1986 issue, which contained an overview article. *QEX* and AMSAT's *Amateur Satellite Report* have reported on availability of ACSSB equipment, who needs/offers technical help, and on-the-air activities. A number of technical talks on ACSSB have been given in AMSAT forums over the past two years. In the near future, *QST* will feature a comprehensive technical article on ACSSB. So, in various ways, the word is getting out that ACSSB is a neat technology there for the grabbing.

ACSSB's main attraction initially seems to be for use with amateur satellites employing linear transponders, eg, OSCAR 10. With the given dynamic ranges and power budgets, ACSSB offers an automatic frequency control and a way of getting good signal-to-noise ratios without hogging precious power from the satellite. Spectrum conservation is not a pressing issue with OSCAR 10 since (a) the modulation scheme currently in use (SSB) is spectrally efficient, and (b) there are not too many present users for the bandwidth available.

Amateur Radio terrestrial use of ACSSB offers other possibilities. There, we have a problem of crowding in the VHF bands, principally in the two-meter repeater subbands. ACSSB could replace FM and cram three or four channels in the space presently occupied by one FM channel. In addition, the voice signal would sound just as good and would provide increased range watt for watt. But then, amateurs have a considerable installed base of FM equipment—more than 10,000 repeaters plus many more mobiles, hand-helds and scanners. Would it be worth the 300% to 400% spectrum conservation to throw out our FM gear? "Hmmm...," a land-mobile engineer would say, "déjà vu all over again!" No, it doesn't make much sense to junk good FM radios. But there is enough allure to ACSSB to ask why we should continue to clone more spectrally fat FM transceivers without pausing for a twinge of guilt for not using the spectrally compact model.

So what's holding us up? ACSSB is an equipment-starved technology. The ARRL liberated about 60 sets of ACSSB boards from Sideband Technology, and those boards are in the hands of Amateur Radio experimenters. Unfortunately, not enough of them have been put on the air to date because it's a bit of a technical challenge. We've done it here at ARRL HQ, but then we have a laboratory replete with engineers and test equipment. It's considerably more difficult if you have to fight for space on the kitchen table and your test gear consists of a slightly intermittent volt-ohm meter.

Why don't *they* do something about it? Manufacturers? Why should they? We're talking about something that's fairly risky as a commercial venture. How does a manufacturer know whether anyone will buy ACSSB radios if they make such a business investment? You mean there aren't any ACSSB ICs available that you can just drop into an existing transceiver design? What if we took off on the wrong standard? Industry would view this as chicken-and-egg stuff. If hams could decide what they wanted and were willing to buy the products, industry would respond to the pull of the market.

So, how can we remove some of the risk from manufacturing ACSSB gear for the Amateur Radio market? Perhaps we could borrow a page from the book of amateur packet radio. At a strategic time in the early experimental days, the Vancouver Amateur Digital Communications Group and Tucson Amateur Packet Radio (TAPR) designed terminal-node controllers that made it possible for packet radio to reach critical mass. TAPR's refinements effectively took the risk out of designing a TNC. Manufacturers also could proceed with the confidence that hams had defined a standard link-level protocol—AX.25. Is there a group out there in radioland that would like to bootstrap ACSSB in a similar manner?—W4RI

Correspondence

Packeteers v ATVers

I read with interest the Michigan Packet Radio Frequency Plan that will make use of the 430-MHz segment for FM packet radio simplex and digipeating coordinating channels. Your plan specifically states 430.025, 0.075, 0.125, 0.175, 0.225, 0.275, 0.325, 0.375, 0.425 and 0.475 MHz as being the affected frequencies. The discussion of recently losing the lower 420- to 430-MHz segment to the Canadian Business Band interest hurt few radio amateurs. It was not populated with FM, SSB or satellite enthusiasts, but fast scan TV operators who were severely hampered with this legislation. The frequency 421.25 MHz is used for ATV repeater outputs and 426.25 and 427.25 MHz are common simplex channels. The standard simplex and repeater input channel across the US is 439.25 MHz. Michigan area ATVers now have the only other option of an ATV channel designated as 434.0 MHz. Your idea to immediately populate near this frequency is questionable in the ATVers opinion. TV carriers are wideband and the packet links will experience ATV interference if such a frequency is chosen. I wonder how the 432-MHz sidebanders will take to this proposal as well?

Perhaps there will be no problem. The USATVS representative in the Michigan area is Alan L. Smith, WB8YOB, 6303 King Arthur Dr, Swartz Creek, MI 48473. Those involved in this project should discuss this further with him. We have a large number of UHF ATVers active in the Michigan area. I also access packet using a C64 and PAKRATT-64 system. I love the mode, too, but let us think compatibility!—*Mike Stone, WBØQCD, Editor/Publisher of The Spec-Com Journal and Iowa Section Mgr USATVS, PO Box H, Lowden, IA 52255.*

Interface Solution Needed

I have a Timex TS1000 computer system that includes 64 kbytes of memory, a modem and a printer. The problem I'm faced with is how to interface the Timex keyboard and computer to the Kenwood or Swan transceivers. I assume that I need an interface or terminal unit and I'm willing to purchase one, but beyond this point, I'm lost. What data can I reference to accomplish this task?—*Donn Hornberger, KAØSOH, 8514 Mathilda, St. Louis, MO 63123.*

ACSSB Boards Wanted

I am active on OSCAR 10 Mode B almost every day and am interested in ACSSB. Is anyone selling their boards or interested in corresponding with me about ACSSB?—*Jaime Gaete, CE3BCF, Technical Advisor, Amateur Radio Club Federation, PO Box 4700 Correo-2, Santiago, Chile, South America.*

Feedback

In the April 1986 issue of *QEX*, p 17, BITS announced the availability of Annie, a software program for determining antenna radiation patterns and MiniNEC, a program that analyzes wire antennas. The address for James C. Rautio, AJ3K, is Sonnet Software, 4397 Luna Course, Liverpool, NY 13090, tel 315-622-3641.

Monitoring ACSSB Signals

• My purchase of ACSSB boards last year netted me an audio and RF board. Both boards have been fully operational since about August 1985 and my main interest lies in using ACSSB on OSCAR 10, Mode B. I am set to receive signals from OSCAR 10 over the frequency range of 145.9 to 145.945 MHz with a VXO, and I can transmit over a 4-MHz range in the 435-MHz band.

I have an uplink station for OSCAR 10 that consists of a Kenwood TS-600 50-MHz transceiver, followed by a homemade transmitting converter. The converter's output drives a homebuilt 100-W, 435-MHz amplifier. This set up is shown in Fig 1.

The Kenwood generates an SSB signal at 10.7 MHz. The SSB signal is then heterodyned to the desired 50-MHz frequency. All I do is derive an ACSSB signal in the vicinity of 10.7 MHz and inject it into the Kenwood at its heterodyne unit. I do this by taking the 5-MHz ACSSB signal from the sideband filter, buffering it with an FET source follower, mix the signal with a 6-MHz crystal, amplify it with an MC1349 chip and apply the resultant 11-MHz signal to the heterodyne unit in the Kenwood. With the exception of the FET source follower, all the remaining circuitry was made using a spare ACSSB RF board that I had purchased for parts. To zero in on the desired downlink frequency, I use my ICOM 271-A.

Prior to working on the ACSSB boards, I assembled and tested the "Level One" audio Expandor/Compandor module that I can use with my transceivers on any frequency. This is a unit similar to those offered by the AMSAT net and mentioned in the *Amateur Satellite Report* except that it has no pre-emphasis or de-emphasis circuitry.

I will be happy to make schedules with any interested party to test either of these systems.—*Edward F. Nowak, W1FAJ, 36 Bonnie Dr, Farmington, CT 06032.*

• I have been doing Level One ACSSB tests on OSCAR 10. Anyone interested in monitoring my signals can tune to 145.957 MHz between 6-9 PM PDT.—*James Eagleson, WB6JNN, 15 Valdez Lane, Watsonville, CA 95076.*

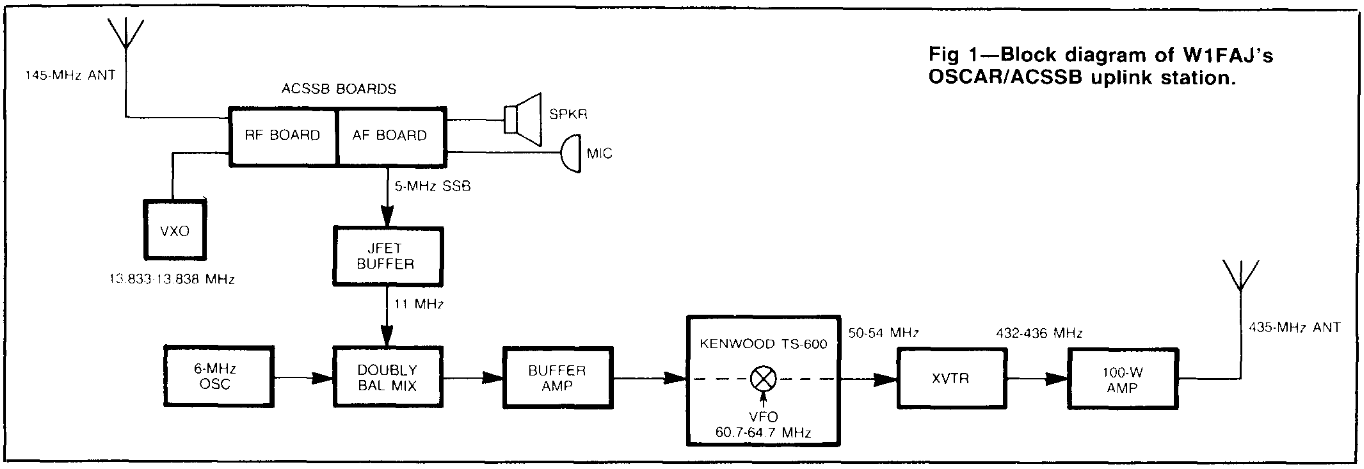

Fig 1—Block diagram of W1FAJ's OSCAR/ACSSB uplink station.

An Evaluation of Duping Algorithms

By Ron Todd, K3FR
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South Portland, ME 04106

Personal computers are frequently used to perform duping and logging tasks during an Amateur Radio contest. Early programs used for this purpose stored call signs in a linear array of strings, then sequentially probed or accessed these arrays to determine if the station had been worked previously. This method is adaquate for a small number of contacts, but becomes unbearably slow as the volume of calls to be processed increases. Advanced methods may use one of three structures and sparsely populated arrays to accelerate the search algorithms. The performance difference between these methods is a result of the size of the array, the routine that assigns locations (search methods) and the way in which the calls are encoded. All these variables have an effect on the performance of the dupe search operation of a particular program.

Development of the Programs

The first program to aid contesters did little more than copy the algorithms expressed in the ARRL Dupe Sheet. It was not efficient in either coding or use of available storage. The main difficulty was the distribution of calls over the available array space—they were not uniform. The block arrangement on the Dupe Sheet is an indication of this distribution (compare the space allotted to the 6s or 8s to the 5s). The proportion of calls received in a given call area will vary with station location, equipment used and contest. Arrays of different sizes are required to accommodate everyone.

Later programs used advanced search and insert algorithms. One well-known technique is called "hashing." It involves the use of sparsely populated arrays. When a call is processed, it is first converted to a key. The key indicates where the call might be found. If the call is found at the computed location in the array, a dupe condition exists. If a different call is found at the location, another location must be computed, examined and the process repeated until the situation is resolved. If no call is found, the station has not been worked. When each call is worked, it is placed in the array. We can see that hashing quickly degenerates into a sequential (read as SLOW) search.

One method used to convert a call to a key value is to take the ASCII values of the characters of the calls, sum these values and subtract a constant offset from the result. A little math produces a reasonable address space and should, therefore, yield good duping performance, right? No, the distribution of calls over the address space is not uniform. Some key values occur more frequently than others, thus, necessitating longer and more frequent searches. The condition that occurs when one call translates to the same key value as another call is known as a "clash" or "collision." The method of resolving clashes is known as rehashing. Both the initial scattering or hashing method and the rehashing method must be chosen when setting up one of these algorithms.

Wayne Overbeck, N6NB, and James Steffen, KC6A, introduced a dupe program with great potential.[1] Their program simplifies the task of handling an Amateur Radio log. The calls are stored as two integer values; this quickens the comparison of calls over methods that retain the "string" format of the calls being stored. It compares call signs by numerical operations rather than by string operations. Another benefit is that integers store more compactly than do strings and capacity is also improved.

The Overbeck-Steffen Algorithm

The Overbeck-Steffen hashing algorithm examines the first letter of the call suffix and takes the ordinal value of that character as the first key. Clashes (there will be many) are resolved by a pointer that starts at a value just above the last value obtained by the initial hash. This pointer is incremented every time a new call is placed at a location other than where the hash value indicates and is stored along with the call. It indicates where the next call in the current sequence is to be found; there are 26 possible sequences. This form of rehashing is known as a "linked list." It is an efficient method of resolving clashes.

For practical purposes, this algorithm provides a fairly uniform distribution of calls over the hash map (range of possible values provided by the hash function). There are inconsistencies to this hashing method, primarily that calls are assigned in alphabetical order. Calls that hash on the letter "A" occur more frequently than those that hash on the letter "Z." This injects a skew in the relative frequency that a particular sequence of calls occurs and in the relative length of the sequences.

In a large contest, this method is not much better than the method that invokes the sum of the ASCII values of the characters of the calls. It gets its speed from the numerical nature of its comparisons rather than from the number of comparisons performed. Why is this? Look at Table 1. It shows what the distribution of 2975 calls might look like when spread over the 51 hash values computed by summing the ordinal values of the last two letters in a call sign.

Table 1

H	N	H	N	H	N	H	N
0	4	13	62	26	110	39	53
1	8	14	66	27	106	40	48
2	13	15	71	28	102	41	44
3	17	16	75	29	97	42	39
4	22	17	79	30	93	43	35
5	26	18	84	31	88	44	31
6	31	19	88	32	84	45	26
7	35	20	93	33	79	46	22
8	39	21	97	34	75	47	17
9	44	22	102	35	71	48	13
10	48	23	106	36	66	49	8
11	53	24	110	37	62	50	4
12	57	25	115	38	57		

There is a great disparity between "AA" calls (hash = 0) and "AZ" calls (hash = 25). The Overbeck-Steffen method evenly distributes the 2975 calls over 26 values. An average of 114 calls would be assigned to each value. In all but one case, the ASCII sum method has fewer calls assigned to its hash value. This is a rather restricted case, but it illustrates the problem presented when selecting a dupe program algorithm.

Algorithm Proposal

I would like to propose a dupe program that hashes by weighting the ordinal value of the last two alphabetic charac-

Notes appear on page 6

ters of a call before summing these values. This is regardless of whether the characters are both in the suffix or are split between the suffix and prefix. Clashes are to be resolved with a linked list as in the Overbeck-Steffen program.

Let's now evaluate the performance of these three duping techniques. Considered parameters are:
• the probability of hashing all possible keys,
• the number of rehashes required, and
• the empty space in the array.

One assumption to be made at the start of our evaluation is that all clashes will be resolved with a linked list. If this is not used, the probability of clashes increases almost exponentially.

Suppose we can class a large number of items into B groups with all items having a probability 1/B of occurring. If there are K groups that are subsets of these groups, then the probability of selecting an item to be in one of the K groups is:

$$Ps = K/B. \qquad \text{(Eq 1)}$$

Repeating the same selection for N items, the probability of selecting items that only fall within the K of B groups is:

$$Psn = (K/B)^N. \qquad \text{(Eq 2)}$$

Interpret N as the number of contacts you make and B as the number of initial hash values that your algorithm produces. Finally, let K = B − 1. This shows that there is a real, though low, probability that after many contacts, there could be at least one initial hash value that will not be occupied. (See Table 2.) Another explanation is that except for values of B approximately equal to N, there is a good chance that all initial hash values will be covered and at least one rehash will be needed after some number of contacts.

The hashing algorithms that summarize the ASCII value of the call seem to be better on the surface. They create a larger group of hash values—51 compared to 26 when we consider the call group consisting of the 676 calls "AA" through "ZZ." This is an illusion, however, because these calls are not evenly distributed over the space of possible hash results shown in Table 1. Only one call hashes to the minimum value while 26 calls hash to the mid value of the hash map. The equation for the number of calls that result in an initial hash value equal to a given h is:

$$G = 26 - |h - 25|. \qquad \text{(Eq 3)}$$

Clearly, there are hs that occur more frequently than others. The equation representing the probability that a given h will occur with this algorithm is:

$$Ph = G/676. \qquad \text{(Eq 4)}$$

The value h = 25 occurs 26 times more frequently when either h = 0 or h = 50. Check Table 1 to verify this. Extending this discovery, we learn that after many contacts, h = 25 means 26 times more calls than h = 0 and that it will likely be referred to 26 times more frequently. The number of rehashes is dependent on the frequency of occurrence of the key. This means that this algorithm will conduct long searches and they will be much longer than with the simple algorithm of hashing only one call letter. The initial hashing algorithm must uniformly map all calls on to its result space.

Quantifying Rehashes and Searches

We have evaluated rehashes and searches without quantifying them. Let us do that now. It is clear that for K = 1 with a uniform distribution, we get the probability of selecting a particular item that falls in one of the possible B groups. This probability is:

$$Ph = 1/B. \qquad \text{(Eq 5)}$$

The number of calls referenced by any hash value h after N contacts is:

$$Mh = N \times ph. \qquad \text{(Eq 6)}$$

Since we must evaluate all calls, plus the space at the end of the list to be sure that there are no dupes, the number of rehashes required to resolve the clash is:

$$Rh = Mh. \qquad \text{(Eq 7)}$$

This calculation is valid for nonuniform distributions because it relies on the probability of a given h occurring after N entries. Consider what happens when we insert the probabilities for the distribution based on the non-weighted ASCII sum and shown in Table 1. On your next contact there is a 73% chance of working a station whose call will have to be rehashed more than the average 57 times. In fact, there is a 38% chance that it will have to be rehashed more than 90 times! The Overbeck-Steffen program shows an even probability of rehashing 114 times, while the weighted ASCII sum proposed has an even probability of rehashing only 4 times. At the same time, a 1.2% chance exists of not having to rehash at all! What performance! There must be something wrong with this proposed method. There is—efficiency. As we will see next, even efficiency is an insignificant problem.

Efficiency

The worst case efficiency of the weighted ASCII sum map is 79.2%. This seems low, but the real efficiency of my method is greater than 99%. The sequential search doesn't become a problem because it should usually be less than 10 calls deep, whereas with single-letter hashing, the search would be more than 200 deep near the end of the contest.

One may now argue that 676 array locations is a lot to reserve for the initial hash map. For a personal computer running a 10-kbyte BASIC duping program in 64-kbytes of memory, there is space available for more than 3000 calls in memory when we assume six bytes of storage per call. The average contester probably does not tax the capability of such an arrangement. In any case, the hashing algorithm could be modified easily to map to fewer values with proportionally longer searches and increased free space in the array. If a larger array is needed, the contester should consider either a bigger computer or more efficient usage of memory (ie, running an assembly language program to free up much of the space required by BASIC). Of these two options, the latter is preferred because the program runs faster and allows more array space. A note about generic BASIC: Many of the BASIC interpreters and compilers for personal computers in the amateur service are not capable of accessing more than 64-kbytes of memory. Even with added memory, your system will not be able to utilize it for increased array space. The smaller storage space offered by a compiled or assembled program, its fast speed and low cost are the preferred choice.

Efficiency of array usage by the algorithm needs to be addressed. The efficiency is defined as:

$$e = 1 - (No/Nt). \qquad \text{(Eq 8)}$$

Table 2

Algorithm	B	Ph	Psn	Rh	e 9's
O-S	26	0.038	7.94E-52	115	>12
Wt-ASCII	676	0.001	1.18E-02	4	5
Wt-ASCII	338	0.003	1.38E-04	9	7
Wt-ASCII	169	0.006	1.85E-08	18	>12
Wt-ASCII	52	0.009	5.02E-26	58	>12
ASCII-min	51	0.001	1.58E-26	4	>12
ASCII-nom	51	0.027	1.58E-26	81	>12
ASCII-max	51	0.038	1.58E-26	115	>12

where

N_o is the number of open sites, and

N_t is the total number of sites available.

The number of open sites is only dependent on the number of initial hash values unoccupied. The rest of the array is assumed to be filled by virtue of the linked list. This can best be indicated by the probability of not selecting one of the initial hash values in the entire time we are filling the rest of the array. The probability that a particular value will not be selected is:

$$Pns = 1 - (1/B), \qquad \text{(Eq 9)}$$

and that it will not be selected in N successive tries is expressed by:

$$Pnsn = Pns^N. \qquad \text{(Eq 10)}$$

This relates to only one value not being selected. By evaluating the value, we can conclude that there is a small, but real chance that there will be one initial hash value that is unoccupied. We may substitute the probability of having one unoccupied value into the efficiency formula to evaluate the various selection for our hashing algorithm:

$$e = 1 - (((1 - (1/B))^{Nt})/Nt). \qquad \text{(Eq 11)}$$

By evaluating the various hashing algorithms, we find that the efficiency of all methods is good, ie better than 0.99 when the arrays are nearly full.

The Value of Hashing

It should be clear that a large hash map space is beneficial to the searching algorithms used in contest duping programs. It does not significantly affect the efficiency of array utilization and it does search much faster than a small map. The performance of the searches can, for all practical purposes, be as good at the end of the contest as they are at the beginning. Finally, rehashes must be dependent only on the initial hash value. The linked lists in the Overbeck-Steffen programs satisfy this goal.

Clearly, an algorithm that maps many calls to a small number of values while mapping only a few calls to the other values is undesirable. Not only will some values occur more frequently, but since those values reference more calls, searches on those values will involve many more rehashes. Rehashing means comparisons and these take time. The key to designing a duping algorithm is that all possible calls be evenly distributed among the possible values for the hash mapping algorithm. This prime consideration significantly improves the performance of searching for a call by at least 50%. Further improvements in dupe program performance are to be had by increasing the hash space to decrease the search time and by running more efficient programs on faster computers. N6NB has pointed out that overall program performance is not only a function of the hashing and searching algorithms, but also of the other contest house keeping functions that include saving the contact on disk, scoring and keeping track of multipliers.[2] While this is certainly true, the delay between entry of a call and the response of the computer with dupe conditions is highly critical in the fast-paced world of contesting.

As mentioned before, if you want more array space, run an assembly language program. This disposes of the BASIC shell that can occupy up to 40% of your computer's memory. At the same time, the assembled program probably consumes only half of the space required for the same program in a higher-level language. An additional benefit of an assembled or compiled program is that it runs quickly. Long searches respond in record time. If you must use a higher-level language, PASCAL or a compiled version is a much better choice than BASIC.

In summary, Table 2 presents the results of the mathematical evaluations of the three dupe program methods discussed in this paper. The final choice is yours. The column headings correspond to the similar values found in the text, except the efficiency; that is given in significant 9s following the decimal point. Several values of hash map size are given for the weighted ASCII algorithm. The values for the non-weighted ASCII algorithm are best case, typical case and worst case. The values for Psn and Rh are based on 3000 contacts.

Program Changes

Since I have been touting the benefits of an increased hash map, it is only fair that I show how to achieve one. The following changes should be made to the Overbeck-Steffen CP/M "Sweepstakes Logger" program to give a hash map of 676 possible calls based on the weighted ASCII sum technique using the last two alphabetic characters in a given call.

Change line 200 to: SS = 677
Change line 350 to: L% = 676
Change line 3430 to: H% = 0

Add the following lines:

```
3431 FOR J=6 TO 1:IF E(J)
  <27 THEN H%=H%*26+E(J)
3432 IF H%>26 THEN H%=H%-26:
  GOTO 3440
3433 NEXT J
```

Changes are also necessary to the "Dupeprint" program to enable it to work with the revised hash table format. The changes to the CP/M program version are:

Change line 380 to: FOR K=1 TO 676

While these changes are for the CP/M program versions and run on my KAYPRO II, they should also work for the other versions of these programs and on other computers. Similar changes, though, will not work for the "Dupechecker," "General Contest Logger" or "Field Day Logger." The separate tables for each band require too much storage to be set aside in these programs. N6NB has suggested that a table size near 100 may work for these programs.[3] This might be done by taking the integer of the value obtained by dividing the computed hash value by some number between 6 and 8. The corresponding values for the variables and constants changed would be the integers above or below the value obtained by dividing 676 by the same number. For example, if 8 is selected, the logging program would look like:

FOR 676/8 = 84.5
SS = 85
L% = 84

The final value of H% before going to the search would have to be changed to:

H% = INT((H% - 26)/8)

and the terminal value of the FOR-NEXT loop in "Dupeprint" would become:

380 FOR K=1 TO 84

One final note relating to these changes: The files produced by this revised hashing algorithm are not usable with unmodified programs. Similarly, the modified logging and "Dupeprint" programs are not usable with files generated with the unmodified programs.

Happy contesting. QRZ K3FR

Notes

[1]W. Overbeck and J. Steffen, *Computer Programs for Amateur Radio* (Hasbrouk Heights: Hayden Book Co, 1984).

[2]Wayne Overbeck, N6NB, *Personal Communication*, Sep 1985.

[3]ibid.

A Xerox 820-1 Compendium

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The August 1985 issue of the *AMRAD Newsletter* presented a Xerox™ 820-1 Compendium, compiled and introduced by Andre Kesteloot, N4ICK. *QEX* is proud to present this same information to its readers, with permission to do so granted by the Amateur Radio Research and Development Corporation. The Compendium will be presented in several installments, beginning this month. Every experimenter familiar with the Xerox 820-1 will find this reference material of extreme value.

A number of articles on the Xerox 820-1 computer have appeared in this newsletter[1] over the past 18 months and in a few other publications during the past several years. The Xerox 820 was chosen by the ARRL ad-hoc digital committee for developing network systems,[2] and AMRAD decided to present complete reference material required to help the experimenter get his or her computer up and running.

History

During the summer of 1980, Digital Computer of Texas marketed a Z80® computer in kit form and named it the Big Board, or BB-1. The hardware was designed by Jim Ferguson of Ferguson Engineering,[3] but by late 1980, Xerox had bought manufacturing rights to the circuitry. The company rearranged the circuits on a multiple-layer board and renamed it the 820-1. (Beware of hidden connections; some of the +5-V and ground lines are now sandwiched inside the fiberglass board!) The circuitry remained identical, but all IC numbers were changed. (See note 4 for a comparative description of the BB-1 vs the 820-1.)

By 1982, Xerox marketed the 820-2. It sported a faster clock speed, double density and offered a possibility of adding a 16-bit co-processor. Although there are similarities between the 820-1 and the 820-2, there are also a number of differences. This Compendium will deal exclusively with the 820-1. For a comparison between the 820-1 and the 820-2, see note 5.

Notes appear on page 8

As obsolete 820-1 boards were removed by Xerox and replaced with the newer 820-2 board, the 820-1 surfaced on the surplus market. By October 1982, these surplus boards were selling for $435 each, and as of July 1985, they could be found for as little as $50 (untested).

Description

The Xerox 820-1 is a single-board computer using the Zilog Z80 CPU, one of the most popular CPUs ever made. The board operates under CP/M® 2.2 and features 64-kbytes of RAM, one parallel (PIO) and two serial (SIO) outputs, an 80 x 24 video display and a single-density disk controller.

Hardware

[During 1985 when the Compendium was first published, the 820-1 board and components were available for the prices listed. Because the parts are a surplus item, prices will fluctuate. Call or write the referenced sources for product availability and a new price listing before sending a check in the specified amount.—Ed.]

To install a workable system, the following items are the minimum requirements:

An 820-1 board—They are available untested "as is" from Xerox Surplus Outlet[6] for $50, plus shipping. Mine arrived with a damaged crystal and a bad video-output chip. Because of the board's configuration, crystals are quite likely to suffer in shipment. New crystals can be obtained from BG Micro for $3 each.[7] (Some boards operate as soon as they are connected; others need attention. Depending on your technical capability, you may opt for an "as is untested" or a tested board.)

The boards can be purchased in tested and operating condition from SW Computers[8] for less than $100. You might also check with Lolir Lectronics Corp[9] and Ferguson Engineering.

Ferguson Engineering also sells the 820-1 board, as is, less the two ROMs and the 1771 disk-controller chip, for $45. Those three chips should be available separately for about $20 total.

Wilcox Enterprises[10] offers many goodies for the board: cables, CP/M, connectors, ROMs and so on. A flyer will be sent on request. BG Micro sells a bare board, the two ROMs, the data and the 32 memory chips for $40, but you will have to assemble it.

A power supply—The 820-1 requires +5 V at 3 Amps, +12 V at 0.25 Amps and −12 V at 0.5 Amps. One or two 5-inch disk drives or even a 12-V video monitor may be attached to your setup. The equipment can easily be powered by a small switching power supply manufactured by California DC (part no. LR1015) and sold by BG Micro for $24.95. It comes ready to run and is equipped with the correct mating plug for the Xerox board! I have used both the California DC and the Harris no. 144813 supplies with equal success. Astec makes a suitable power supply, too (part no. AA11760), but I have not tried it.

A keyboard—The original design requires a parallel ASCII keyboard. These keyboards are available from a variety of sources. The *Computer Shopper*[11] and *Nuts and Volts*[12] often list classified ads of this nature. If you cannot find a parallel keyboard, or if you already own a serial ASCII keyboard, a parallel-to-serial interface[13] can be built easily. This gives you the advantage of being able to use a coiled, 4-wire telephone-like cable between the keyboard, instead of the 11-(minimum) conductor cable required for the parallel ASCII keyboard (8 wires for the eight bits, plus one wire each for +5 V, strobe and ground). If you construct your own parallel-keyboard cable, I recommend connecting several conductors in parallel for the ground return. Very flexible, round, 15-conductor cable can be purchased by the foot from Arlington Electronics.[14] (I am using 5 feet of Alpha Wire (part no. 1181-15) cable between my 820 board and my keyboard without any problem.)

A video monitor—The 820-1 generates positive-going noncomposite video, positive-going horizontal sync and negative-going vertical sync pulses. These signals will directly drive a TTL-video monitor and 12-inch video monitors (available at hamfests for around $20). A cute 5-inch TTL monitor is available from Halted Specialties and from United Products for less than $30. It needs only the above signals and +12 V at 1 A

(I have two of these monitors and they work well. For a review of this monitor, see note 15). If you are interested in using a composite-video monitor, a section describing my composite-video board will follow in an upcoming installment. Finally, if you do not need TTL video and you only want a composite-video output and you don't mind modifying your 820-1 board, follow the modifications performed by David Borden, K8MMO, and outlined in another section of this Compendium.

A 5¼-inch disk drive—BG Micro sells excellent Canon drives (2/3 height) for $45. Other drives, such as the Shugart 455 or the Teac FD55F ½ height drives work just as well, albeit priced in the $100 range. Look in *Computer Shopper* and *Nuts and Volts* for sources. (Details on how to connect these drives follow.)

Cables—You may have to construct the cables that go between the keyboard and the 820-1 board. Another cable will have to connect the board to the disk drives. This cable, Xerox part no. 117P80668 REV A, is available from SW Computers, Epic Sales[16] and Ferguson Engineering. (While it is possible to make your own cable, I don't recommend it.)

Connectors—Nine connections are necessary to make your system work. I will go through each of them.

- Power Connectors (J5): pin 1 = −12-V dc; pin 2 = +12-V dc no. 1; pin 3 = +12-V dc no. 1; pins 4, 5 and 6 = dc ground; pin 7 = +12-V dc no. 2; pins 8 and 9 = +5-V dc.
- Video Output (J7): pins 1 and 2 = no connection; pin 3 = vertical sync; pin 4 = horizontal sync; pin 5 = video; pins 6 through 10 = ground.
- Channel A Serial I/O Connector (J4): pin 1 = protective ground; pin 2 = transmit data (TXD); pin 3 = receive data (RXD); pin 4 = request to send (RTS); pin 5 = clear to send (CTS); pin 6 = data set ready; pin 7 = protective ground; pin 8 = carrier detect (DCD); pin 15 = transmit clock; pin 17 = receive clock; pin 20 = data terminal ready (DTR); pins 9 through 14, and pins 16, 18, 19 and 21 through 25 are unused. (It is possible, by changing the strapping on J9, to allow serial port A to communicate either with a modem, or with a terminal. See the Xerox documentation package.)
- Channel B Serial I/O (J3): pin 1 = ground; pin 2 = received data; pin 3 = transmitted data; pin 4 = clear to send; pin 5 = request to send; pin 6 = data set ready; pin 7 = ground; pin 8 = terminal ready; pin 20 = data-carrier detect; all other pins are unused.
- Keyboard connector (J2 on the 820): pins 1 through 8 are connected, respectively, to bits 0 through 7; pin 9 = strobe; pin 10, 11 and 12 = unused; pin 13 = +5-V dc; pins 14 through 25 = ground.
- Connector on the Keyboard: My original Xerox keyboard is a Micro-Switch, part no. 630107-02 (Xerox part no. 2160095). If you have one of these, here is how to connect it to your Xerox motherboard. Looking into the pins of the connector on your keyboard, the upper row is comprised of odd-numbered pins, with pin 1 being on your right, and pin 29 on your left (nearest the edge of the keyboard). Pin 1 = bit 7; pin 3 = bit 6; pin 5 = bit 5; pin 7 = bit 4; pin 9 = bit 3; pin 11 = bit 2; pin 13 = bit 1; pin 15 = bit 0; pin 27 = strobe; pin 29 = +5-V dc; pins 17, 19, 21, 23 and 25 are not used. The even numbered pins of the bottom row (near the printed-circuit board) are or should be grounded and are to be connected to the 820-1 ground (J2 pins 14 through 25).
- Video Monitor Connector (J6): pin 1 = ground; pin 2 = +12-V dc.
- Parallel I/O Connector (J8): (You can use this port to feed a printer, but remember to ground *all* odd-numbered pins of J8 to ground on the 820-1 board. Xerox forgot to do it! See note 17 for more details). For the even-numbered pins—pin 2 = port A strobe; pin 4 = port A ready; pins 6 through 20 = port A bit 0 through 7, respectively; pin 22 = port B ready; pin 24 = port B strobe; pins 26 through 40 = port B bit 0 through 7, respectively.
- Disk Drive Connector (J1): (Note that the following description matches the 820-1 board. The listing shown in the Xerox Service Manual, p 10-50, is incorrect.) pin 1 = no connection; pin 2 = 8-inch/5-inch select (this pin must be grounded for 5-inch drives); pin 3 = no connection; pin 4 = index sensor; pin 5 = select drive no. 1; pin 6 = select drive no 2; pin 7 = side select; pin 8 = head load; pin 9 = step direction; pin 10 = step command; pin 11 = write data; pin 12 = write gate; pin 13 = track 00 sensed; pin 14 = write protect notch open; pin 15 = read data; pin 16 = low current; pin 17 = drive ready; pin 18 = (this pin can be used to supply +12-V dc to the disk drives, or for any other purpose); pin 19 = +5-V dc; pins 20 through 37 = ground.

Documentation—Although this Compendium lists all the connector pins and other basic information you need to get your board running, you may want to obtain additional information. There is a complete 820-1 documentation package available from Ferguson Engineering for $15. It is very useful, but the drawings are not always legible. Ferguson also offers a set of six schematic diagrams, measuring 18 × 24 inches. It is available for $18. A CP/M Primer (the handbook Xerox packaged with its computers) can be purchased for a cost of $7.50.

MicroCornucopia[18] is a magazine published six times per year. It is devoted to single-board computers such as the Big Board, Xerox, Kaypro and the Slicer.

Accessories—If you want to modify the 820-1 for double density operation, you will want to add one of two double-density daughterboards available. The first, made by SWP Microcomputers of Arlington, TX[19] (not to be confused with SW Computers and Electronics of Albuquerque, NM), plugs into the 1771 floppy disk controller-chip socket. No modification to the board is required, but the double-density format produced by this board is not compatible with most other systems. (I understand that this SWP board was supplied by Xerox as an upgrade; it is much simpler to install). The 32-page instruction manual is well-written and very informative. The second board, marketed by Emerald Microware[20] requires a few trace cuts and other alterations to the 820-1 board, but produces a double-density format that is generally Kaypro-compatible. (Terry Fox, WB4JFI, built and installed the Emerald board on his 820 and is satisfied with it.) That board is sold with an excellent set of instructions. Before deciding which board to purchase, write to both manufacturers for details and for a comparative study of both boards (see note 21). Next month's installment will feature "smoke" tests, the Xerox 820 Big Board and the 820 and Packet Radio.

Notes

[1]*AMRAD Newsletter,* PO Drawer 6148, McLean, VA 22106-6148

[2]T. Fox, WB4JFI, "Protocol," *AMRAD Newsletter,* Nov/Dec 1984.

[3]Ferguson Engineering, PO Box 300085, Arlington, TX 76010; tel 817-640-0207

[4]J. P. Marlin, "Xerox 820 Notes," *MicroCornucopia* No. 8, Oct 1982.

[5]J. P. Marlin, "Xerox 820 Notes," *MicroCornucopia,* No. 9, Dec 1982.

[6]Xerox Surplus Outlet, 1341 W. Mockingbird, MS503, Dallas, TX 75247; tel 214-960-3367.

[7]BG Micro, PO Box 280298, Dallas, TX 75228; tel 214-271-5546.

[8]SW Computers, and Electronics, 3232 San Mateo, NE, Albuquerque, NM 87110; tel 505-821-2521.

[9]Lolir Lectronics, 13933 N Central Expressway, Suite 212, Dallas, TX 75243; tel 214-234-8032.

[10]Wilcox Enterprises, PO Box 395, Nauvoo, IL 62354; tel 217-453-2345.

[11]*Computer Shopper Magazine,* 407 S Washington Ave, Titusville, FL 32781.

[12]*Nuts and Volts Magazine,* PO Box 1111, Placentia, CA 92670.

[13]Philip Plumbo, "Serial Keyboard Interface," *MicroCornucopia* No. 10, Feb 1983.

[14]Arlington Electronics, 3636 Lee Highway, Arlington, VA 22207; tel 703-524-2412.

[15]David McLanahan, "The Kagadenchi Five-Inch Monitor," *Computer Smyth,* Feb 1985, p 46.

[16]Epic Sales, 132 Walnut Plano Center, Garland, TX; tel 800-223-EPIC.

[17]J. W. Mink, "Parallel Printing With the Xerox 820," *MicroCornucopia* No 18, June 1984.

[18]*MicroCornucopia,* PO Box 223, Bend, OR 97709; tel 503-382-8048.

[19]SWP Microcomputer Products, 2500 E Randol Mill Rd, Arlington, TX 76011; tel 817-924-7759.

[20]Emerald Microware, PO Box 6118, Aloha, OR; tel 503-642-1860.

[21]Mitchell Mlinar, "The Xerox Column," *MicroCornucopia* No. 23, April/May 1985.

The Birth of a New Bird

By Maureen Thompson, KA1DYZ
Assistant Editor, QEX

Each time a new satellite is launched, there is a feeling of pride within the amateur satellite community. Many world-wide support groups, who offered months of dedicated service, receive the opportunity to display their accomplishments. Glancing back at the history of the AMSAT-OSCAR program, this has occurred numerous times. Other countries such as France, Russia and Great Britain have joined these ranks with successful launches of their own radio communications satellites. Another country soon hopes to be added to that list. This August, Japan will launch its very first Amateur Radio Satellite. JAS-1 is the result of a joint effort by JARL (Japan Amateur Radio League), in conjunction with NASDA (Japanese national space agency), the Nippon Electric Company (NEC) and JAMSAT (Japan Amateur Radio Satellite Corp—they designed and built the satellite). Simply called JAS-1, it will become airborne via an H-1 rocket launched from Tanegashima Island, Japan.

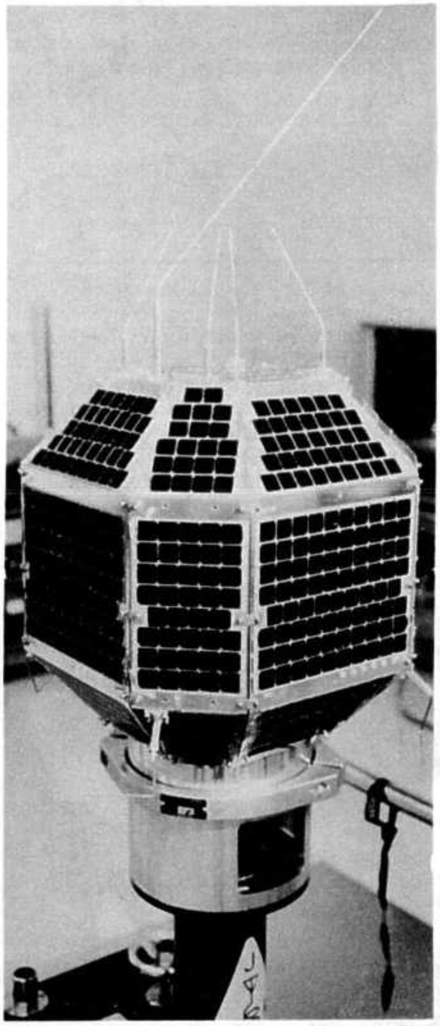
The mission will provide reliable worldwide Amateur Radio communications, enable amateurs to study tracking and command techniques, and offer an in-space proving ground for Radio Amateur developed and built transponders and subsystems. It will also provide an opportunity for NASDA to carry out a multi-payload launch using the new H-1 launcher. Though it is the first Japanese satellite, Japan has supported AMSAT projects both financially and technically in the past, one of which was OSCAR 8.

Important specifications for the early August 1986 launch of the JAS-1 satellite are:

- estimated inclination: 50 degrees
- estimated altitude: 1500 km
- estimated period: 120 minutes
- estimated window per pass: 20 minutes
- estimated passes per day: 8
- estimated lifetime of the satellite: 3 years

Two Mode-J transponders will be on board the satellite: one a linear transponder, the other a digital "store-and-forward" transponder. Several items were considered before choosing Mode J. JAS-1 will act as successor to OSCAR 8's Mode J. Interference, both manmade and natural, is often prevalent on 145 MHz when it is used as a satellite downlink, thus 435.910 MHz was chosen for the downlink. Therefore, the uplink pass band is 145.90 MHz to 146.00 MHz. The downlink pass band will be 435.80 MHz to 435.90 MHz. The beacon frequency is 435.795 MHz and the translate frequency is 581.80 MHz.

Three antennas will permit operation through JAS-1. The first is a 2-meter receiving antenna, requiring a special interface board. The other antennas are a slant ¼ wave monopole isotropic (−4 dBi gain) and a 70-cm transmission antenna: Mode JA will feature a slant turnstile LHCP +Z axis + 3 dBi gain and Mode JD will have a slant turnstile RHCP −Z axis + 3 dBi gain.



The JAS-1 satellite. Physical dimensions measure 15.75 inches (diam) × 18.50 inches (height). It weighs in at 110.23 pounds and its 26 faces are covered with a total of 979 solar cells that will generate 8.5 W of power. Three groups of antennas that include a 2-meter and 70-cm antenna and a slant ¼ wave monopole sit firmly attached to the top of the satellite. (photo courtesy of Fujio Yamashita, JS1UKR)

JAS-1 features Mode JA and JD. To work Mode JA, your OSCAR 8 station will suffice. However, JAS-1 uses the standard AX.25 protocol and 1200-bps data rate. Ground stations will be able to use a TAPR TNC, a 2-m FM transmitter and a 70-cm receiver without modification. The JAS-1 modem, a special interface board, will be available to amateurs and contain the Manchester modulator and an audio PSK demodulator. (A complete paper on how to modify your modulator and build an audio PSK demodulator can be found in *The ARRL Amateur Radio 5th Computer Networking Conference.*[1])

Several articles about the JAS-1 satellite have been published in *Amateur Satellite Report* and *QST.*[2,3] I recommend referring to this material for additional technical data.

Notes

[1]F. Yamashita, "Outline of Satellite JAS-1," *The ARRL Radio 5th Computer Networking Conference,* (Newington: ARRL, 1986), pp 5.122 to 5.126. This publication is available from the ARRL for $10.

[2]*Amateur Satellite Report,* no. 119, March 1986. This is a bi-weekly special interest newsletter catering to amateur satellite users and published for the Radio Amateur Satellite Corp (AMSAT). Subscription rates for the US, Canada and Mexico are $22 and foreign is $30 (US funds only). Mail to Satellite Report, 221 Long Swamp Rd, Wolcott, CT 06716.

[3]V. Riportella, "Introducing Japanese Amateur Satellite Number One (JAS-1)," *QST,* June 1986, p 71.

Bits

Product Review List Available

The ARRL is now offering a complete list of Product Review items that appeared in *QST* from 1976 to 1985. Interested? Send $3 and your request to the Technical Department Secretary, ARRL, 225 Main St, Newington, CT 06111. You won't have to question equipment performance anymore!—*KA1DYZ*

By Bill Olson, W3HQT
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RF Transistor Chips: The Saga Continues

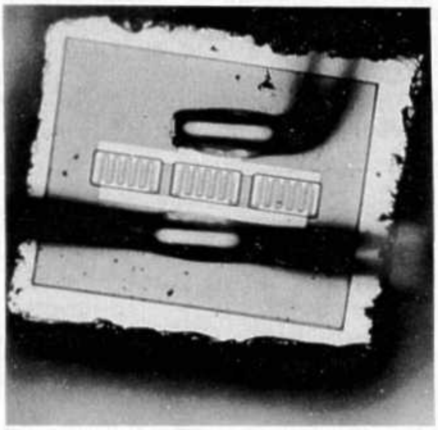
Last month we discussed the processes used in manufacturing silicon bipolar transistor chips. This month, we'll take a quick look at how gallium arsenide chips are made and examine special cases, such as multi-cell chips, internally matched devices and emitter ballasting. Then, we'll see how the chips are connected to the package.

Gallium Arsenide

While the process used for making gallium arsenide (GaAs) wafers into GaAsFET chips is completely different from the silicon bipolar process, the basic method is the same. Since gallium arsenide wafers are around ten times as expensive to make as silicon wafers, maintaining a good yield is important. This is especially true for large, high-power devices where the maximum possible chips per wafer is low.

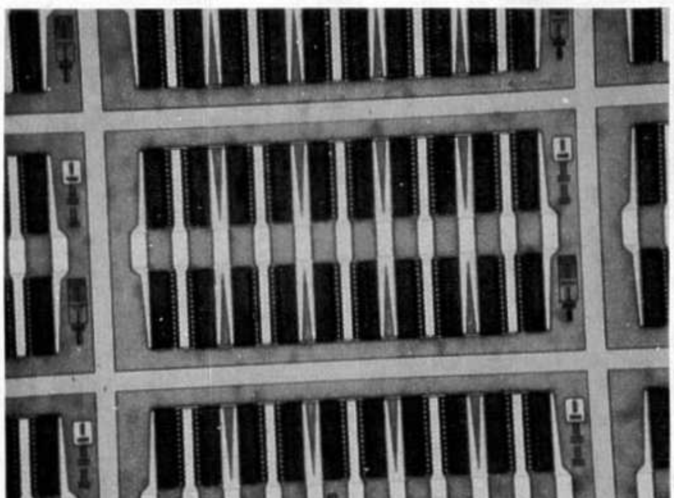
MOS Capacitors

Most modern microwave transistors have internal matching circuitry to bring the input and/or output impedance to 50 ohms. This greatly simplifies practical applications by eliminating complicated external matching circuitry. Internally matched transistors have L-C matching networks inside the package. The chip bond wires serve double duty as the inductors in this tiny circuit. The length and height of these wires can be controlled to yield the correct inductance.

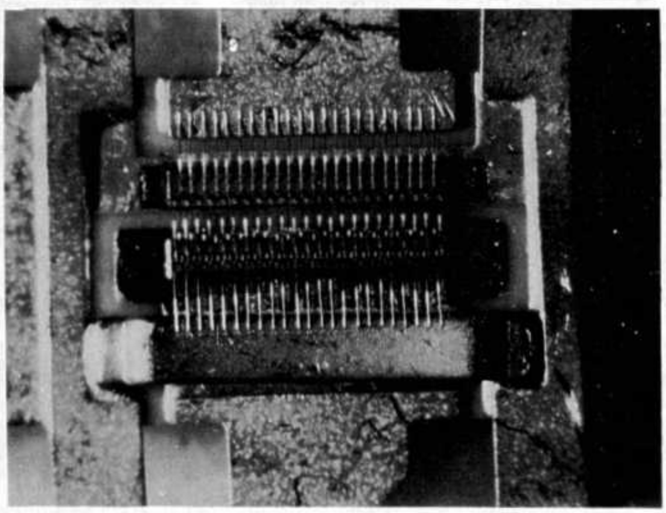


Closeup of the chip in a low-noise receiving device. The chip has three cells tied together with top metal. Note that the bond pads are almost completely covered by 0.001-inch wire bonds! The chip is approximately 0.008 × 0.010 inches. The rough edges are caused by the diamond sawing operation. (photo courtesy Thomson-CSF Semiconductor Division)

Capacitors for internal matching circuitry, known as *MOS capacitors* (metal-oxide-silicon) are simply another type of chip. They are manufactured in a manner similar to that of transistor chips except that the process is much simpler. The silicon used for MOS capacitor wafers is a very conductive type. This conductive surface forms one plate of the capacitor. A layer of nonconducting silicon oxide is grown on top of the conductive silicon as a dielectric, and then a layer of metal is plated on top of the oxide to form the other capacitor plate. By controlling the size of the top metal area and the thickness of the oxide layer, capacitances from less than 1 pF to more than 1500 pF are made possible.



The chips on this wafer are for 1-GHz power devices. Each chip has six base bond pads and five emitter bond pads. Chip size is about 0.120 × 0.060 inches. This device is capable of 100 W pulse power at a 5% duty cycle. (photo courtesy Thomson-CSF Semiconductor Division)

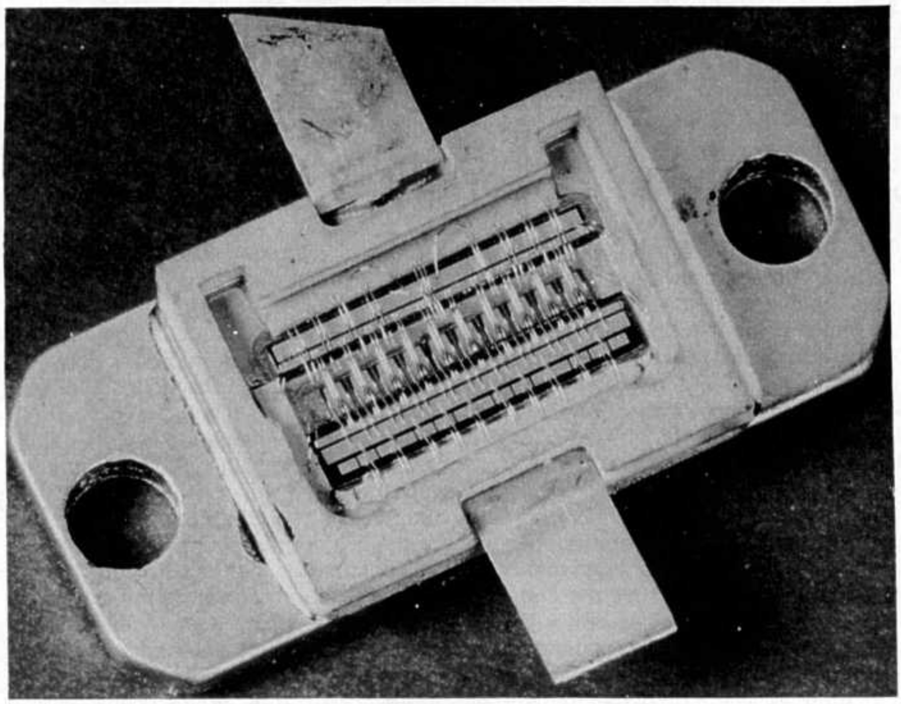


This 900-MHz, 50-W CW device is mounted in a 900-MHz JØ package. It features internal input matching with a MOS capacitor. It has 23 base bond pads and 23 emitter bond pads, each connected with 0.001-inch gold wire. Note that the base wires go to a bridge, as described in April *QEX*. (photo courtesy Thomson-CSF Semiconductor Division)

Multi-cell Chips

As mentioned last month, transistor manufacturers often mount several chips in a package for more power. This modular approach is also used within a single chip for most high-power designs. Several (sometimes 20 or 30) separate transistor areas are defined on each chip and then connected together with the top metallization.

Top metallization on a multi-cell chip does more than just serve the electrical contact area to the device. It is responsible, in part, for assuring that each area on the chip shares power equally. Here the chip metal becomes much like microstrip circuitry on a PC board. The distance from the bond pads to each transistor area is made equal for best current sharing. There are drawbacks, however. As the chip size increases, capacitance between the top metal and the collector becomes significant and tends to limit chip performance at high frequencies. Chip designers take great pains to ensure that the individual runs of metal are large enough to handle the required current, yet at the same time are small enough to keep capacitance at a minimum.



Ten separate chips are inside this 300-W (pulse), 900- to 1200-MHz transistor. Input and output matching is accomplished with MOS chip capacitors. There are at least 85 wire bonds! This is a hermetic package—after testing, a metal lid is soldered to the top, providing an airtight seal. (photo courtesy Microwave Semiconductor Corp)

Emitter Ballasting

The thermal resistance of silicon and the gain of a bipolar device both increase with temperature. If one area of a chip is running hotter than another (caused either by the design or by nonuniformity in attachment to the package), there is a tendency for the chip to get very hot in that area. This is called *hot spotting* and can be responsible for failure of either all or part of a device.

To minimize hot spotting and to force better current sharing among cells of a multi-cell device, transistor manufacturers often employ a technique called *emitter ballasting.* This is done by placing resistors in series with the metal fingers that attach to each emitter contact. These resistors are usually a thin film of high-resistance metal such as nichrome. In some cases, other metals are actually diffused into the silicon wafer. If the current starts to increase in a certain area of a device, the increased voltage drop across the emitter resistor tends to "turn off" that area. The result is equal current sharing of all areas on the chip.

Emitter ballasting is especially important in class-A linear devices where the transistor is always "on" and dissipating power continuously. In this case, ballasting not only serves to improve linearity by forcing all areas of the chip to be forward biased at the same level, but also provides a measure of self bias, as well as protection. The trade off with emitter resistors is that they are degenerative—that is, they lower the gain of the device. Another balancing act for the device designer!

Connecting the Chip to the Package

The final process before we humans get to play with the finished transistor is the assembly process where the chip is placed in the package and wired up. The process by which the back of the chip is attached to the package collector area is known as *die mounting.* For most devices, this is a eutectic process similar to soldering. The package is heated to the proper temperature (400-500 °C), and the chip is placed (gold-plated back side down please) on the gold-plated collector pad. The chip is mechanically scrubbed back and forth until a gold-silicon eutectic is formed. At this time, the two gold surfaces start to flow into one another and the mount is complete. When done in the proper inert atmosphere to prevent oxidation, the eutectic process forms an excellent electrical and thermal bond.

For low-power devices, the chip is sometimes mounted using a conductive (usually silver filled) epoxy cement. This method does not give a very good thermal connection, but it's cheap and fast and acceptable for small-signal type devices.

The emitter and base connections are made to the bond pads using a *wire bonding* machine. Done at a much lower temperature than die mounting, wire bonding forms a connection more like a compression weld than a solder joint. Compression, heat and sometimes ultrasonic vibration are used to cause the wire to join to the bond pad. On a device with many wires, this process is akin to sewing; hence the name *stitch-bond* for a wire bond that goes from package to bond pad and back to the package again.

Ashes to Ashes

When a chip is wired, it has finally lost its separate identity. We now have a complete *transistor.* The device is now ready to be sealed up and turned over to some technician or ham whose job it is to turn the chip back into sand again by connecting the power supply backwards . . .

Next month we will discuss some applications of the various transistor types, as well as how to select a device for a particular application and what trade-offs can or should not be made.

Intellectual Properties

By Bill Conwell, K2PO
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The Right to Copyright

More amateurs are writing their own software to perform various calculations and functions in the ham shack. This month's column discusses the use of copyright protection to discourage unauthorized copying of such computer programs and other "works of authorship."

How to Maintain Ownership of Your Work

The copyright laws were established almost two hundred years ago to protect the works of authors from those engaged in the art of unauthorized copying. The scope of copyright has broadened over the intervening centuries to include a great variety of subject matter that ranges from computer programs to Cabbage Patch Kids™. The law provides the creator of any such work a limited monopoly to make copies of the work. This limited monopoly is inexpensive and relatively easy to obtain.

To illustrate the procedure, let us examine the case of an experimenter who writes a new antenna-design program for a personal computer. Our experimenter's copyright claim begins automatically the instant the program is written. There is no lengthy application and approval process, but certain requirements must be met if the protection is to remain in force. The most important requirement is that the programmer add a copyright notice to the work which informs the public that the programmer claims ownership rights in the work and that it may *not* be freely copied. In the United States, a proper copyright notice generally includes a "C" in a circle (©) or the word "Copyright," together with the name of the "author" and the year the "work" was first published. Sometimes computer programmers substitute a "C" in parentheses for a ©. At least one court has stated that this latter form of notice is improper!

The copyright notice should appear in a conspicuous place. In our experimenter's computer program, the copyright notice should be included in the first lines of source code and should be displayed on the first screen when the program is run. If the program is maintained in object code, the copyright notice should be encoded at the beginning of the program in ASCII so that it appears when the object code is printed. Copyright notices should also be printed on all floppy disk packages or ROMs containing the copyrighted code and in any software instructions or supporting materials.

If a work is published (ie, made available to the public) without a copyright notice, or includes an improper copyright notice, it generally falls into the public domain. This means that the author's rights have been forfeited and the work *can* be freely copied by the public. Countless programmers have naively lost their copyrights by distributing programs without proper copyright notices.

The omission of a copyright notice, however, does not always mean that the author's rights have been forfeited. There are certain circumstances in which copyright in a work published without a proper copyright notice can still be preserved if certain efforts are made to "cure" the omission.

The Copyright Process

So far, the copyright process is free. The protection begins from the moment of creation and there is no cost associated with the notice. However, to enforce a copyright against a copier in court, our experimenter's copyright must be "registered." This process costs ten dollars and is done by submitting two copies of the work and an appropriate form to the Copyright Office in Washington, DC. For computer programs and other "literary" works, form "TX" is used. If all the formalities are met, the Copyright Office stamps the form with the registration number and returns it to the programmer. The work is then protected for the lifetime of the programmer, plus fifty years.

The Copyright Office is a division of the Library of Congress. Works submitted for registration are at the disposition of the library and are usually, in the case of books and some other published writings, added to the library's public collection. In certain unusual situations, computer programs submitted for registration can sometimes also be made available to the public. If our experimenter wants to limit public inspection of the program, two options are available. The first option is to submit an object-code listing of the program. The Copyright Office frowns on this procedure and accepts it under their "Rule of Doubt." Under this procedure, the Copyright Office issues the registration, but gives no opinion as to its validity. The second option is for the programmer to submit only a part of the source-code listing, usually the first and last 25 pages. (Submission of less than the first and last 25 pages can sometimes be negotiated with the Copyright Office.) This partial submission procedure is explicitly authorized by the law to encourage registration of proprietary software. Some people, of course, take advantage of this provision and reorganize their programs so that the interesting parts are removed from the first and last 25 pages. This technique, however, can complicate proof of infringement if the copier has copied only the middle sections of the program.

Why Register Your Work?

As noted, our experimenter's copyright cannot be enforced against a copier in court unless it is registered. A copyright registration can generally be obtained after the copying has begun. However, there are several advantages to registering the work promptly after its creation, within certain time frames set by the copyright laws. The first is the availability of statutory damages against a copier. Statutory damages cannot be less than $250 nor more than $10,000, unless the copying is willful. In such a case, a court can increase statutory damages to $50,000. If the work is not registered, our experimenter can only recover the amount of his or her actual loss or the profits of the copier. These amounts are often negligible or are difficult to determine.

Registration promptly after creation also allows a court discretion to award our experimenter attorneys' fees if a copyright infringement suit is won. This benefit is not available if the work is registered after infringement.

There are certain other benefits associated with registering works that are "unpublished" (ie, not intended for public distribution). Such details are beyond the scope of this column.

Fingerprints—A Clue to Exposing Plagiarism

Let us now assume that someone begins selling an unauthorized version of our experimenter's antenna-design program. To prove infringement, our experimenter must prove copying. This is normally shown by proving that the suspected infringer had access to the copyrighted work and that his version is substantially similar to it. The requirement of access is needed because "independent creation" is a defense to infringement. Thus, if the suspected infringer independently created a duplicate of our experimenter's software, he has not infringed the copyright.

Sometimes access can be inferred even when it cannot be directly proven. This most often occurs when certain unusual features, or "fingerprints," are found both in the original work and in the copied work. One common fingerprint is the presence of inconsequential errors in a work. This technique was originated centuries ago by map makers who deliberately added nonexistent towns and other topographical features to their maps. If these errors later appeared in the maps of other map makers, plagiarism was established. Similar techniques are used today by programmers.

Devising suitable fingerprints is an exercise of creativity. The first step is to imagine how a copier might change the program to make it look different. Likely techniques would be to change the variable names and the program order. Subroutines could be merged into the main code. The program could even be translated into another language. To be effective, the fingerprints must persist even after these changes are made.

One fingerprint well adapted for scientific code is the use of an inaccurate pi constant. The constant pi might be deliberately set equal to 3.1415931 instead of its truer value 3.1415927. The deviation would not affect operation of the program and a copier who sees pi listed to eight significant figures may think that such accuracy is necessary and thus copy all of the digits. If this same erroneous value of pi appears in a suspected infringing copy, it would be incredible to attribute the similarity to happenstance.

Another fingerprint technique is to insert "dead code" in the program. This can be code that is never reached during operation because a conditional branch always skips it. Such code, however, is relatively easy to detect in source-code listings and would likely be found by a savvy copier.

A more attractive technique is "wasted code." This method uses several lines of code to explain something that could have been written in a single line. For example, if two numbers are to be multiplied, this can be done by summing their logarithms. Similarly, if two numbers are to be added, this can be done by adding each number to a constant, adding these sums and then subtracting out the constants. If such code is found in a suspected infringing version, there can be little doubt but that it was copied from the copyrighted program. These examples just barely scratch the surface of some of the tricks that can be used to fingerprint programs.

Conclusion

There are few things more disheartening to a programmer than writing a program, distributing it to a local user's group and later finding a pirated version in the marketplace. With just a few precautionary steps, programmers can maintain the rights in their programs for their lifetimes and beyond.

While the foregoing discussion has focused on computer software, copyright is similarly applicable to other "works of authorship," such as books, music and artwork. The Copyright Office has a telephone service for answering questions about copyright and for ordering forms (the forms are free). The number is 202-287-8700.

Bits

(photo courtesy of Bopla Enclosures)

Bopla Offers New Digital Housing Display

Bopla Enclosures of McLean, VA has announced a new digital housing display that can be adapted to the many needs of the amateur experimenter. The handheld enclosure measures 5.9 inches long × 3.15 inches wide × 1.18 inches high and is molded in black ABS plastic. Four models similar to that shown in the photo are available. The photo displays a stylish design that incorporates a recessed key pad area, moveable side switch, battery compartment with door and a cut-out for an LED. Other designs feature an enclosure with or without a side switch and two different window sizes. The battery compartment is located on the back side or bottom and is designed for two AA batteries or a one 9-V battery.

The digital housing display is an off-the-shelf enclosure. The price range for a small-quantity order is $9.50. In large quantities, the price is approximately $5 per box. For complete information on these enclosures, contact Gary Compton, Bopla Enclosures, 1350 Beverly Road, Suite 115/338, McLean, VA 22101, tel 703-549-7242.—KA1DYZ

Two New Books of Interest to the Amateur Community

Howard W. Sams & Co has recently published two new books: one discusses the design and maintenance of mobile radio systems; the other is a guide to Motorola's M68000 family of 16/32-bit microprocessors. *Mobile Communications Design Fundamentals* by William C.Y. Lee is an introduction to mobile communications design and covers topics on predicting area-to-area signal path loss, antenna design, frequency spectrum utilization and much more. Methods of analysis are presented in an easy-to-understand format and presentations are explained through physical interpretation rather than mathematical. The publication consists of 304 pages in a hardbound edition. It retails for $34.95.

The second publication is called *68000, 68010, 68020 Primer* by Stan Kelly-Bootle and Bob Fowler of the Waite Group. It was written to introduce novice and experienced programmers to the instruction set and addressing modes common to the 68000 family. Subject matter covered in the publication focus on how to program in assembly language, how code mapping works, how to use various instructions and registers and simply how to use the 68000 to its fullest. Programming examples are presented throughout the book and a tear-out card with listed instructions can often be conveniently referenced. The book contains 368 pages and retails for $21.95. For more information on these and other engineering publications, contact Howard W. Sams & Co, 4300 W 62nd St, Indianapolis, IN 46268, tel 800-428-SAMS.—KA1DYZ

Bits

Future Antenna From Future Communications

The future of satellite communications is here today. Future Communications, located in Colorado Springs, has introduced a flat plate satellite antenna known as PhaseCom. The antenna can be installed in a window, inside a house, on a roof and in some cases, an attic. Because of its possible placement, the PhaseCom antenna is ideal for apartment dwellers. The antenna is approximately five feet square and less than 2 inches thick. It weighs about 20 pounds and resembles a solar panel when mounted. (See photo.)

The flate plate technology represented in PhaseCom has been tested by NASA and used by the military for several decades. Price ranges for the consumer market range from $421 to $1,189. Regular and deluxe units are available. For more information, contact Fred White, Future Communications, Inc, 3624 Citadel Dr N, Suite 239, Colorado Springs, CO 80909, tel 303-591-9683.—KA1DYZ

(photo courtesy of Future Communications)

ACSSB Technical Information Source

After several months of searching for individuals involved in ACSSB technology, one such person has come forth to offer assistance to builders of the Sideband Technology boards. Leslie Varnicle, WA3QLW, is personally familiar with the design and product modifications of the Sideband Technology unit. She has been employed at Syntonic Technology, Harrisburg, PA for most of her 17 years as an engineer associated with mobile communication technology.

Leslie requests that you ask specific technical questions pertaining to the construction of your kit. She can be reached during working hours at 717-561-2400, ext 57. If you must write, you must include a business-size SASE, and again, specific technical questions only. Her address is D107, Box H30-RFD 1, Hillcrest Dr, Etters, PA 17319.

I encourage other individuals possessing technical knowledge in this area to contact me. ACSSB can be used successfully with Amateur Radio and the OSCAR satellite. If this is one of many directions our interest is heading, why not work together?—KA1DYZ

AMSAT Announces "Project Linkup" Satellite Tests

AMSAT has announced a series of on-the-air tests aimed at verifying the concept of easily accessible bulletins relayed by amateur satellite. The tests will use a powerful 436-MHz FM downlink on AMSAT OSCAR 10 to ensure excellent audio quality and broad coverage.

Repeater operators, gateway stations and individuals are being sought to participate in these tests. Bulletins will normally be sent when the satellite is positioned for North American coverage during convenient hours. AMSAT OSCAR 10's orbit provides hours of coverage with little or no tracking required. AMSAT, ARRL bulletins and general Amateur Radio news (ie, *Westlink Report*) will be available to any station listening to the satellite either directly or through gateway stations.

Project Linkup involves five subsystems working together:

- An earth station which uplinks the bulletins on 1.3 GHz
- An amateur satellite (AMSAT OSCAR 10) which relays them
- Terrestrial gateway stations that receive the 436-MHz FM satellite downlink and relay the message to terrestrial repeaters
- Terrestrial FM repeaters that will relay the bulletins to users on convenient VHF or UHF repeaters
- Terrestrial FM repeaters that will relay the bulletins to the user community with, for example, 2-m or 70-cm handhelds

If these tests are successful, regular bulletin service may be available this autumn. Project Linkup also sets the stage for future satellite systems. AMSAT's Phase 3C, due for launch this fall, will include a new Mode S transponder with a 2.4-GHz downlink, and three other transponders.

Project Linkup will use a downlink frequency of 436.55 MHz. To receive good quality signals direct from the satellite, your station should include a 70-cm antenna (any polarization) with at least 12 dBi gain, a low noise preamp at the antenna and a 436-MHz FM receiver. An elevation rotator for the antenna is helpful, but not mandatory. (Southern stations will benefit most from elevation rotators.)

Operations schedules and antenna pointing guides for various locations will be transmitted on AMSAT's HF nets. A list of AMSAT net times and frequencies is available from AMSAT Headquarters as part of its Project Linkup information packet.

The free Project Linkup information packet is available from AMSAT for a large (9 x 11 inch) SASE with $.56 postage affixed. Write to AMSAT, Project Linkup, PO Box 27, Washington, DC 20044. Donations to help defray project costs are welcomed.

For further technical information, contact Vern Riportella, WA2LQQ, AMSAT President, PO Box 177, Warwick, NY 10990, tel 201-284-2352 (days) or 914-986-6904 (evenings). AMSAT, The Radio Amateur Satellite Corporation, is a nonprofit scientific, educational corporation of the District of Columbia founded in 1969. Its Headquarters are located at 850 Sligo Ave, Silver Spring, MD 20910. Membership at $24 per annum is open to the public.—WA2LQQ

Ham Bats Zero Against Nature

Ham radio operators in warm climates have quickly found that Old Sol rapidly dispenses with antenna and tower materials. Thanks to the sun, many times I have found the remains of "good" plastic cable ties lying in the grass around my tower.

On another occasion, I needed to put some preamps and relays on the tower near the antenna. I considered using a plastic cover, but went the extra length to house my electronics with an aluminum cover. Plastic exposed to constant sunshine is destroyed with time and will fall apart easily at the touch of a human hand.

Not long ago I noticed something strange hanging out of the open bottom of the equipment cover. It looked like a huge ball of loose yarn, and I didn't recall my wires looking like that. Lowering the tower I found the box filled with Spanish moss!

Shortly after this episode, some of the electronics in my box failed to work. Did I blow another GaAsFET? There hadn't been any thunderstorms. I laboriously cranked the tower down again to find that a number of no. 22 AWG control wires (not the larger power wires) had considerable mechanical damage. It looked like a young child with innocent perversity had been let loose with a pair of dull wire cutters. This puzzled me.

Casting about for an answer, I spotted the culprit in a nearby tree. A squirrel, one of the copious population that resides in my backyard, developed another chewing habit—my vinyl-covered no. 22 AWG wiring.—*Dick Jansson, WD4FAB, 1130 Willow Brook Trail, Maitland, FL 32751.*

New Parts Source

Whether you play a role in research and development on the job or as part of your Amateur Radio interests, you should contact Utronics Electronic Parts (UTEP) for a listing of their electronic parts and manufacturer products in stock. Stocked items range from books to components to power supplies, soldering irons and wire. If you are searching for a warehouse of supplies, contact UTEP for more information. Their address is 80 Century Dr, Stratford, CT 06497, or call direct to their parts counter at 203-377-4423.—*KA1DYZ*

Bishop Graphics, Inc Assists CAD Users

Quik Circuit™ is a new printed circuit board CAD/CAM system specially designed for the Apple® 512-kbyte Macintosh computer. The software is available separately or you can order the system that includes the Quik Circuit software, an Apple 512-kbyte Macintosh computer and an Imagewriter™ printer. The printer features an output capability for a variety of pen plotters, photoplotters and CNC drilling machines.

The Quik Circuit system produces layouts with the precision of a 32-bit graphics-oriented microcomputer. The program is fast, precise and easy to learn. A grid and coordinates (in inches) helps you keep track of your work area. The View Size menu allows the user to zoom in on areas as small as 1.4 inch × 0.25 inch. Each side of a double-sided PC board can be viewed on screen simultaneously; dark traces are on the component side and gray traces are on the solder side. The Patterns menu lets you choose the component elements to work with. The Edit menu enables you to correct or customize your pattern. The mouse offers a "cut-and-paste" feature for changes. A "group-and-store" feature lets you reuse the same pattern repeatedly.

When you are ready for PC board production, Bishop also has a network of qualified manufacturers ready to work with your company and Quik Circuit layouts. If price quotes and layout are satisfactory, you can even send your layout data using a modem!

Bishop is considered to be the world's largest manufacturer of printed circuit design products and can supply you with virtually any design or drafting aid. Technical Bulletins about the Puppets™ PC Layout System, a new precision overlay drafting punch known as Accupunch™, a low-cost precision glass linear measuring system called Opto-Scale II® and others are available free of charge. For a catalog of products, information about Quik Circuit and the Technical Bulletins, write to Bishop Graphics, Inc, 5388 Sterling Center Dr, PO Box 5007, Westlake Village, CA 91359-5007.—*KA1DYZ*

New TI Modem Offers Many Benefits

Texas Instruments has produced a new, low-cost TCM3105 modem for applications requiring high-speed data transmissions in a single direction. The single-chip FSK modem implements either the Bell 202 or CCITT V.23 standard. The modem is capable of operating full-duplex at 600 or 1200 baud on the forward channel (receive), or 5, 75 or 150 baud on the backward channel (transmit).

The TCM3105 price tag reflects a $20 decrease from what a full-duplex 1200-baud modem (Bell 212 standard) would cost and is fabricated in silicon-gate LinCMOS technology using switched-capacitor filter techniques. Other features of the TCM3105 modem include carrier detect level adjustment and carrier fail output, on-chip transmit and receive filtering and local copy/loop back test capability. The chip operates from a single 5-V supply and typically uses 5.5 mA. It is available in a 16-pin ceramic dual-in-line package (DIP) and is offered in two temperature ranges (commercial range of 0 to 70° C; industrial range of -40 to 85° C), and is priced at approximately $10 and $15 in 1000-piece quantities, respectively. For more information on the TCM3105 modem, contact Texas Instruments Inc, PO Box 809066, Dallas, TX 75380.—*KA1DYZ*

Search Your Shack

Help a museum get up and running. Motorola Communications and Electronics, Inc, in Anchorage, Alaska, is establishing a Museum of Early Two-Way Radio Equipment. They have already acquired a few post-World War II tube-type items, but would greatly appreciate any donations of equipment or assistance from amateurs who may have interesting or unusual examples of two-way radio gear. Let's drag out those old pack sets, turkey roasters and other ancient radios in mint condition, and help preserve our heritage from the early days of VHF and UHF FM communications. Contact curator Don Parker, 5333 Fairbanks St, Suite 1, Anchorage, AK 99502.—*Craig V. Bledsoe, K4TXK/KL7, 1893 Woodbine Dr, Fairbanks, AK 99709.*