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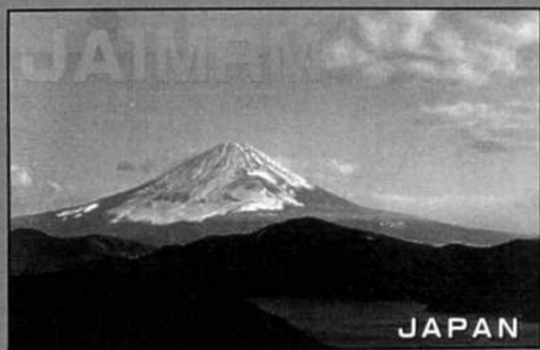
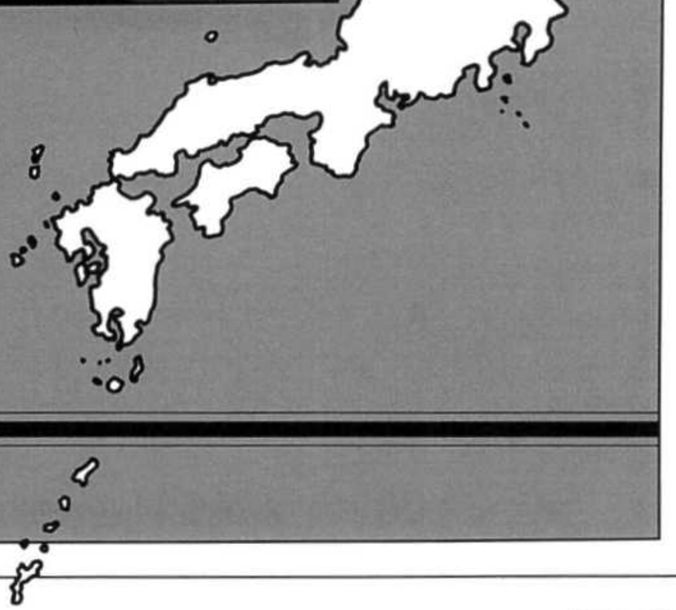
QEX 89

ARRL Experimenters' Exchange

JULY 1989





NET98.EXE: TCP/IP —Japanese Style

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JULY 1989 QEX ADVERTISING INDEX

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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. . .

HF Packet Initiative

"The Great 1989 HF Packet Design Quest" article in May *QST* announced a new initiative to stimulate amateur development of more effective HF packet transmission systems. If you're interested and haven't seen the article, get hold of a May *QST*. As this is written, we are in the process of finishing several bibliographies on HF channel characteristics, modems, protocols and digital signal processing. We will be mailing the bibliographies to people who have indicated an interest. Soon, we will be asking prospective participants for resumes and some information on what they would like to contribute to the project. For the participants ultimately selected by the ARRL Digital Committee, there will be an opportunity for reimbursement for certain out-of-pocket expenses, such as components needed to build modems. If you would like to be added to the mailing list, please write or call Lori Weinberg at ARRL HQ.

Turning the Page

In March 1986, *QEX* went to a small magazine with glossy two-color cover and some advertising to offset the increased printing costs. For these past three years or so, we have carried *QEX* at a loss amounting to a few kilobucks each year. This is not unusual for magazines when they are growing circulation.

Now we have a tiny problem. Those of you who read "It Seems to Us. . ." in June *QST* and the 1988 audited financial statements understand that the League had some red ink last year. It comes as no surprise that every kind of expenditure has come under scrutiny—including *QEX*.

It was time to get out the sharp pencils. We asked our printer how we could save a few bucks. Well, he said, "Funny you should ask; we've had a 30% increase in paper costs since we bid the job to you." It kind of reminded me of trying to cancel an insurance policy—the salesman's job is to get more money, not less. Not wishing to compromise my reputation as a nerves-of-steel negotiator, we finally arrived at a formula for squeezing out some printing cost. Gone, with this issue, is the two-color cover on coated stock, and we lightened up on paper weight without compromising quality. We have also decided to lighten up on so-called "house ads"—the *QEX* ads that promote League publications—to save a few pages of printing here and there.

So what's the big deal? Haven't some *QEX* readers been telling us that they don't care that much about a fancy printing job? They just want the information. The bottom line is that we have brought the *QEX* books into balance without compromising the editorial space. With some skillful execution, we can work on building the circulation, plumping up the issues, and getting better coverage of some experimental subjects.

In October 1986, AMSAT Satellite Journal was added to the *QEX* subtitle line. That lasted until our June 1989 issue, when the Post Office told us either to get an AMSAT Third Class mailing permit on file in Hartford or to pay a higher rate for postage. AMSAT NA President Doug Loughmiller, KO5I, knows it's nothing personal, and that we will welcome AMSAT back on the masthead as soon as the mailing permit is in place. As some of you may know, AMSAT NA also has done some realignment of its publications. Exactly how *QEX* will fit into AMSAT's new scheme will evolve in the months ahead.

There have been some changes in editorial handling of *QEX* here at ARRL HQ. For years, Maureen Thompson, KA1DYZ, was the Assistant Editor, meaning that she did most of the work. Upon her departure, her functions were shared among the *QST* technical editorial team headed up by Associate Technical Editor Paul Pagel, N1FB. In the past couple of months because of workload demands in Paul's shop, I have done more hands-on editing of *QEX*. I couldn't do that (and everything else) without the able help of our new Assistant Editor Lori (Maty) Weinberg. Again, that title means that she does most of the work, but I'm more actively involved than I have been for several years. I'll be particularly interested in improving *QEX* so it can best serve its readers—you!—*W4RI*

NET98.EXE: A Japanese Version of the KA9Q Internet (TCP/IP) Package

By Masahiro Yamada, JK1NNT and Takayuki Kushida, JG1SLY

NET98.EXE, BM30N.EXE and JBM.EXE are the main components of the KA9Q Internet Package for the Japanese users. These programs are the modified version of the KA9Q Internet Package. The modification includes the support of Kanji characters and the support of the PC-9801 series personal computer. Modification methods and the evaluation of these programs are discussed.

What the Japanese Version is

The original version of the KA9Q Internet Package, unfortunately, cannot be used in Japan. Firstly, because it does *not* handle the Japanese Kanji characters and, secondly, because it does *not* run on the PC-9801, the most popular personal computer in Japan.

The purpose of the Japanese version of the KA9Q Internet Package is to fill these requirements for the users in Japan. Thus, the feature of the Japanese version includes:

a. Modifications of the NET.EXE and BM.EXE to support Kanji characters in mail, telnet sessions and trace lines.

b. Modifications of the NET.EXE to support PC-9801:

1) Serial Interface Driver for the PC-90801.

2) Escape character that allows escape from session mode to command mode without the use of the F10 key.

The modified version of the NET.EXE and BM.EXE are named NET98.EXE, BM30N.EXE and JBM.EXE, and are running at various users' shacks throughout Japan.

Kanji Support

Japanese personal computers usually have the ability to input or output Kanji characters, and therefore the users can easily write or read files including Kanji characters. The Shift-JIS Kanji code, which represents one Kanji character with two 8-bit bytes, is used in most Japanese personal computers. The use of the Shift-JIS Kanji code requires the 8-bit transparent channel to exchange the messages with Kanji characters.

But the programs in the KA9Q Internet Package do not assure the 8-bit transparency except where the protocol specifications allow the 8-bit transparent data transfer. The KA9Q Internet Package even turns off the MSB (the most significant bit) of each character in the message to zero. It is because the RFC821 (SMTP) and RFC822 (Mail text format) are the protocol specifications for the messages consisting only of 7-bit ASCII code. These circumstances force us to prepare messages consisting of only 7-bit data, if the message is sent through SMTP, UUCP or other media used in the USA.

This problem arises not only in the amateur packet radio network, but also in every computer network in Japan. There are at least two solutions for this problem. One is simply converting 8-bit data into 7-bit data using the UUENCODE routine. Another is to employ a Kanji data code consisting only of 7-bit data.

Besides there modifications of the mailer program, the following modifications of the NET.EXE program are required for consistency.

a. Kanji characters and Kana characters should be. transferred correctly in the telnet sessions or AX.25 connected sessions.

b. Kanji characters or Kana characters should appear correctly on trace lines.

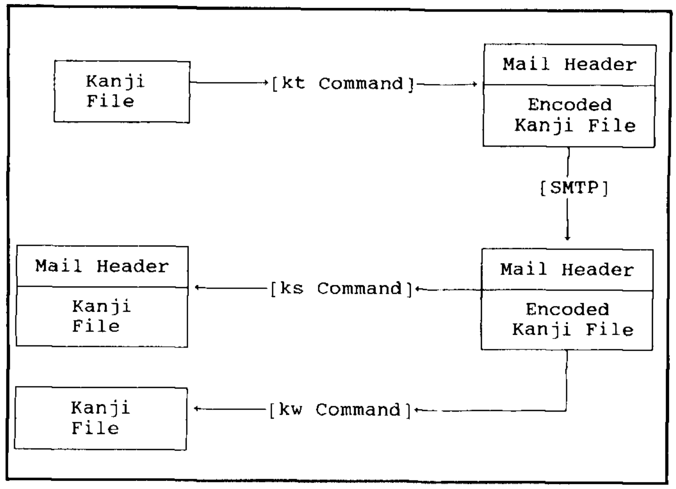

Fig 1—ASCII Message Transfer

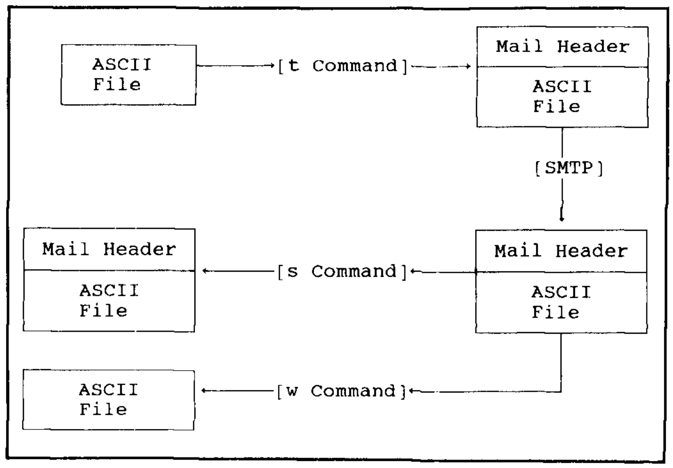

Fig 2—Kanji Message Transfer

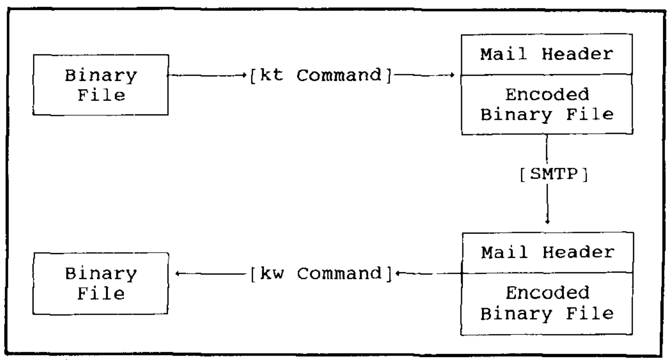

Fig 3—Binary File Transfer

MODIFICATION OF THE BM.EXE

BM30N.EXE

This is the first approach to send Kanji messages. The routines uuencode.c and uudecode.c were modified and renamed to bmencode.c and bmdecode.c respectively, and were incorporated into the modified mailer program named BM30N.EXE.

We added the kt, ks and kw commands to support Kanji message transfer.

The kt command first calls bmencode (modified version of the UUENCODE) to make an encoded file which does not include 8-bit data, then copies it to the mqueue directory using the dosmtpsend routine.

The ks command copies a message from the mail file to a work file, then calls bmdecode (modified version of UUDECODE) to make it readable.

The kw command works almost the same as ks, but this command makes files without mail headers.

Table 1

File Type	*Command to send*	*Command to read*
ASCII	t	s / w
Kanji	kt	ks / kw
Binary	kt	kw

Figures 1, 2 and 3 show the data and the file conversion using these commands.

JBM.EXE

This is another approach to the Kanji message transfer. There are many codes to express Kanji characters.

a. JIS Code—JIS code is the data code authorized by the JIS (Japanese Industrial Standard). JIS code is the base of the various codes, but is not very popular for use with personal computers. It requires the escape character sequence to change from Alphanumeric characters to Kanji characters, and vice versa, and is rather complicated for personal computer users. There are two sets of JIS code: 8-bit JIS code and 7- bit JIS code. The difference between them is not the difference in the representation of the Kanji characters, but the difference in the representation of Kana characters. 8-bit JIS code represents the Kana character with an 8-bit byte with the MSB on. 7-bit JIS code represents it with a 7-bit byte (ie, MSB if off) preceded by a shift-out character.

b. Shift-JIS Code—Shift-JIS code is a variation of the JIS code that does not require the escape sequence to change from alphanumeric to Kanji. For this reason, Shift-JIS code is the most popular code used in personal computers for personal use, like PC-9801.

c. Other codes—There are other groups of Kanji codes which were authorized by main frame computer makers such as Fujitsu, NEC, Hitachi and IBM. These main-frame codes are easily converted to and from JIS code.

While the method mentioned under BM3ON.EXE uses the 8-bit Shift-JIS code and uses the encoding technique to convert them to 7-bit data, the method used here is to convert the 8-bit Shift JIS to 7-bit JIS code.

This method is implemented in the JBM.EXE program with the following modifications.

a. Code conversion for received mails. JBM converts the code from JIS to Shift-JIS when it makes the work file at its initialization. While JBM reads the messages in the mail file, it searches for the three-byte sequence, ESC-'$'- 'B'(0x1b 24 42) which is the shift-in sequence to Kanji. After finding the sequence, the following two-byte pairs are translated from JIS to Shift-JIS code. While this code is translating, JBM scans for another three-byte sequence, ESC-'('-'J'(0x1b 28 4a) which is the shift-out sequence from kanji. When JBM finds the shift-out sequence, it stops the code translation. This code translation enables the users to read the received mails expressed in 7-bit JIS code on the PC-9801 computer display; the JBM prints the content of the mail not from the original mail file but from the work file.

b. Code conversion for outgoing mails. JBM converts the code of the outgoing mail from Shift-JIS to 7-bit JIS while it copies the mail file (xxx.txt) from the work file. While copying data, JBM searches for the 8-bit code(8x81<c<0<9F or 0xEO<c<0<FC) in the work file. After finding the code, JBM translates the code from Shift-JIS to JIS by assuming that it is the first byte of the two-byte Shift-JIS data. This code translation enables the users to edit the mails in Shift-JIS code. It is very important for PC-9801 users to be able to edit their mails in the Shift-JIS code; PC-9801 DOS and the editors on it support the Shift-JIS code only.

Modification of the NET.EXE

Though the Kanji support is indispensable in Japan, Kanji support in the Internet Package must be limited because the Internet Protocol does not basically allow 8-bit communications.

For the time being, the NET98 supports the following functions:

a. Kanji characters are displayed on the trace lines when ASCII trace mode is specified. If HEX/ASCII mode is specified, Kanji does not appear on the screen.

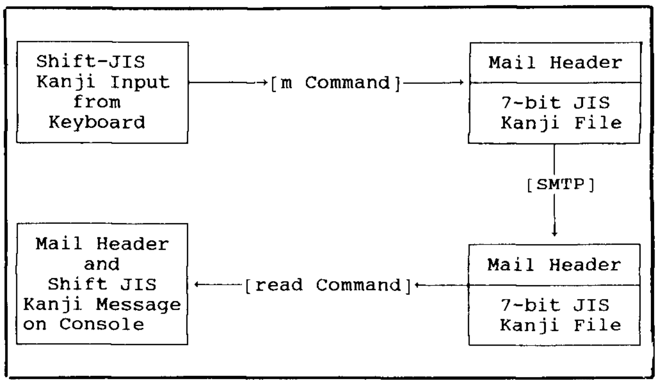

Fig 4—Kanji Mail Transfer using JBM

```
<7-bit JIS>
1b 24 42
24 33 24 6c 24 4f 21 22 34 41 3b 7a 24 4e 35 61
25 43 25 3b 21 3c 25 38 24 47 24 39 21 23
1b 28 4a

<Shift-JIS>
82 b1 82 ea 82 ed 81 41 8a bf 8e 9a 82 cc 83 81
83 62 83 5a 81 5b 83 57 82 c5 82 b7 81 42
```

Fig 5—Sample of 7-bit JIS and shift-JIS code data.

b. Kanji characters can be sent and received in telnet sessions or AX.25 connected sessions.

Modifications for Kanji support were simple and were made only to eliminate the coding to turn off the MSB.

PORTING OF NET.EXE FOR PC-9801

Serial interface driver

The PC-9801 uses the 8251 as its serial port device while the IBM PC uses the 8250. Because of this difference, redesign of the serial interface driver in the NET.EXE was required.

There were two approaches for the driver redesign: write a new device driver suitable for the 8251; or, utilize the functions for the serial interface included in the MS-DOS for the PC-9801.

We selected the latter as it looked simpler.

a. Module relation in the NET.EXE

Fig 6 shows the Module relations of the serial interface related modules in the NET.EXE. Function names are listed in Fig 1. Names n parenthesis indicate the source module names in which the function in included.

b. Changes in the module structure Because we choose to utilize the functions in DOS, the same modules (asyint, asytxint, asyrxint, asy1vec, . . . , asy4vec) were deleted and the module structure was changed as shown in Fig 7.

c. Modification of the modules

Module modifications are as follows:

asy__recv, asy__output

Modified to user system calls of the DOS to access serial port.

asy__speed

Modified to use extended system calls to initialize serial port.

asy-init, asy__stop

modified to not do the initialization of the device driver.

Escape Character Support

The IBM PC version of the NET.EXE uses the F10 key as the signal to escape from the converse mode of a session to the command mode. However, because the character sent to the program when the F10 of the PC-9801 is pushed is not the same as that sent with the IBM-PCs, modification of NET.EXE is required.

There were two approaches to solve this problem: use the PC-9801's F10 key as the escape signal; or, use the escape key as the escape signal.

We choose the latter approach for two reasons. One, use of the escape key as the escape signal looked more natural; and, two, the routine to handle the escape key as the signal to escape was already built in the NET.EXE.

Program modifications were very simple. First was to revive the routines for the escape key which were disabled if the switch "MSDOS" was specified. Second was the modification of the kbread function to handle the escape key instead of the F10 key.

Evaluation

As a result of our Internet Package modification, BM30N.EXE, JBM.EXE and NET98.EXE are running on PC-9801s and are contributing to the construction of the Internet Network in Japan. Unfortunately, there seemed to be many problems yet to be solved in these programs and the original versions of these programs.

1. Comparison of BM30N.EXE and JBM.EXE

a. Operability

Fig 8 shows the operations required for writing a Kanji mail using BM30N and JBM.

Fig 9 shows the operations required for reading a Kanji mail using BM30N and JBM.

```
doattach ---> asy_attach ---> asy_init  (asy.c)
(main.c)       (slip.c)    |-> asy_stop  (asy.c)
                           |-> asy_speed (asy.c)
dospeed ------------------/
(main.c)

Slipq -----> asy_start ---> asy_output ---> asytxint
(slip.c) /   (slip.c)        (asy.c)    /    (asy.c)
        /                              /
doslip -----> asy_recv                /
(slip.c)      (asy.c)                /
                                    /
asyBvec ----> asyint ----------------------> asyrxint
(asyvec.asm)  (asy.c)                        (asy.c)
```

Fig 6—Module Relations in the original NET. EXE

```
doattach ----> asy_attach ----> ASY_INIT  (asy.c)
(main.c)        (slip.c)      | ASY_STOP  (asy.c)
                              | ASY_SPEED (asy.c)
dospeed ---------------------/
(main.c)

slipq ------> asy_start -----> ASY_OUTPUT
(slip.c) /     (slip.c)         (asy.c)
        /
doslip -----> ASY_RECV
(slip.c)      (asy.c)

[Note: Module names in capital letters indicate
the modules requiring modifications for PC-9801.]
```

Fig 7—Module Relations in the NET98. EXE

BM30N	JBM
1. Invoke Editor 2. Edit Kanji Message 3. Quit Editor	1. Invoke JBM 2. Enter "m" command 3. Input Mail content Enter "~e" command to invoke editor, if needed 4. Quit JBM
4. Invoke BM30N 5. Enter "kt" command 6. Quite BM30N	

Fig 8—Operation for writing Kanji mail

BM30N	JBM
1. Invoke BM30N 2. Enter "ks" command 3. Quit BM30N 4. Print the mail using MS-DOS TYPE command	1. Invoke JBM 2. Enter read command 3. Quit JBM

Fig 9—Operation for reading Kanji mail

As shown in Figs 7 and 8, the operability of JBM is superior to that of BM30N. Not only because the number of operation steps is smaller, but because JBM does not require the function of other programs or DOS commands.

b. Binary data transfer

BM30N has the ability to send binary data files as a byproduct of the support for Kanji mail transfer. JBM does not have this ability. The code translation in the JBM is to change the Kanji code into 7-bit data stream and it is not intended to generate 7-bit data stream from binary data. The ability to send binary files as a mail, in some cases, seems to be effective. We think JBM should have this function.

c. Compatibility to UNIX mail systems

One reason for the adoption of the 7-bit JIS code in JBM is the compatibility to the UNIX mail systems. UNIX mail systems use various Kanji codes within their systems according to their respective make. However, they usually use 7-bit JIS code for mutual communication.

We thought, in the future, the KA9Q Internet Package would be connected to some UNIX mail systems.

BM30N does not seem to have a good compatibility to the UNIX mail systems. It uses the 7-bit encoding technique provided in the KA9Q Internet Package, and generates 7-bit encoded data stream for the Kanji mail.

The comparison of BM30N and JBM shows that 7-bit JIS code seems to be better than the UUENCODED data stream as the data code used in the data transfer with SMTP. Accordingly, if JBM had the ability to send binary data using the UUENCODED technique, it would become an ideal mailer program for the Japanese user.

2. Problems of the NET98

a. Multiple serial port support

Because the NET98.EXE was made with minimal modifications, the support for the serial port is using the DOS functions and it does not allow the user to utilize the multiple serial port on the PC-9801. We think it is necessary to write a device driver for the PC-9801 serial port with the ability to handle multiple serial ports correctly.

b. Integration of the coding for PC-9801 to the Internet Package

The greatest problem of the NET98 is that coding for for the PC-9801 is not integrated in the Internet Package. This will oblige us to again port the NET.EXE each time a new version of NET.EXE is issued.

Acknowledgement

We would like to thank Akira Kaneko, JA1OGZ, Hideo Kambayashi, JH3XCU, and Kohjin Yamada, JR1EDE, for introducing the KA9Q Internet Package to Japan and for contributing to the construction of the Internet network in Japan.

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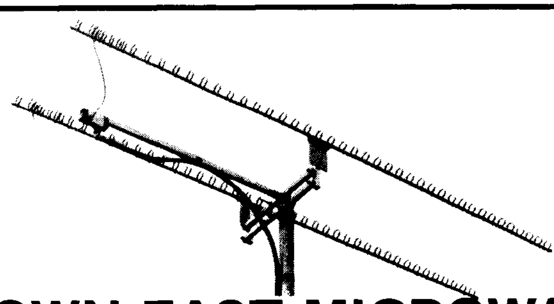

Correspondence

In his article, "Path Selection—Part 2" (Jan 1989 *QEX*), Dennis Haarsager, N7DH, describes a method of calculating the distance and bearing between two locations. Fortunately, there is an easier—much easier—way of doing it. This method uses the square grid that is on all USGS topographic maps. One doesn't have to use the cumbersome sexagesimal (degrees, minutes, seconds) number system of spherical trigonometry to calculate bearings and distances.

The square grid on USGS maps is the Universal Transverse Mercator (UTM) grid. In this system the earth's sphere is divided into 60 zones: Each zone is six degrees of longitude wide. The zones are numbered from west to east beginning at 180 degrees of west longitude. A square grid is superimposed on each zone. The grid is oriented so that it is parallel to the center line (central meridian) of each zone. In the northern hemisphere the north-south dimension of the grid has its origin (zero point) at the equator. To avoid negative numbers, the UTM east-west coordinate at the central meridian is arbitrarily made equal to 500. The units of the UTM system are kilometers.

On many USGS maps, the UTM grid is printed as thin black lines. Maps printed before 1982 or so don't have the black lines, but the position of the grid lines is shown as blue tick marks along the edges of the map. Next to the tick marks or at the end of the black lines you will find 3 or 4 digits. These are the UTM coordinates. The first one or two digits are printed in smaller type than the last two digits. Ignore the size of the type and read the coordinate as a 3 or 4 digits. Thus, a number along the right side of the map such as 5166 is the UTM north coordinate. It represents a line that is exactly 5166 kilometers north of the equator. A number along the top or bottom such as 347 is the UTM east coordinate for that zone. To find the UTM coordinates of your hilltop or other location, interpolate between the grid lines on either side and above and below the point in question. The UTM system is decimal-based, so it's quite easy to "eyeball interpolate" a 7½ minute map to an accuracy of 0.1 kilometer. For better accuracy you can use a ruler to measure the distance from a grid line to the point in question and also the distance between grid lines. Simple proportion of these numbers gives you the fraction of the value from the left or bottom reference grid lines.

Once you have determined the UTM coordinates you can calculate the distance between locations as follows: Call the UTM coordinates of location 1 E1 and N1; those of location 2 can be designated E2 and N2. The distance between the two locations is:

$$\text{Distance} = \sqrt{(E1 - E2)^2 + (N1 - N2)^2} \qquad \text{Eq 1}$$

Remember, the units of this calculation are kilometers. Multiply kilometers by 0.62 to express the results in statute miles.

To calculate the azimuth, or bearing, from one point to another, use the following equation:

$$\text{Bearing} = \arctan \frac{N2 - N1}{E2 - E1} \qquad \text{Eq 2}$$

Be careful when you use this formula, though. Your answer may be in error by 180 degrees depending upon the signs of the numbers that you use. This ambiguity is easily resolved just by looking at the map and mentally deciding which one is correct.

For highest accuracy, you will need to make a slight correction to the bearing computed using Equation 2. This is because the UTM grid is not exactly parallel to the lines of constant longitude (except at the central meridian). A diagram in the lower-left hand corner of USGS maps shows the correction that needs to be applied to your calculated bearing. With this diagram you can determine the magnitude and sign of the correction. Within the continental US this correction will never be more than 2½ degrees.

This diagram also shows the magnetic declination (compass correction) in the area covered by the map. Be sure to account for this when you use a compass to orient your antenna over a non-line-of-sight path. Also, be aware that magnetic declination is not a constant—it changes with time. In many parts of the US this change amounts to one degree or more every ten years. If you are using an old map, the declination printed on it may be several degrees different from today's value.

The UTM coordinate system can be very useful, especially when you are making calculations over short distances—say 300 miles or less. It is possible to convert UTM coordinates to latitude-longitude and vice versa. The equations are quite involved, however, and are best solved by a computer. I will furnish these equations to anyone who is willing to use them in a computer language of his choice.—*Robert E. Cowan, K5QIN, 1240 Sioux, Los Alamos, NM 87544*

Bits

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LAN SAKES

ISO/IEC 8802-3 is Ethernet's new name assigned by the Organization for Standardization and the International Radiotechnical Commission. This new international standard was adopted on February 24, 1989, and is substantially the same as IEEE/ANSI 802.3 but with different words.

Practical Spread Spectrum: An Experimental Transmitted-Reference Data Modem

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Introduction

Direct-sequence spread-spectrum systems may be classified into two broad categories: stored-reference and transmitted-reference systems. The circuits I have described so far in these columns[1,2,3,4] have all been of the stored-reference kind, in that a replica of the pseudonoise sequence used at the transmitter site was also stored at the receiver. The main problem then facing the designer was to build into the receiver a circuit which would (a) extract the clock from the transmitted signal, and (b) synchronize the two identical, but out of phase, sequences.

A radically different approach consists in transmitting simultaneously on a frequency F1 the PN sequence XORed with the data, and on a frequency F2 the PN sequence alone. If the receiver uses a second intermediate frequency (2nd IF) equal to (F1-F2), it is possible to modulo-2 add the two signals and recover the original data[5]. This approach has a major advantage: its simplicity. It also has two main drawbacks for military applications: It is easy to either jam the receiver by transmitting a carrier equal to the IF, or for unauthorized listeners to decode the signal with a very simple receiver. Neither of these problems is of concern to the radio amateur, and it was therefore decided to design a simple data link using the transmitted reference approach. The description of the circuitry used will be brief, as most of its elements have already been described in some of my previous articles. (This paper does not aim to be a "construction article," but to give enough pointers to the interested that they may decide to use this information as a starting point, and try their hands at experimenting with spread spectrum.)

Specifications

The equipment described, an experimental modem operating around 70 MHz, can transmit and receive ASCII data at rates higher than 38 kilobauds. The 70-MHz output, about 7 MHz wide, can be up-converted to 440 MHz or any other amateur band of interest.

[1]Notes appear on page 11.

General Description

Referring to Fig 1, the transmitter consists of two oscillators, one on 69.8 MHz, the other on 73 MHz. The 73-MHz carrier is also divided and used as a clock for the pseudonoise (PN) generator. The output of this PN generator is mixed in a doubly balanced mixer with the 69.8-MHz carrier to create a BPSK signal, while the same PN sequence is XORed with the data and then applied in a similar manner to the 73-MHz carrier. The resultant BPSK signals, one centered on 69.8 MHz, the other around 73 MHz, are then *summed* (not mixed) in a hybrid combiner, the output of which, in the time domain, looks like a "double hump" centered on 71.4 MHz as shown in Fig 2. This output, 6.85 MHz wide between the two first nulls, is then up-converted to the 440-450 MHz band. At the receiver, a similar 374-MHz local oscillator creates an IF centered on 71.4 MHz. This signal is split through a hybrid and applied to two identical bandpass amplifiers, one broadly tuned to 69.8 MHz, the other to 73 MHz. The outputs of these two bandpass amplifiers are then fed to the two input ports of an active doubly balanced mixer, the output of which is our baseband data. It is then filtered, amplified and regenerated through a Schmitt-trigger stage.

Transmitter Circuit

As shown in Fig 3, the transmitter consists of two identical frequency synthesizers, one functioning on 73 MHz, the other on 69.8 MHz. (Only one, the 73 MHz, is shown for simplicity.) The circuit is comprised of an MC1648 voltage-controlled oscillator tuned to the frequency of interest, an MC3396 divide-by-20 stage, and a MC145151 synthesizer chip. (The operation of this synthesizer was described in more detail in the November 1988 *AMRAD Newsletter*, Vol XV, No. 5.) The output of the MC3396 divider-by-20 stage is a clock at 3.65 MHz. This clock is buffered by four sections of U4, a 4049 hex-inverter, and used for three separate functions. After another division by two in U9B, a 7474 flip-flop, the resulting 1.825-MHz square wave clocks a 7-stage PN generator comprised of U5, a 74164 shift register, and U6, a 7486 XOR chip. This PN generator arrangement has already been described previously.[6] The PN sequence is used directly to drive the IF port of an SBL-1 passive doubly balanced mixer (only one of two shown on this diagram).

The PN sequence is also XORed with data. This data can be either an internally generated test square wave, or some external signal. The square wave is the clock divided by 100 (in U7 and U8), while the external signal is whatever is fed to the RS-232 port. Either signal, selected by S1, is then resynchronized via U9A, a 7474 flip-flop. The output of the flip-flop is then XORed with the PN sequence in U6D, which then drives the IF port of a second doubly balanced mixer (see Fig 1). This output is shown as point "A" on Fig 1.

Two separate frequency synthesizers were used so that I could easily adjust, for experimental purposes, the frequencies of the two carriers, and hence, the IF. Should the reader wish to duplicate this setup, it would be much simpler to use two straightforward crystal oscillators.

The outputs of the two doubly balanced mixers are then added in a summing network, here a TV antenna coupler/hybrid combiner (Radio Shack® part #15-1141). One could also manufacture one's own by winding a few turns of trifilar wire on a ferrite core, but the Radio Shack part is perfectly satisfactory, and comes already shielded and fitted with F connectors.

The output of the summing hybrid is centered on 71.4 MHz, and occupies a minimum bandwidth of about 6.9 MHz. As shown in Fig 1, the output of the summing hybrid feeds yet another doubly balanced mixer, wherein is mixed the 374-MHz local oscillator signal, thus heterodyning the whole band, from 67.975 to 74.825 MHz to the 440-MHz band.

Although the heterodyning and amplification process are by no means trivial, they are not novel and have already been covered in the literature. This article concentrates on the spread-

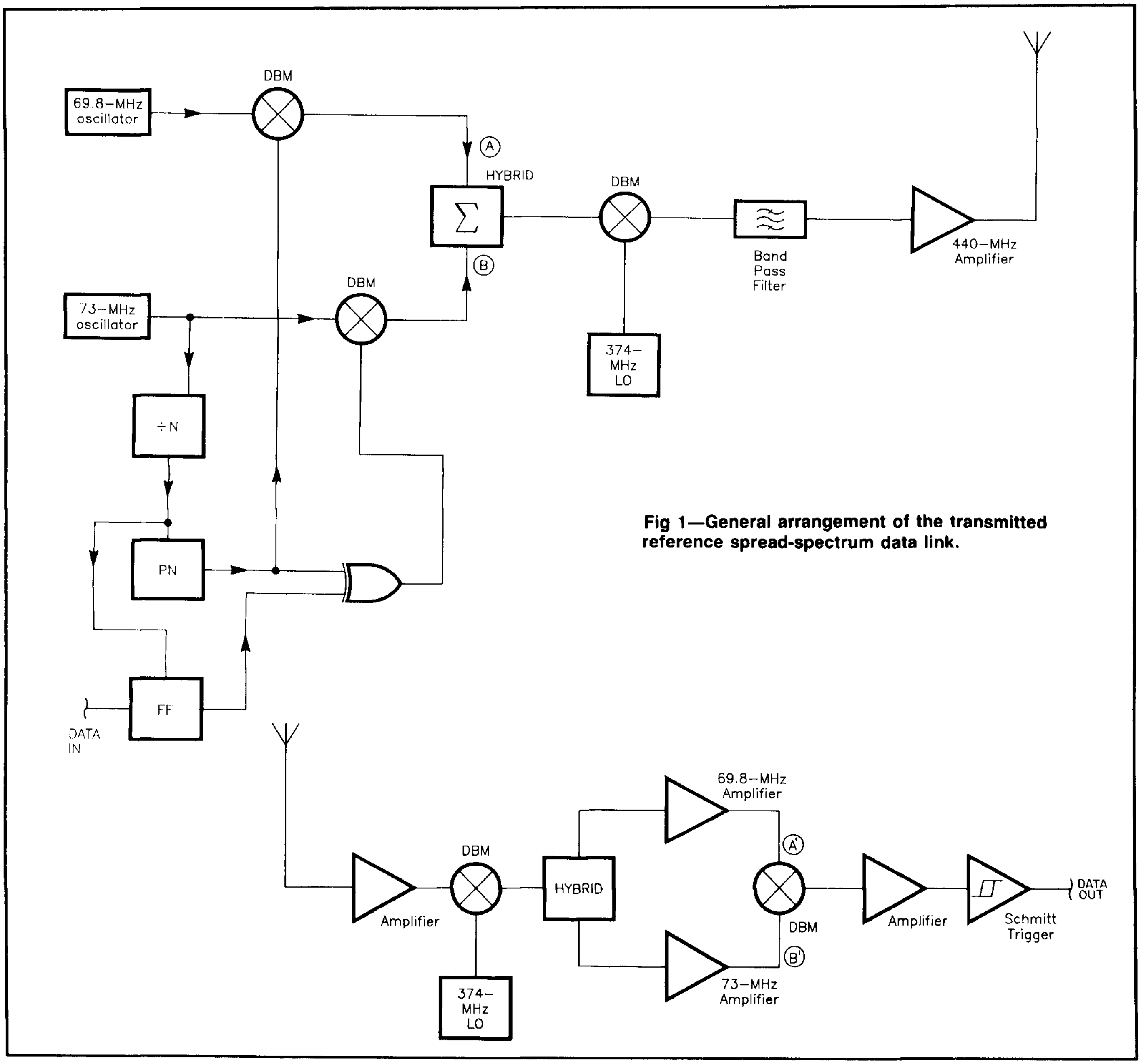


Fig 1—General arrangement of the transmitted reference spread-spectrum data link.

spectrum aspect of the project.

The Receiver

Fig 1 shows the general arrangement, while Fig 4 shows the details. After mixing with a local 374-MHz oscillator, the incoming signal is once again centered on a 71.4-MHz intermediate frequency. This signal is then split into two paths, each fed to a band pass amplifier, one centered on 69.8 MHz, the other around 73 MHz. The outputs of those two amplifiers are shown as A and B in Figs 1 and 4. These outputs are now fed to the two input ports of U101, an MC1496P active doubly balanced mixer. In the absence of an input signal at the transmitter, the two PN streams are in phase, but if data is applied, that portion of the PN sequence which corresponds to a "data high" will be inverted. (See reference 1 for additional details of a similar data recovery scheme.)

A replica of the data is thus available at the output of the MC1496P DBM. After passing through a lowpass filter, the data is amplified through U102 a CMOS op-amp, and finally regenerated through U103, a 4093 Schmitt trigger. RS-232 level conversion and buffering is then accomplished with U104, an MC1488 IC.

Operation

Testing was conducted as shown in Fig 5, with the data used being ASCII characters generated by the computer. A test program was written by Lawrence Kesteloot, N4NTL, and is available on the

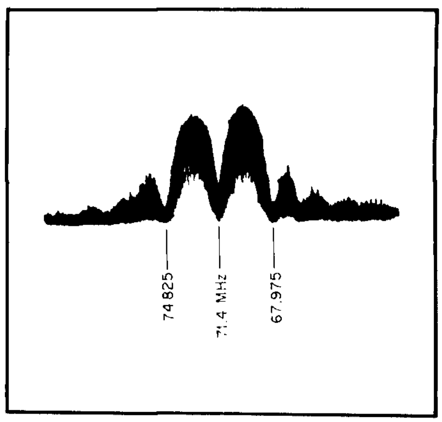
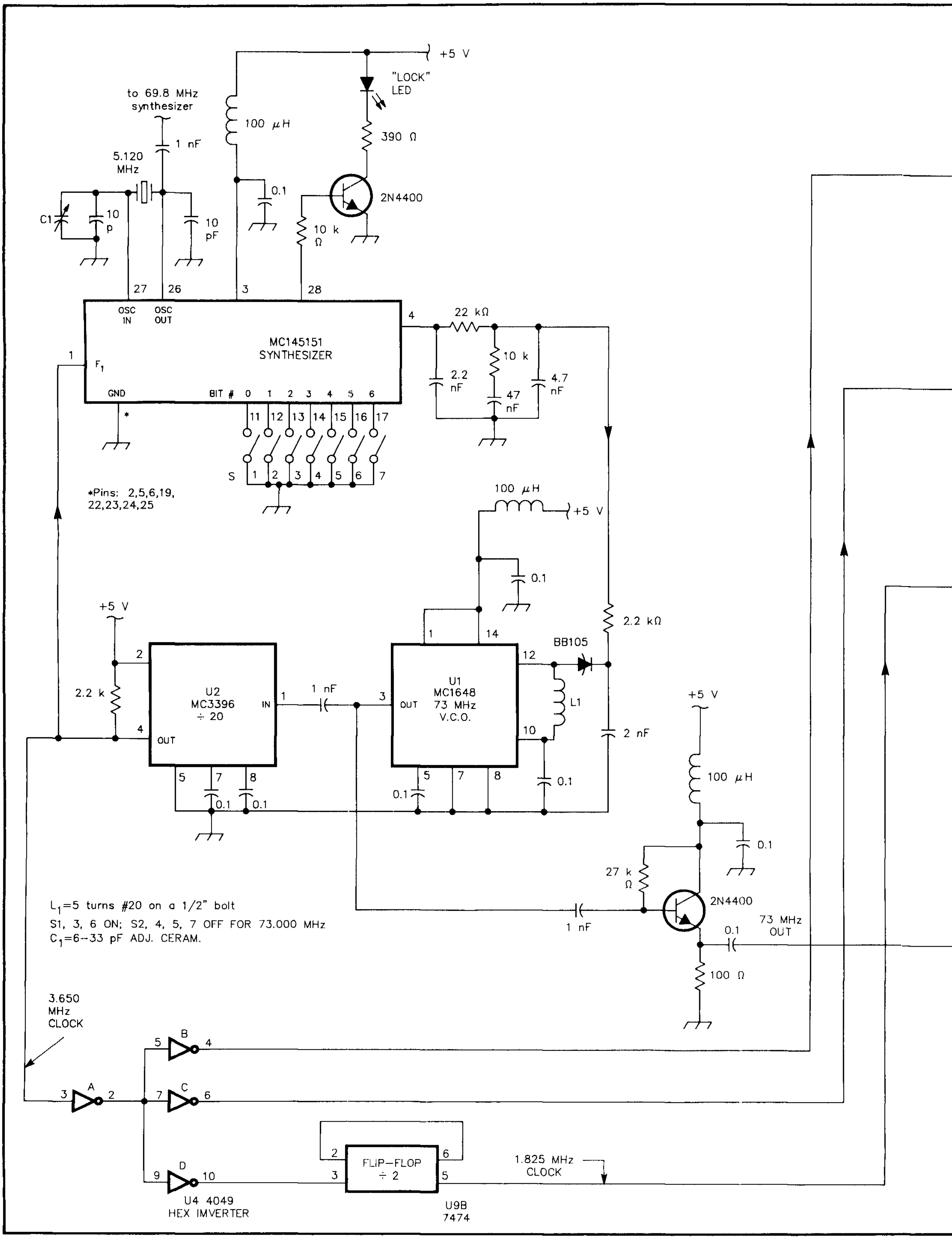


Fig 2—Output of transmitter summing hybrid.



+5 V
"LOCK"
LED
to 69.8 MHz
synthesizer
100 µH
390 Ω
1 nF
5.120
MHz
0.1
2N4400
C1
10
p
10
pF
10 k
Ω
27
26
3
28
OSC
IN
OSC
OUT
4
22 kΩ
MC145151
SYNTHESIZER
1
F_1
10 k
2.2
nF
4.7
nF
47
nF
GND
BIT # 0 1 2 3 4 5 6
11 12 13 14 15 16 17
S 1 2 3 4 5 6 7
*Pins: 2,5,6,19,
22,23,24,25
100 µH
+5 V
0.1
+5 V
2.2 kΩ
BB105
2.2 k
U2
MC3396
÷ 20
IN
OUT
1 nF
U1
MC1648
73 MHz
V.C.O.
OUT
L1
2 nF
0.1
0.1
0.1
0.1
+5 V
100 µH
0.1
27 k
Ω
2N4400
1 nF
0.1
73 MHz
OUT
100 Ω
L_1=5 turns #20 on a 1/2" bolt
S1, 3, 6 ON; S2, 4, 5, 7 OFF FOR 73.000 MHz
C_1=6--33 pF ADJ. CERAM.
3.650
MHz
CLOCK
A
B
C
D
FLIP-FLOP
÷ 2
1.825 MHz
CLOCK
U4 4049
HEX IMVERTER
U9B
7474

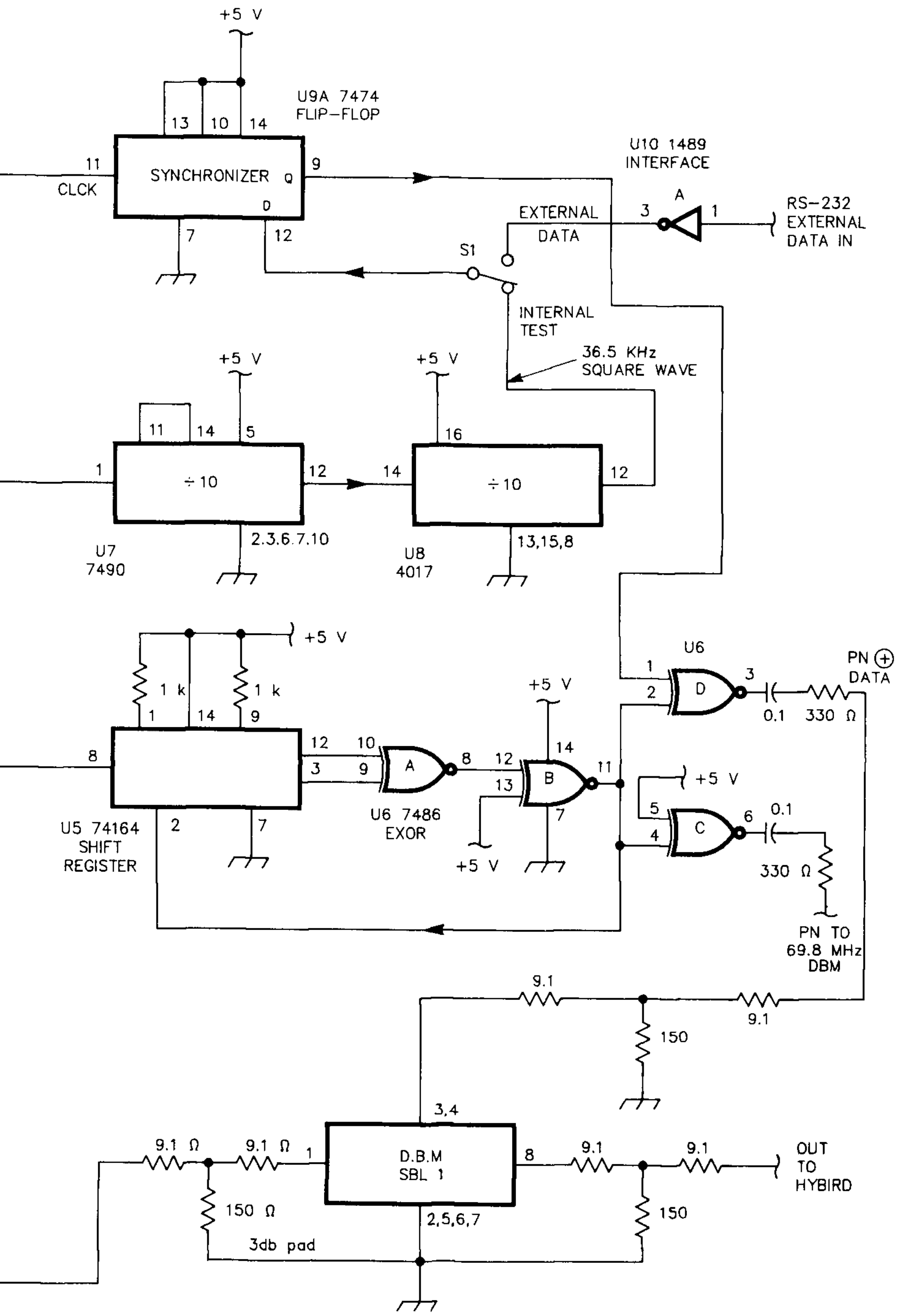


Fig 3—Transmitter circuit.

AMRAD BBS in the spread-spectrum area[7]. The program continuously sends, in ASCII format, all the letters of the alphabet, and after each letter, checks whether the letter coming back from the receiver is the same as the one just sent. The highest speed (easily) available at the RS-232 port of my IBM® clone is 38 kilobauds, and Fig 6 shows on the upper trace, the signal at the input of the transmitter, while the lower trace shows the receiver output. The two signals are essentially indistinguishable from each other, and we may infer from these preliminary results that much higher speeds are attainable. (The final version of the hardware will probably include a more sophisticated data interface, such as NRZ, etc.) At 38 kilobauds, during tests repeated over several days, the error rate was always 0 (zero) error for over 2,000,000 (two million) letters of transmitted data. This kind of error rate is due, at least in part, to the fact that this was an ideal bench setup without any interference at the IF. In a practical realization, one would obviously benefit from the addition of an LC circuit tuned to the IF of interest, at the output of U101 (between pin 12 and ground). Another circuit which would need to be added is an automatic gain control (AGC) for the IF strip, something not exactly trivial for direct sequence.

Acknowledgements

Some of the ideas implemented in this design were originally discussed with two other members of the AMRAD core group: Glenn Baumgartner, KAØESA, and Chuck Phillips, N4EZV. Their support is gratefully acknowledged.

Figures 4-6 appear on the next page.

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[1]A. Kesteloot, "Experimenting with Direct Sequence Spread Spectrum," *QEX* Dec 1966, pp 5-9.

[2]A. Kesteloot, "'Practical Spread Spectrum: A Simple Clock Synchronization Scheme," *QEX* Oct 1986, pp 4-7.

[3]A. Kesteloot, "Practical Spread Spectrum: Achieving Synchronization with the Slip-Pulse Generator," *QEX* May 1988, pp 6-11.

[4]A. Kesteloot, "A Direct Sequence Spread Spectrum UHF Link," *QST* May 1989.

[5]R. Dixon, *Spread Spectrum Systems*, (New York, Wiley) 2nd ed, 1984 pp 224-225.

[6]*The 1989 ARRL Handbook*, Bruce Hale, Ed, (ARRL, Newington, CT), 1988, Chap 21, p 12.

[7]The AMRAD BBS: 703-734-1387. (300/1200/2400 baud, 8 bits, 1 stop bit, no parity.)

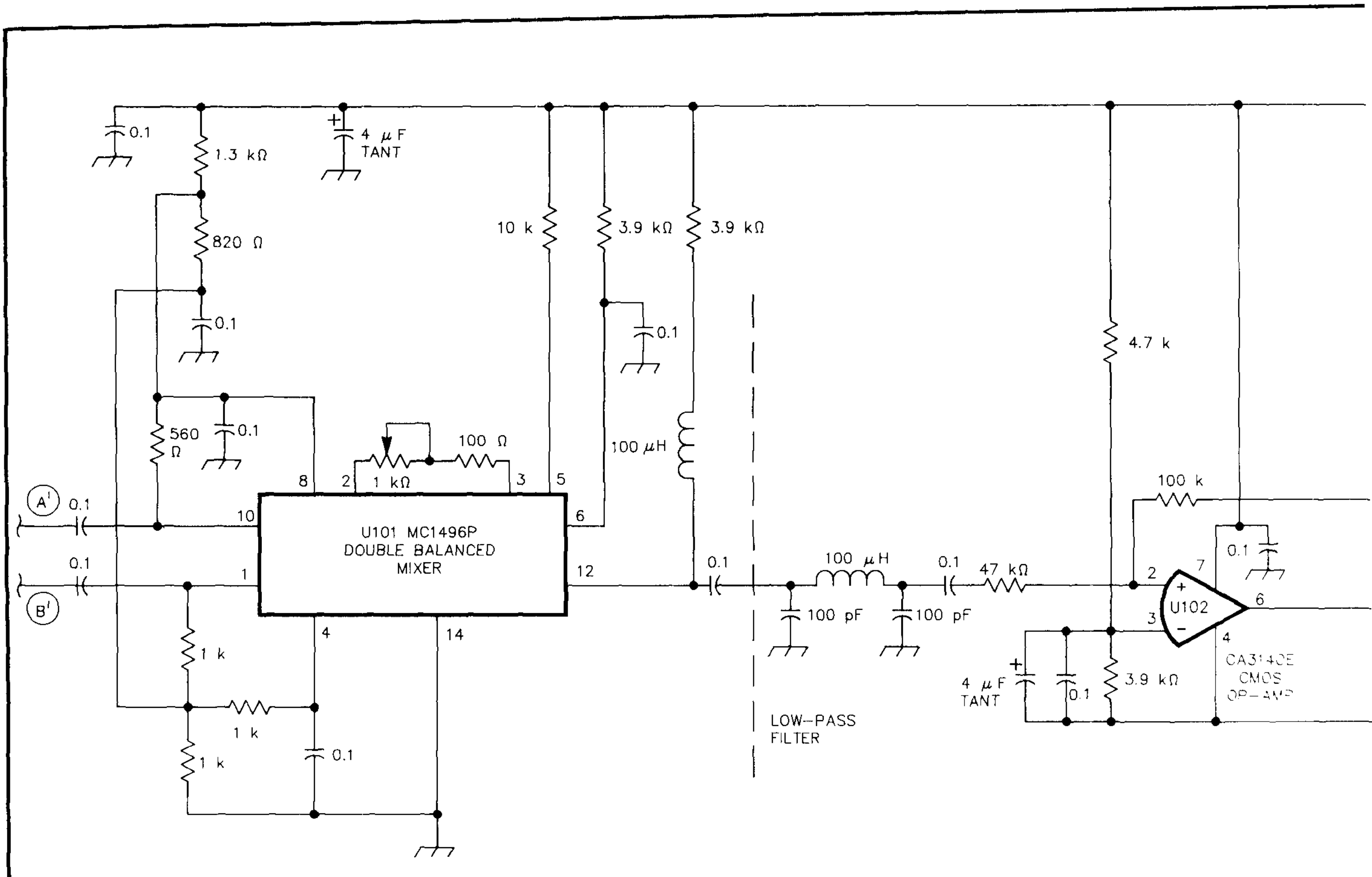


Fig 4—Demodulator circuit.

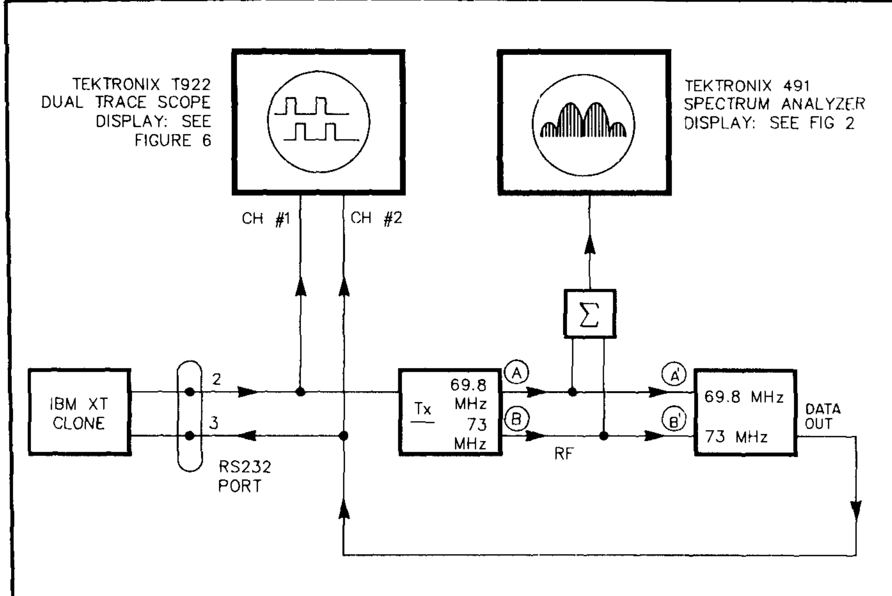


Fig 5—Test set-up transmitted reference spread-spectrum data link.

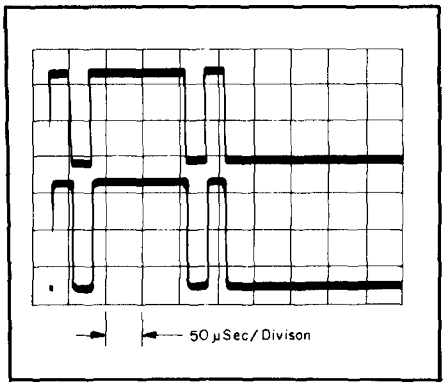
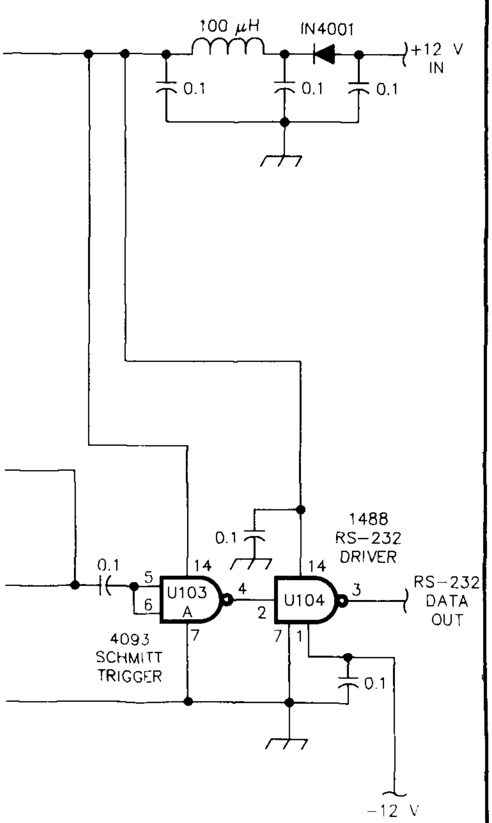


Fig 6—The letter "A" at 38 kilobauds. Upper trace is the transmitter input, lower trace is the receiver output.



Bits

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The following items are available from Project OSCAR. All are available for a donation to Project OSCAR. Donation is listed. Mailing address is: Project OSCAR, Inc, PO Box 1136, Los Altos, CA 94023-1136.

OSCAR-13 Handbook

AMSAT-UK, in association with AMSAT-DL, announces the arrival of the *OSCAR-13 Handbook*. The book is almost 60 pages and includes the following topics: history of OSCAR-13, the Ariane rocket; launch and positioning; operations; scheduling, communication, Doppler shift, time delay, typical session, band plan, operating events, user-station requirements, transmitting system, modulation modes, receiving system, antennas and polarization, typical stations; orbital predications and tracking; home computers and demodulators; satellite hardware; transponders, attitude control, beacons, Mode B, Modes L and JL, Mode S, RUDAK, frequencies, command stations; telemetry and data formats; RTTY telemetry, BPSK telemetry, telemetry decoding; information sources; reference books; the future; AMSAT organizations.

For your copy of the *OSCAR-13 Handbook* send $12 donation to OSCAR-13 Handbook, Project OSCAR, Inc.

SQUINT PLAN PROGRAM FOR PC COMPATIBLES

AMSAT-Australia announces the availability of *Squint Plan*. The program is derived from Plan-10/13 and was developed by Geoff Chapman, VK2AIT. Squint Plan is primarily a program for predicting the actual comparative azimuth, elevation and squint angles at two different locations during a particular QSO. Squint Plan has built-in utilities for updating the Keplarian elements for OSCAR-10 and 13, QTH Information, Transponder Operating Schedule and Satellite Attitude. Data can be directed to the screen or printer. Each diskette includes both the compiled program and the readable program written in Microsoft® QuickBASIC 4.0. For your copy, send a $35 donation to Squint Plan, Project OSCAR, Inc.

PLAN-13 TRACKING PROGRAM

PLAN-13 gives the user accurate azimuth and elevation information, indicates when satellite operating conditions are the best during each orbit, calculates where OSCAR is pointed during each orbit (squint angle), and gives details on when the satellite is in sunlight, twilight, or total eclipse.

Some versions of PLAN-13 include a compiled form. Each diskette includes a copy of PLAN-13 in BASIC so you can list the program and learn how it functions. Some knowledge of editing a BASIC program is required. PLAN-13 is not recommended for the first-time OSCAR users; it is aimed at the individual who has some satellite operating experience.

PLAN-13 is available on disk for the C-64®, C-128® (in the C-64 mode), TRS-80® (I/III), IBM-PC®, Apple® IIe and IIc, and for PC compatibles. All disks are 5¼ inch. C/PM or 3½-inch disks are available on special order (and additional donation). To order PLAN-13, send a minimum donation of $25 to PLAN-13, Project OSCAR, Inc. (All donations for PLAN-13 will be put back into the Amateur Satellite Program.)

AO-13 SATELLITE MUTUAL WINDOWS PROGRAM FOR C-64 AND IBM COMPATIBLES

This program provides the user with a choice of 20 different locations around the world. Then by answering the questions that appear on the screen, you can determine the length of a mutual window, along with the squint angle each station will experience.

Commodore C-64 Version: Provided on a 5¼-inch diskette in compiled form. The user will find their own QTH data in addition to Keplarian data stored on the disk. Information can be updated using utility programs provided. Output may be sent to the screen or printer.

PC Compatible Version: Provided on a 5 ¼ inch diskette in both compiled form and BASIC. All data used by the PC version is stored within the program and can be updated by modifying the proper lines of the program. Output can be sent to the screen or printer.

To order your copy, send a donation of $25 to Mutual Windows Program, Project OSCAR, Inc.

AMSAT-NA OFFERS TAPR PSK DEMODULATOR BOARDS

Thanks to a recent agreement with TAPR, OSCAR satellite enthusiasts will now be able to obtain TAPR PSK demodulator kits from AMSAT-NA Headquarters. To learn more about this kit, see *Amateur Satellite Report* Number 135 or September 1987 *QEX*. To order from AMSAT, call 301-589-6062. With many PACSATs being launched later this year, order now to avoid the last-minute rush to become operational.

>50

Focus on technology above 50 MHz

By Bill Olson, W3HQT
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Troy, ME 04987

Solid State RF Amplifier Update
Part 1: Receiving Devices

I am continually being asked what transistor is suitable for a particular application at VHF and higher frequencies, so I thought a short update of available devices would answer some questions. I will include some of my favorite circuits in upcoming issues of *QEX*. Be sure to write if you have any particular circuits you would like to see. The state-of-the-art is moving very quickly—especially at the higher frequencies, so performance is improving, old stuff ("old" meaning more than a year old in some cases!) is showing up as surplus, and in many cases prices are still going down. This column will include devices that I personally know have been used at amateur frequencies. Just because a device isn't mentioned here doesn't mean it's not usable, it just means I don't know about it or I think there's something better for that application. (eg, I won't discuss using MRF901s as receiving amplifiers at 1296 because there are devices as cheap or cheaper that work better.)

I will divide all the RF devices into two categories (a brave thing to do, I'm sure): receiving amplifiers and transmitting amplifiers. This leaves out oscillator devices which is certainly a good subject for at least one or two future columns. Receiving devices are usually selected for low noise performance, but also for dynamic range which means sometimes they need to handle some power without overloading. Transmitting devices are usually selected to generate power, but low-level stages are needed which have high gain, which means they are often the same as receiving devices. Generally, however, we know the difference between receiving and transmitting devices. Recent advances in RF wafer processing have impacted the low-noise and high-frequency markets most drastically and there are new GaAsFET receiving devices and microwave power devices showing up almost weekly. Performance in silicon is advancing quickly also, especially in the Silicon Power FET and low-noise/high-frequency areas. Advances in the development of both silicon and Gallium Arsenide MMICs has had an impact on both receiver and transmitter design.

RECEIVING DEVICES

The state of the art seems to be changing most quickly these days in the area of low noise receiving devices. This is mostly due to high volume consumer applications such as cellular telephones at 900 MHz, TVRO systems at 4 GHz and DBS satellite downlinks at 12 GHz, which have helped push the development along and bring the prices down. Performance that wasn't available 8-10 years ago at any price is now available off the shelf for a couple bucks! For the ultimate in low noise performance, there are GaAsFETs available from at least 15 manufacturers. While there are new low-noise bipolars available, their performance is comparable to even the least expensive GaAs devices for around the same price. The GaAsFETs have better dynamic range so I will only mention the small-signal bipolars as low level transmit stages next month. The MMICs have the advantage of stable, 50-Ω in, 50-Ω out performance but with noise figures that make them better suited for second and third stage receiving amps. Avantek has some new, lower noise silicon MMICs that are promising, but still don't match up to FET performance. MMIC advantages are high gain, stability, ease of construction and cascadability.

Because of the aforementioned consumer applications, just about all of the receiving devices are available in the cheap plastic packages. While the ceramic packages have less loss and therefore lower noise figure and higher gain, for many amateur applications the plastic parts are perfectly adequate. For frequencies up to at least 1296 MHz, the plastic dual-gate GaAsFETs are a real value. These devices are characterized at 900 or 1000 MHz, obviously for the cellular telephone and UHF TV tuner markets. I have used the Motorola MRF 966, NEC NE41137 and NE25137. For a buck or two any of these will provide under 1-dB noisefigure up to 450 MHz, around 1 dB at 900 and around 2 dB at 1296 MHz. I have an NE25137 on 432 MHz that measures 0.7-dB NF and over 15-dB gain. Not bad for 99 cents! Nice when the preamp gets hit by lightning, too. For lower noise in the 50 - 432 MHz region, say for EME applications, any of the C-Band devices such as the Mitsubishi MGF1302 or NEC NE72084 are about all you can use. Noise figure at these frequencies is as much a function of circuit losses as of device parameters. The two above devices are each under $10 and will both do well under 1-dB NF at 900 MHz and 1296 MHz. My favorite device in the 400 - 6000 MHz range (there are 6 ham bands in between there) is the Avantek ATF10135. Performance is a wee bit better than the 1302 at 432-1296 MHz but it really starts to shine at 2304 and 3456 MHz where noise figures of 0.6-0.8 dB and gains of 12-14 dB are possible. At 5760 MHz the 10135 will have 10-dB gain and 1-dB NF. At 10,368 MHz, my choice is the Avantek ATF13135 which can exhibit 1.5-dB NF and 10-dB gain[1]. The 10135 and 13135 are packaged in the ceramic "micro-x" package which is a fairly low loss yet inexpensive package. Avantek has recently packaged the 131 chip in their inexpensive plastic "85" package (actually it's called the 84 package which is the 85 with short leads for surface mount applications). Designated the ATF13284 and ATF13484, these devices were designed for second and third stages in DBS (Direct Broadcast Satellite) applications. The 13284 exhibits performance comparable to the 10135 at 2304 and 3456 MHz with a bit more gain and a tenth or two higher NF. Since the device was designed for use at 12 GHz it is very usable at 10 GHz and costs around 6 dollars. The 13484 is a slightly higher noise/lower gain grade out and costs around $4. These devices should be available through Avantek distributors by the time you read this. While there are many other devices available from the various manufacturers, the ones mentioned above are available in small quantities from distributors who cater to amateurs. They are low in cost, and as far as I'm concerned exhibit the best performance per dollar that's available.

MMICs

Most everyone is familiar with the Avantek "Modamp"™ (MSA) series of silicon MMICs (Monolithic Microwave Integrated Circuit)[2,3,4] sold by Avantek distributors and marketed by Minicircuits as their MAR series of amplifiers. While not nearly as low in noise as the GaAsFETs mentioned above, they are cheap, plentiful, stable and require almost no work or expertise to get running. These devices range from very low power (a couple of milliwatts) to a half watt or so and noise figures from 3 to 7 dB depending on the device and frequency.

The Avantek devices are available in many different package configurations but the plastic -04 and -85 devices are the best value. The 01, 06 and 08 chips are the most commonly used in receiving applications, the 06 being the lowest noise that is unconditionally stable. The 08 has better noise figure than the 06 at some frequencies and is capable of putting out a bit more power but is known to be unstable at times especially when cascaded. Typical noise figure and gain for these devices is shown in Table 1. While the Minicircuit MAR series of MMICs are purported to be identical to the Avantek MSA's (MAR6 = MSA0685 etc). Experience has shown that they are not the same especially at the higher frequencies. They are, however, slightly cheaper and available in a "designers kit" which includes 5 each of 7 different devices if you want to fool around with the different types.

The newest silicon MMICs on the scene are Avantek's new ISOSAT™ family of low noise devices. Designated the INA01, 02 and 03 they are presently available only in expensive hermetic packages but have very high stable gain and low noise figures compared to the MSA devices (Table 2). The devices will eventually be available in the 85 plastic package and the INA03 looks like a good bet at least through 2304 MHz with well under 4-dB NF and 20-dB gain at that frequency.

While there are numerous Gallium-Arsenide MMICs made for commercial and military users, they haven't seen much acceptance in amateur gear. The Siemens/MSC CGY series is used somewhat. These devices tend to have lower noise and at the same time higher power output capability than similar silicon devices so would seem to fit into a system that used the same device bilaterally as a receiving front end and a transmitting amplifier. The CGY40 will put out 50 mW at 3456 and has 3 dB or so noise figure. Cost is around $25.

Table 1

GaAsFETs

Frequency	*144 MHz*		*432 MHz*		*1296 MHz*		*2304 MHz*		*3456 MHz*		*10,368 GHz*	
	*NF**	*Gain**	*NF*	*Gain*	*NF*	*Gain*	*NF*	*Gain*	*NF*	*Gain*	*NF*	*Gain*
Device	*(dB)*	*(dB)*	*(dB)*	*(dB)*	*(dB)*	*(dB)*	*(dB)*	*(dB)*	*(dB)*	*(dB)*	*(dB)*	*(dB)*
RF966	0.6	20+	0.7	20+	1.5	15						
NE41137	0.7	20+	0.8	20+	2.0	12						
NE25137	0.6	20+	0.7	20+	1.5	15						
MGF1302	0.5–	20+	0.6–	20+	0.6	14	1.1	10	1.3	8		
NE72084	0.5–	20+	0.6–	20+	0.6	14	1.1	10	1.3	8	3.0	7
ATF10135	0.4	20+	0.4	20+	0.5	16	0.6	14	0.7	12	?	
ATF13135	0.6–	18	0.7	14	1.4	10						
ATF13284	0.9	15	1.0	13	1.6	9						

*Typical values in real-life circuits.

Table 2

MMICs

Frequency	*144 MHz*		*432 MHz*		*1296 MHz*		*2304 MHz*		*3456 MHz*	
	*NF**	*Gain**	*NF*	*Gain*	*NF*	*Gain*	*NF*	*Gain*	*NF*	*Gain*
Device	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)
MSA0185	5.5	20	5.6	18	6.0	14	6.5	12	7.0	8
MSA0685	2.9	20	3.0	18	3.4	14	3.8	12	4.2	8
MSA0885	3.2	32	3.3	27	3.6	20	4.2	16	5.0	12
MINA021	70	1.9	32	2.0	32	2.8	25	4.0	15	
INA03170	2.3	23	2.3	23	2.3	23	4.0	22	5.5	15

*Typical values in realizable circuits.

CONCLUSIONS

With the exception of the INA MMICs and the ATF13135, all the devices mentioned above are available for under $12 in small quantities, many for as little as $1.50. This is sure a far cry from the situation 10 or so years ago. I can remember paying close to $50 for a bipolar transistor that would do 1.5 dB at 432 MHz! At 1296, low-noise devices were available but they all seemed like they oscillated to me! Next month I will discuss power transistors in a similar manner to what I did this month. Glad to be back.

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[1]Ward, Al, WB5LUA, "Simple Low-Noise Microwave Preamplifiers," May 1989 *QST*.

[2]Ward, Al, WB5LUA and Wagner, Marcus, N5GEJ, "Nonlinear Applications using the Avantek MMICs," June 1989 *QEX*.

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