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TABLE OF CONTENTS

COLUMNS

ABOUT THE COVER

FAX is a popular communications mode in Japan because its 16-bit code easily accommodates the complex characters of the Japanese language. Yoshi Iwasaki, JA3CF, is an avid FAX enthusiast and has won many Amateur Radio awards. His most recent goal is to qualify for the special WAC award for FAX operation. Our cover features some of the QSL cards he's received while working toward that goal.

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.

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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.

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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*.

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Empirically Speaking. . .

The BK's Thorny Road to our Home

Ed Note: Ever wonder how the Soviets are doing with personal computers? The following is a condensed rough translation of A. Lyukshin's interview of Genrikh Pavlovich Morozov, Director of the Eksiton Plant, Pavlovskiy Posad, Moskovskaya Oblast, makers of the BK computer. The article appeared in Radio, *June, 1987. A summary of translations from* Radio *is courtesy of Dex Anderson, W4KM.*

Q: We're aware of the difficulties in acquiring personal computers. Will it become easier to buy them in the near future?

A: I don't think so, even though we plan to increase production of the BK-0010s significantly. Our main task is to equip schools, teachers' colleges, and technical institutes. Already there are over 1000 computer classrooms throughout the country, containing about 15,000 BK-0010s. But after all, informatics is included in the curriculum of all schools, and many more classrooms are needed. This is why it is difficult for BKs to get to the store shelves for purchase by individuals. But production of BKs may stop altogether. Effective 1 July 1987 a GOST (state standard) will take effect, dividing all personal machines (PMs) into five classes: PM1 for individual use; PM2 for students; 3 for teachers, and PM4 and PM5 for automating professional activities. Our machines are closest to class PM1 and are subject to the following requirements: word length 8-16 bits; speed >500,000 operations per second; RAM >64 kbytes. . . Neither the machine we produce today nor those we plan to produce in the near future meet these requirements. So if we are required to meet the GOST by 1 July 1987, we will have to stop producing microcomputers. Of course, the GOST is motivated by a good goal—that of bringing order to the production of PMs. Each type of machine has its own user, from school child to scientist, housewife to plant director. The GOST envisages production of various professional machines, but excludes everyday computers. But these are necessary, as proven by the demand for the BK-0010 and the publicity in your magazine about the Radio-86RK microcomputer.

Q: A big question for many users concerns programs. Everyone cannot write programs himself, but there's nowhere to buy them.

A: Producing programs has grown from a technical problem into a social one. To liquidate computer illiteracy it is necessary to give all those who wish to do so the possibility of using computers. For now, only those who are independently capable of creating programs can use everyday computers. Today we could offer users a (Riga) BASIC interpreter. Those who use PCs at work would be interested in a packet of programs for statistical analysis and graphic processing. We didn't forget about the popular computer games. A packet of 10 programs would interest many. But, having prepared a program, we cannot offer it to users. In our way are organizational, not to say bureaucratic, difficulties. Many problems evident for years have not been resolved. For example, no copyright protection exists for programs. There is no price list for programs. And, finally, the most important thing does not exist—program standards. For a long time now we've been trying to convince the comrades responsible for producing TV sets to mount a video input on each set. The signal from the computer still has to be delivered to the antenna input, and for this we make a video modulator.

Q: The editors have received complaints about the poorly prepared manual for the BK-0010.

A: In fact, the manual wasn't prepared in the best way, due to the lack of experience. A revised one will accompany computers beginning in mid-1987.

Ed Note: Isn't that a pleasant relief from all those Chicken Little articles saying our industry is falling behind the Japanese?—W4RI

A Broadband VHF Impedance Measuring Hybrid

By Wilfred N. Caron
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Conventional antenna impedance bridges are extremely useful, especially at HF and lower frequencies. Their usefulness and reliability above 30 MHz, however, are limited by undesirable reactances associated with the potentiometer employed. Even the best carbon potentiometer obtainable has undesirable reactances. To circumvent the bridge problems encountered at VHF and higher frequencies, I developed a broadband hybrid.

The unknown load impedance of a hybrid is compared with a standard reference to find the voltage standing wave ratio (SWR). The standard reference is usually a 50-Ω resistive termination. The resistance and reactance of the load are then determined by the *second-data* method.[1]

Broadband Hybrid Circuit Function

The broadband hybrid is a precision impedance comparator that incorporates a frequency insensitive, symmetrical RF bridge circuit with a detector. Using this arrangement, the SWR of an antenna is determined rapidly and accurately over a wide frequency range. My hybrid is optimized for operation at 50 Ω impedance, but it can be used at any standard coaxial impedance. The hybrid's symmetry makes this flexibility possible.

In Fig 1A, Z_1 and Z_2 are two legs of the symmetrical hybrid circuit, formed by the broadband input balun. The other two legs are formed by two identical resistors, R_1 and R_2. When $Z_1 = Z_2$ and $R_1 = R_2$, the output at the detector port is zero (assuming a perfectly symmetrical hybrid). This circuit is shown in Fig 1B and resembles a balanced four-port unsymmetrical 180-degree hybrid. When a standard impedance reference is connected to port B, and an unknown impedance is connected to port C, the transfer of RF through the hybrid from port A to port D is directly proportional to the complex reflection coefficient (ρ) of the unknown impedance with respect to the standard impedance reference. Thus, a measurement of ρ, and hence SWR, is obtained by measuring the transfer characteristics of the hybrid. This opera-

[1]Notes appear on page 11.

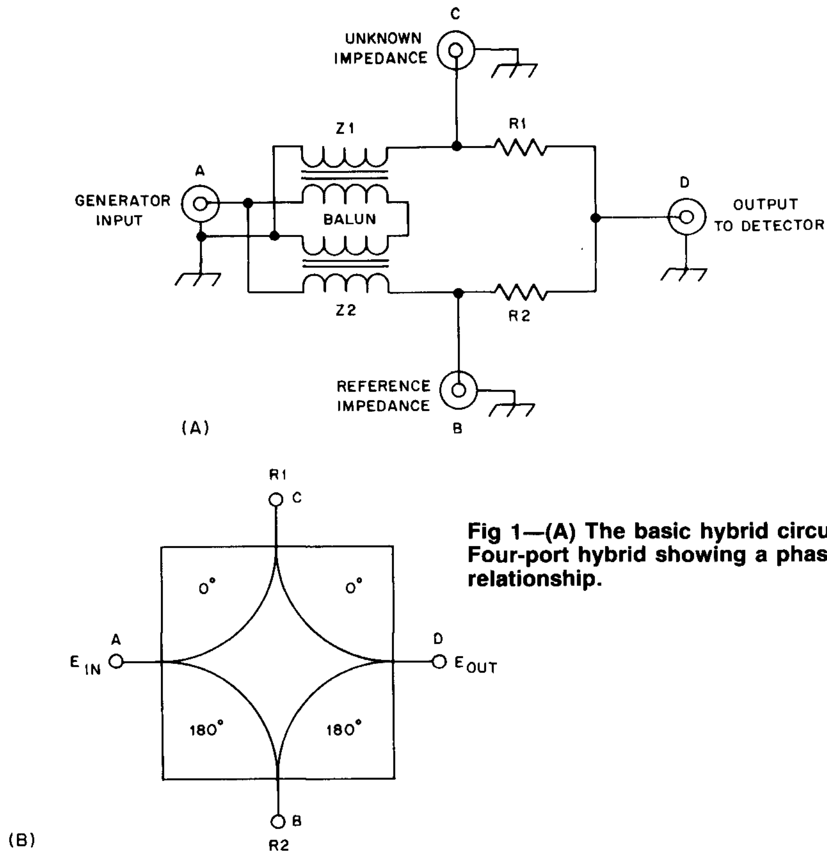

Fig 1—(A) The basic hybrid circuit. (B) Four-port hybrid showing a phase relationship.

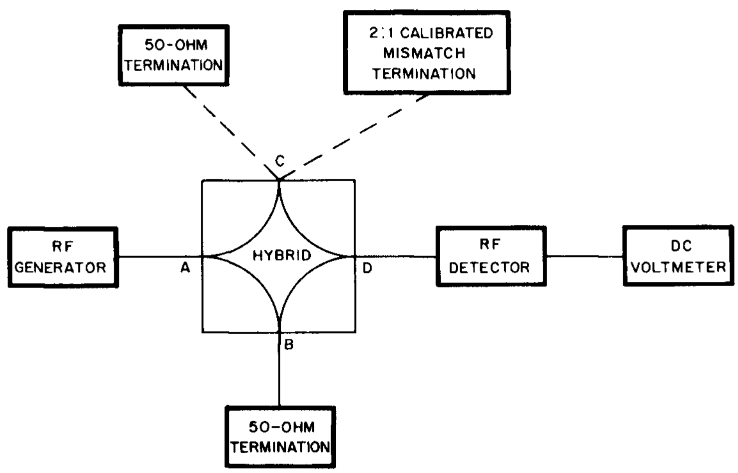

Fig 2—Hybrid calibration set up.

TEST DATA SHEET

Antenna Type: FOLDED "J"   Date: 5-5-87

Special Test Equipment: 2.0:1 mismatch, 27-ohm series resistor adapter

	LOAD ONLY			Reactance	LOAD PLUS 27 OHMS			LOAD IMPEDANCE	REMARKS
Freq	E_{unk}	E_{mm}	SWR	(+) (-)	E_{unk}	E_{mm}	SWR	R ± jX	
50.55	0.46V	0.132V	4.29	—	0.13V	0.132V	1.99	16.5 - j32	
	Measured data	Measured data	Calculated using Equation 5	Sign obtained by affect of C_3	Measured data	Obtained from load only data	Calculated using Equation 5	From Smith chart	

Fig 3—Test data sheet.

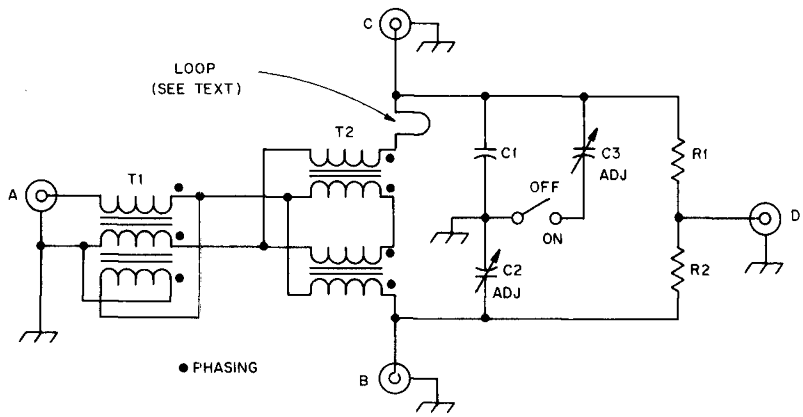

Fig 4—Schematic of a practical hybrid.
C1—10 pF capacitor.
C2, C3—5- to 20-pF capacitors.
R1, R2—matched 50-Ω resistors, ¼ W.
S1—Momentary on, normally open switch.
T1—1:1 balun.
T2—4:1 balun.

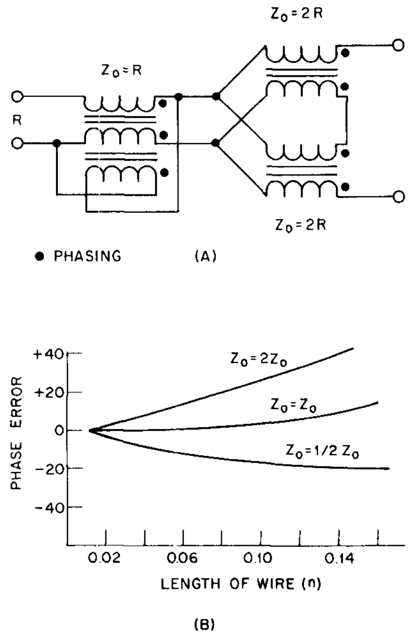

Fig 5—Pitzalis' balun coil winding data.

tion can be expressed mathematically as:

$$E_{out} = KE^2_{in} |\rho|^2 \quad \text{(Eq 1)}$$

where

E_{out} = detector output voltage
E_{in} = generator voltage
K = detector constant
ρ = reflection coefficient of the load impedance

Eq 1 may be rewritten to give the reflection coefficient in terms of SWR. Since

$$|\rho| = \frac{SWR - 1}{SWR + 1} \quad \text{(Eq 2)}$$

then

$$E_{out} = KE^2_{in} \left|\frac{SWR - 1}{SWR + 1}\right|^2 \quad \text{(Eq 3)}$$

K and E_{in} remain unknown. Therefore, a method must be found to measure an unknown, the SWR, through other unknowns, K and E_{in}. This problem is circumvented by the use of a known mismatch in the measurement process.

Use of A Known Mismatch to Determine An Unknown SWR

This procedure measures an unknown SWR for values up to 6.0:1, based on any known calibrated mismatch (MM_c), and you don't have to rely on KE^2_{in}. The hybrid is set up as shown in Fig 2. A calibrated 50-Ω resistive termination is connected to port B, and the calibrated mismatch termination (MM_c = 2.0:1) is connected to port C. The detector output voltage (E_{mm}) is recorded on a test data sheet similar to that in Fig 3. Without disturbing the hybrid set up, remove the mismatch termination and connect the load to be measured to port C. Next, record the detector output voltage (E_{unk}).

The SWR of the unknown impedance for the condition, MM_c = 2.0:1 SWR is:

$$SWR = \frac{3 + \sqrt{\frac{E_{unk}}{E_{mm}}}}{3 - \sqrt{\frac{E_{unk}}{E_{mm}}}} \quad \text{(Eq 4)}$$

To determine the SWR of the unknown impedance with any values of calibrated mismatch (MM_c):

$$SWR = \frac{\left|\frac{MM_c + 1}{MM_c - 1}\right| + \sqrt{\frac{E_{unk}}{E_{mm}}}}{\left|\frac{MM_c + 1}{MM_c - 1}\right| - \sqrt{\frac{E_{unk}}{E_{mm}}}} \quad \text{(Eq 5)}$$

For example, the calibrated mismatch is 2.0:1. E_{mm}, the measured voltage, equals 5.0 V, and E_{unk} is 2.7 V:

$$SWR = \frac{\left|\frac{2.0 + 1}{2.0 - 1}\right| + \sqrt{\frac{2.7}{5.0}}}{\left|\frac{2.0 + 1}{2.0 - 1}\right| - \sqrt{\frac{2.7}{5.0}}} = \frac{3.0 + \sqrt{0.54}}{3.0 - \sqrt{0.54}} = \frac{3.7348}{2.2651} = 1.65 \quad \text{(Eq 6)}$$

The SWR of the unknown impedance is 1.65:1.

A Practical VHF Hybrid

Fig 4 shows the schematic of the VHF hybrid circuit. It is not complicated, but it differs from the Wheatstone bridge in that it does not require a null (resonance), variable capacitor, or potentiometer for accurate impedance measurements. Instead, the hybrid compares voltage ratios. If reasonable care is exercised in the layout, construction, and symmetry of the hybrid, reliable performance is obtained well into the UHF range. The current design objective, however, is to provide a hybrid that operates from 25 to 150 MHz.

My VHF hybrid operates satisfactorily to 3.0 MHz. The highest frequency of operation is limited by the tolerable phase error. Phase error is a function of the winding length of the bifilar wires forming the balun coils. Fig 5 shows a solution offered by Pitzalis.[2] His definition for wire length is:

Maximum length in inches

$$= \frac{7200\ n}{F} \qquad \text{(Eq 7)}$$

where

n = a fractional wavelength determined by the amount of allowable phase error (Fig 5B)

F = maximum frequency of operation in MHz

The Hybrid Baluns

The output of a signal generator is fed to two baluns connected in series. The first is a 1:1 balun, and it is used with a 4:1 binocular balun to improve the balance between the two input legs of the hybrid and to ground. Construction details for the baluns are shown in Fig 6. Completed baluns are mounted to a PC board for rigidity as shown in Fig 7.

Four criteria are important to the design of a hybrid balun transformer:

1) Balun assembly must consist of three single-ended ports: port A for the signal generator, and ports B and C for the load and reference.

2) The balun must offer a match between the input port and the symmetrically balanced ports B and C.

3) The balun must maintain a differential phase of 180 degrees across the symmetrically balanced ports B and C (see Fig 1B).

4) The balun must introduce a minimal amount of loss.

Baluns that are designed similar to transmission line transformers have a low-frequency cutoff determined by the fall off of primary reactance as frequency is decreased. This reactance is determined by the series inductance of the transmission line conductors. This is not a problem with the hybrid transformer design. The residual SWR of the hybrid increased to only 1.07:1 at about 3.0 MHz as indicated in the curve shown in Fig 8. As mentioned earlier, high-frequency performance is enhanced by minimizing the physical length of the transmission line. Minimizing overall length while maintaining suitable reactance is accomplished by using high-permeability ferrite core material such as Amidon Associates material no. 61, which has a permeability of 125.

The Hybrid Circuit

With reference to Fig 4, the hybrid is fed by a generator connected to port A. When legs B and C are opposite in phase and equal in power division, a zero voltage condition is present at detector port D. As with all broadband trans-

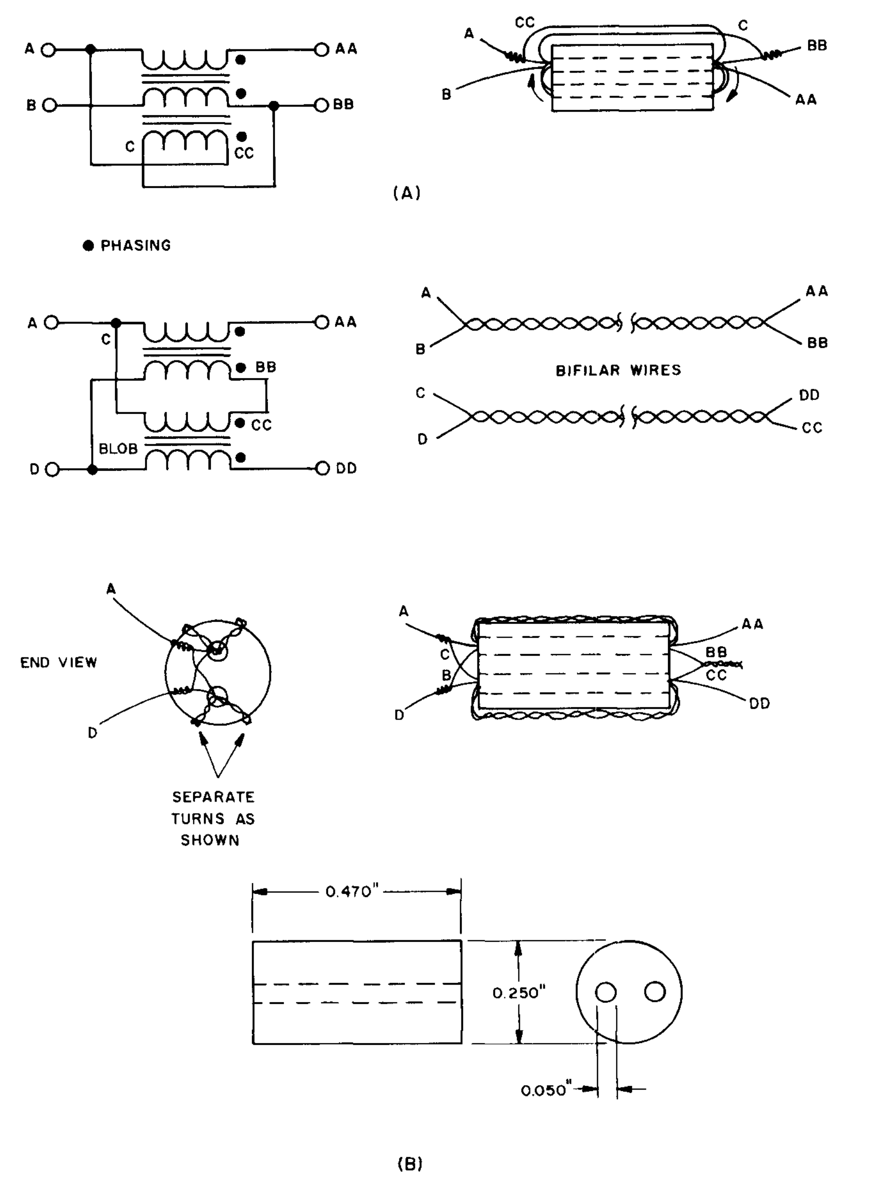

Fig 6—Balun construction details. (A) Details for winding a 1:1 balun. Wind three turns of no. 30 AWG enam wire (each pass through the core constitutes one turn). Pull the wires tight after winding. The pigtails of the C-CC winding are external to the core. (B) A 4:1 binocular balun winding. Wind three turns of twisted no. 30 AWG enam wire (four complete turns per inch; each pass through the core constitutes one turn). Pull the wires tight after winding and separate the turns as indicated to increase effective inductance. Maintain symmetry. I used an Amidon Associates Wideband binocular two-hole balun core (BLN-61-1702) with a permeability of 125.

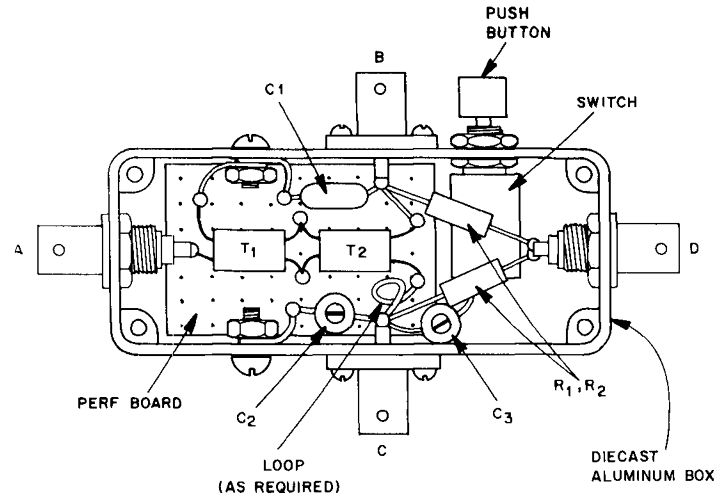

Fig 7—Hybrid layout details.

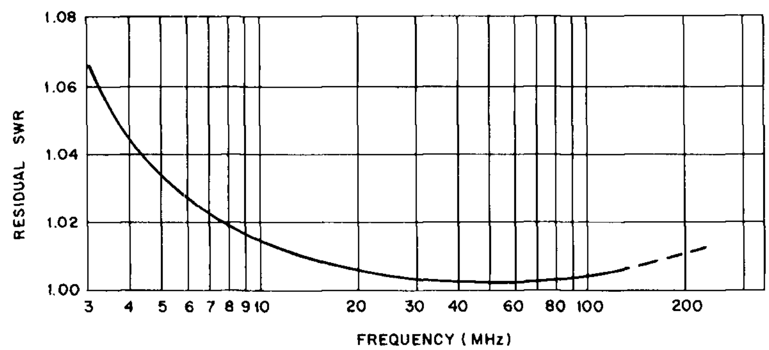

Fig 8—Curve of residual SWR versus frequency.

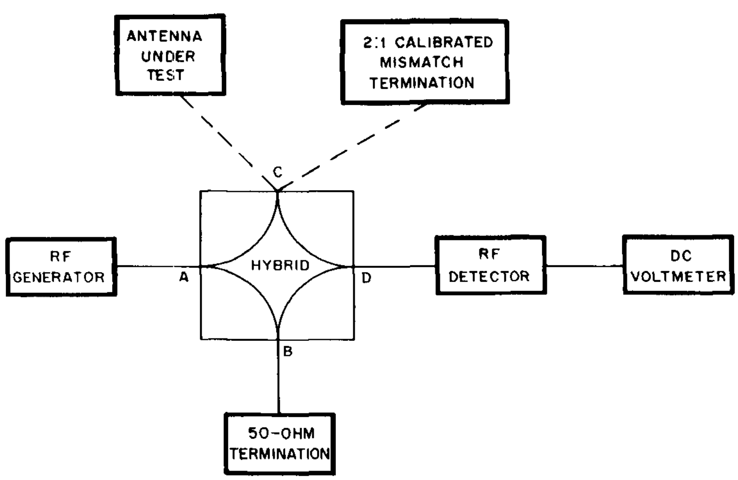

Fig 9—Test setup for antenna measurements.

formers, the coil has an inherent unbalanced inductance that must be capacitor-corrected. C2, the trim capacitor, is adjusted to optimize the differential phase shift across the symmetrically balanced ports. This is performed at the highest frequency. The trim capacitor is internal and no further adjustment is required once it is set. The residual SWR curve (Fig 8) indicates that, once set, balance is maintained over a wide range of frequency. The slight rise in SWR towards the lower frequency end suggests that the balun is slowly running out of inductance.

C3, another trim capacitor, connects to the hybrid's load arm to determine if the load impedance is inductive or capacitive. C3's function is discussed in a later section.

Hybrid Calibration Procedure

Calibrating the hybrid is not difficult. The calibration set up is shown in Fig 2. It is essential that the generator provide sufficient power and/or the dc voltmeter is capable of measuring low levels of dc volts well into the millivolt range. I used a James Millen type 90651A grid dip meter as the generator. For the 25 to 60 and 60 to 150 MHz frequency ranges, a one-turn link coupled the grid dipper to the hybrid. A ten-turn link was used for the 2.9 to 7.5, 6.4 to 16 and 13 to 32 MHz frequency ranges. To compensate for the low grid dip meter power output, a Hewlett Packard 414A autovoltmeter was used as the dc voltmeter. This voltmeter has a 0 to 5 mV scale, which made it convenient for measuring the extremely low levels of dc when the hybrid is properly balanced.

An RF detector that has a flat output response across the frequency range of interest is also necessary for proper calibration. My RF detector was a Wide Band Engineering Co model A33DU.[3] Its response has a flatness of ±0.5 dB between 1 and 900 MHz. Wide Band Engineering 50-Ω matched loads (model A56T50BU), and a Wide Band Engineering 2:1 calibrated mismatch termination was also used.

To properly calibrate the hybrid, set up the equipment as shown in Fig 2. Set the RF generator to the highest design frequency, and the voltmeter to the lowest readable voltage scale. Carefully adjust C2 for minimum voltmeter response. Log this voltage reading as E_{unk} on your test data sheet.

Next, remove the 50-Ω termination from port C and install the 2:1 or other calibrated mismatch termination in its place. Be careful not to disturb the test set up or generator output. Adjust the voltmeter to obtain a readable dc voltage, and log this reading as E_{mm}.

Use Eqs 4 or 5 to find the residual SWR level and the setting for C2. If the residual

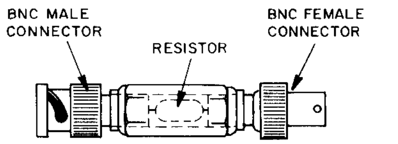

Fig 10—BNC connector-resistor assembly. Drill out 19/64 inch of a connector barrel. Press fit or solder it to the other connectors. The male and female BNC connectors are available from Radio Shack (RS 278-103 and RS 278-113, respectively). A 27 Ω, ½ W, non-inductive resistor is used.

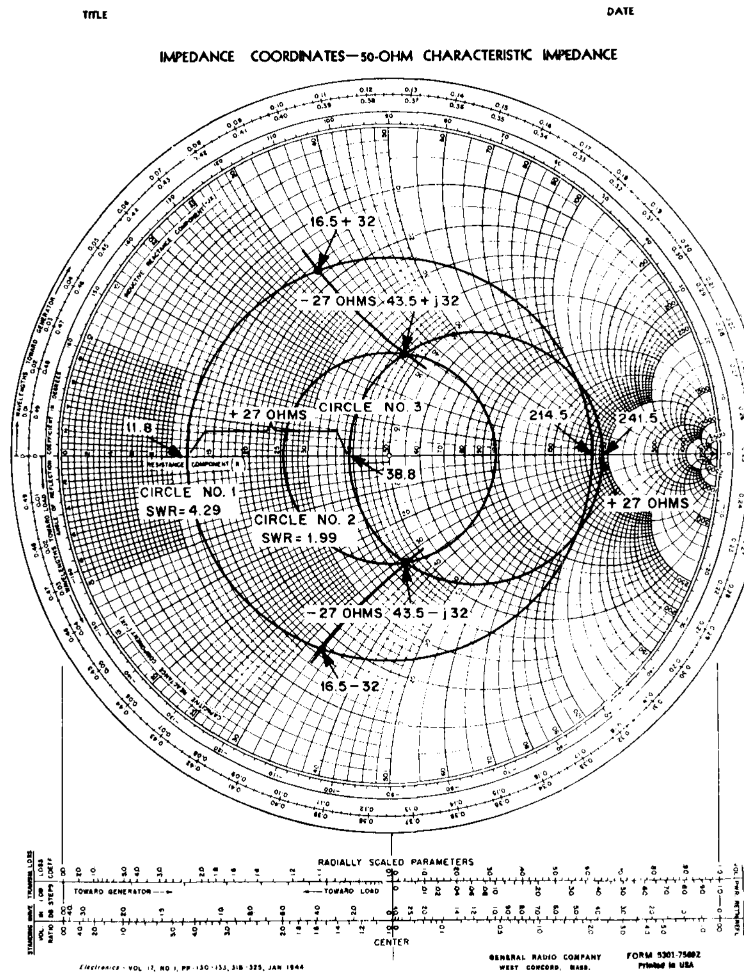

Fig 11—Resistance and reactance values are plotted on a Smith Chart using information obtained by the second-data method.

SWR appears greater than that shown in Fig 8, the hybrid needs further compensation.

Insert a small ½-inch wire loop between the balun lead and port C as shown in Fig 4, and repeat steps 3 to 6. If the residual SWR worsens, the loop may be too large or it should be in the port B leg of the hybrid. If the residual SWR is better, the loop is in the correct leg and may only require additional adjustment (larger or smaller loop). Optimum balance is achieved when E_{unk} = 0 V.

Balance of the hybrid is complete. If a calibration curve such as that shown in Fig 8 is required, measure E_{unk} and E_{mm} at other frequencies. Do *not* adjust C2 unless changes are made to the hybrid; C2 is adjusted at the highest frequency of operation *only* and remains untouched once the balancing procedure is completed.

Impedance Measurement Procedure—SWR

The procedure for measuring impedance is similar to the hybrid calibration procedure. The noted difference is that the item under test, usually an antenna, is used instead of the 50-Ω termination. This procedure provides only the magnitude of the impedance (SWR). The complex impedance of the unknown load (R ±*j*X) is determined by the second-data method (described in a subsequent section).

The antenna impedance measurement (SWR) procedure is performed by arranging the equipment as shown in Fig 9. Connect the antenna to port C of the hybrid, and set the RF generator to the desired frequency. Adjust the voltmeter to obtain the voltage level E_{unk}, and record this value on the test data sheet. Disconnect the antenna from port C and connect the 2.0:1 calibrated mismatch to port C.

Now adjust the voltmeter to obtain the voltage level E_{mm}, and record this value on the test data sheet. Repeat steps 1 through 8 for other test frequencies. Use Eq 4 to obtain the resultant SWR, and record it on the test data sheet.

Impedance Measurement Procedure—Complex

It is more involved to determine the complex impedance of an unknown load because the complex impedance includes resistance and reactance (inductance or capacitance). The second-data method helps determine these unknown values with the use of two additional components: A resistor, usually 27 Ω, is placed in series with the unknown load, and a small capacitor is momentarily placed in shunt with the unknown load. The capacitor determines if the reactance of the unknown load is inductive or capacitive. Only a small amount of capacitance is required. C3 is adjusted to provide a small amount of shunt capacitive reactance to the unknown load.

While performing this test, we need to note if a small voltmeter deflection occurs when C3 is inserted in the circuit. If a lower voltmeter deflection is noted, the reactance of the unknown load is inductive. Conversely, if the voltmeter deflection is greater, the unknown load is capacitive. For this measurement, write a minus sign (to denote capacitive reactance), or a positive sign (to denote inductive reactance) on the test data sheet.

The capacitor is an integral component of the hybrid assembly (Figs 4 and 7), whereas, the 27-Ω series resistor is an integral part of a coaxial assembly comprising of a male and female connector. This assembly is shown in Fig 10.

Second-Data Method For Determining Complex Impedance

Fig 11 helps describe how the second-data method determines the complex impedance. A test data sheet and a Smith Chart with a 50-Ω characteristic impedance are provided as an aid in visualizing the computation process.

Continued on page 11.

Facsimile in Japan

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Although RTTY is a popular mode of transmitting characters in the western world, it is less popular in Japan. The Japanese language is made up of many complex characters called *kanji*. These characters, of which there are between three and four thousand, are not compatible with the code used in RTTY operation. Kanji, on the other hand, makes FAX a more convenient form of communication for the Japanese business community.

New Directions for FAX Communications

In 1970, a small group of Amateur Radio operators gained recognition for their construction of a weather FAX receiving system. This method of FAX reception never became popular, however, because of the difficult mechanical construction method involved.

In 1977, Japanese amateurs were the first in the world to be granted FAX privileges. At first, only a small number of hams operated this mode. Those that did generally used commercial machines available from manufacturers of Amateur Radio equipment.

In 1980, used business FAX machines began to appear on the surplus market at a reasonable price. Those operators interested in FAX operation acquired the machines and modified them for amateur use. This was the beginning of Japan's FAX boom.

As modifications were successfully performed on the surplus units, the changes were documented and published in *CQ Ham Radio*, Japan's largest Amateur Radio magazine. (Japan's *CQ Ham Radio* is not the same *CQ* sold in the US.) Many "construction-oriented" hams responded favorably to the appearance of FAX articles. A number of operators, especially those who were licensed for many years, were familiar with building their own equipment; they were dissatisfied with the highly technical modern equipment because those units could not be easily duplicated or modified. This time the builders warmed up their soldering irons to perform modifications on the FAX machines. Even if their project ran amuck, it wouldn't hurt their pocketbooks much.

System Goals

The criteria for modifying the FAX machines were:

1) To maintain the original functions of the machine, while allowing operation on amateur frequencies.
2) To allow reception of weather and news FAX.
3) To use simple modifications and a minimum number of parts.

Based on these criteria, the group developed the following specifications:

1) Modulation type: SCFM (subcarrier frequency modulation)
2) Sync frequency: 1500 Hz
3) Black line frequency: 1500 Hz
4) White line frequency: 2300 Hz
5) Index of cooperation: 265 to 295
6) Drum speed: 120 r/min (240 or 260)

These specifications frequently vary from country to country. European hams, for example, use 2300 Hz for a sync frequency. Their other FAX specifications, however, are identical to those in Japan and account for the many successful contacts that have taken place between Europeans and JAs.

Frequencies commonly used for FAX operation are 3.5, 14.24, 21.34 and 28.69 MHz. Hams who did early experiments with FAX strived to improve the quality of sent and received pictures rather than to increase the number of contacts. Often, these hams would compete for picture fidelity by sending photographs that contained many grey tones. Once they had completed the modifications and were satisfied with the results, their interests moved to computers and packet radio. About the same time, HF conditions became less favorable for DXing. As a result, FAX activities waned.

Mini-FAX Enters the Scene

About two years ago, a large number of mini-FAX machines (Fig 1) manufactured by the Nippon Telegraph Telephony Co (NTT) appeared in the consumer marketplace. Despite the small size of the unit, it provides good performance. In addition, the units were sold for as little as $70.

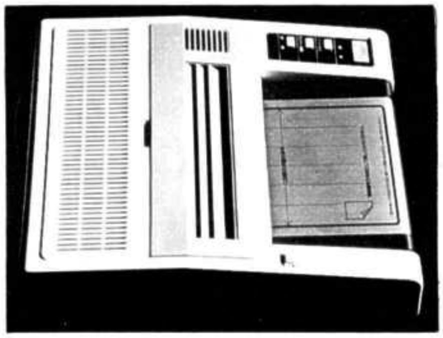

Fig 1—The mini-FAX machine is popular in Japan and has been modified by many to operate on the Amateur Radio bands.

With over 20,000 units purchased by Amateur Radio operators alone, the mini-FAX machines soon adapted AM-PM-VSB (vestigial sideband) and AM-DSB (double sideband) modulation methods. Changing the units to SCFM proved difficult, so the original modulation scheme was not changed for operation on 430 MHz and 1.2 GHz.

Modifying a mini-FAX machine is easy. An external adapter can be installed or the modifications can be made inside the unit. Once the FAX machine is modified, the audio output of the receiver is connected to the unit. Adjustment of the mic gain control is necessary before transmissions commence.

One of the biggest reasons why FAX is popular in Japan is because it can be received automatically—no station operator need be present. FAX units can be used like telephone answering machines. The receiver is left on, and the audio output is connected to the mini-FAX unit. An incoming FAX signal automatically turns on the FAX machine and shuts it off after the signal has been received. If the digital code squelch on your mini-FAX station is set for the access code of your club or group, bulletins or schematic diagrams can be received without your being present.

One group is using a mini-FAX

machine as a bulletin board system. This idea was conceived by Tomoichi Isa, JR6DJ. Between two and six bulletins (or pictures) are entered consecutively at the host FAX machine. The FAX machine and a DTMF decoder are then connected to the host transceiver. Any station with a transceiver, a DTMF encoder and a mini-FAX unit can access the host station and receive the text. Transmission is automatically terminated when all bulletins are sent. Club news and other items of interest are sent to club members using this system.

Communications Trends

The activities I have spoken of use FAX machines only. Personal computers are quickly becoming popular for receiving and transmitting FAX. Many hams are using PCs for such communication purposes. A few commercial units designed for this type of operation are already being sold by manufacturers of Amateur Radio equipment. As personal computers become more powerful, an increase in this type of FAX operation is eminent.

One of the latest communications trends in Japan is acquiring a video signal at TTL levels. The signal is extracted and processed by PCs for viewing. Such a signal is available from newer digital FAX machines, such as the mini-FAX and G3. This is much like an image scanner, and the idea is purely Amateur Radio style!

Personal Experiences

In this article I have focused on the use of FAX and its hardware in Japan. Now, I'll tell you about my FAX operation. In Fig 2, I am seated at my station. It is equipped for the kind of operating I enjoy. The mini-FAX machine that I use is the PANAFAX 1000. It sits to the left of my 2-m hand-held transceiver on the second shelf from the top. My other FAX machine is the NEFAX 1000SB, occupying the space to the right on the top shelf.

Fig 2—The author sits among his well-equipped station. He is active on the HF bands using FAX. Some of his QSL cards are shown on this month's cover.

On the HF bands, I have completed two-way FAX contacts with 16 countries. I operate on 14, 21 and 28 MHz and also use the AO-10 and FO-12 amateur satellites.

I am presently working toward a special WAC award for FAX. In Africa and South America, operation of FAX machines for Amateur Radio purposes is very rare. Rumors abound that hams in those continents are interested in FAX, but equipment is unavailable. In this respect, I feel very fortunate to live in Japan, where equipment is widely available.

In the near future, I believe we will see FAX machines designed with the amateur in mind. Communications using digital modes, as well as video, will be spread to hams throughout the world. In other developments, the techniques presently used with SSTV and FAX may be combined. We should anticipate future technological developments and be thankful for those we have today.

Feedback

There are a couple of errors in the Dodd/Lloyd article, "Measurement of Antenna Impedance," (Nov 1987 *QEX*, p 6). Table 4 is a duplicate of Table 1 and can be deleted. In Fig 8B, the caption that reads E = 76 should be C = 76. In the TOMSMALL program, line 270 should read:

270 IF X >= 0 THEN GOTO 350

A "+" will now appear in front of the result if the reactance is inductive.—*Peter Dodd, G3LDO, 37 The Ridings, East Preston, West Sussex BN16 2TW England, United Kingdom*

Bits

Call For Papers

AMSAT-UK and UoSAT are requesting submission of papers for their Third Annual Space Colloquium, to be held at the University of Surrey (UK), 29-31 July 1988. Proceedings of the Colloquium will be published by AMSAT-UK, and authors are encouraged to submit papers on all aspects of the Amateur Satellite Program. The Colloquium will feature both a technical session and an operational session, so a broad range of papers is needed. Suggested topics include:

- Operation through OSCAR and RS satellites
- Scientific, engineering and educational uses of the UoSAT satellites
- Amateur digital communications via satellites
- Design and construction of amateur satellites
- Novel ground station hardware, software and techniques.

Papers must be received *no later than 2 May 1988* to be considered for publication and/or presentation. Send papers to Dr Martin Sweeting, UoSAT Spacecraft Engineering Research Unit, University of Surrey, Guildford, Surrey GU2 5XH, United Kingdom.—*Tnx Vern Riportella, WA2LQQ, President AMSAT-NA*

Index to *QEX* Issues 61-72

(All dates 1987 unless otherwise noted.)

Antennas and Transmission Lines

Computers

Editorials (Rinaldo)

Educational

Intellectual Properties (Conwell)

Miscellaneous

New Products

A Broadband VHF Impedance Measuring Hybrid

Continued from page 7.

The SWR for *load only* is 4.29. On our Smith Chart, circle no. 1 is constructed with an SWR radius of 4.29 (4.29 × 50 = 214.5 Ω).

E_{unk} is determined with the 27-Ω resistor inserted in the line to the load. Enter E_{unk}'s value on the test data sheet.

The SWR for *load plus 27* Ω is 1.99. Circle no. 2 has an SWR radius of 1.99 (1.99 × 50 = 99.5).

Circle no. 3 on the Smith Chart in Fig 11 is circle no. 1 offset by 27 Ω of resistance added in series to each point of circle no. 1. Circle no. 3 is drawn by adding 27 Ω to both points where circle no. 1 crosses the real axis at 11.8 Ω and 214.5 Ω (11.8 + 27 = 38.8 Ω and 214.5 + 27 = 241.5 Ω). Circle no. 3 is drawn through these two points.

Circle no. 3 intersects circle no. 2 at two points. Both points have the same resistance and reactance values, but the reactance, being on opposite sides of the real axis, have opposite signs (43.5 + *j*32 and 43.5 − *j*32).

To transform the intersections on circle no. 2 to the actual value of the unknown load, 27 Ω must be subtracted from the values on circle no. 2 (43.5 +*j*32 − 27 = 16.5 +*j*32 and 43.5 − *j*32 − 27 = 16.5 −*j*32).

Next, is the load reactance inductive (+) or capacitive (−)? Looking at our results on the Smith Chart, E_{unk} became greater (worse) when C3 was inserted into the hybrid circuit. This indicates that the load is capacitively reactive and the (−) sign is entered on the test data sheet. Therefore, the actual load impedance is 16.5 −*j*32. Enter 16.5 −*j*32 in the appropriate data sheet column.

Notes

[1]R. Rhea, "Measuring Complex Impedance With an SWR Bridge," *Ham Radio*, May 1975, pp 46-50.

[2]O. Pitzalis and T. Couse, "Broadband Transformer Design for RF Transistor Power Amplifiers," *ECOM-2989*, July 1968. A publication of the US Army Electronics Command, Ft Monmouth, NJ.

[3]Wide Band Engineering Co, Inc, PO Box 21652, Phoenix, AZ 85036, tel 602-254-1570.

Feedback

Frequency Changes

Reference the article, "Surviving in the Intermod Jungle," (Nov 1987 *QEX*, p 3). In Figs 5 and 7, the horizontal designator under the graphs should read frequency in MHz.—*Mark Bacon, KZ9J, 2205 File Dr, Decatur, IL 62521*

By Bill Olson, W3HQT
Box 2310, RR 1
Troy, ME 04987

33-cm Band Survey

Our newest band in the >50 realm (and in any realm for that matter) is 902 to 928 MHz (33 cm). Sandwiched between the 70-cm (420-MHz) and 23-cm (1240-MHz) amateur bands, 33 cm has aspects of both these UHF bands. Our new band is adjacent to the 800 to 900 MHz commercial land mobile bands, so a considerable amount of technology already exists for this frequency range. Weak-signal enthusiasts have been on 33 cm since day one, and the ATV gang is using the band for simplex and duplex point-to-point operation—as well as for new ATV repeaters. There is little channelized FM operation that I know of (yet!).

Propagation on the 33-cm band is much like 70 cm and 23 cm. Results from stations using modest equipment (there are very few 33-cm "big guns" yet) show the range to be quite a bit better than 23 cm during average conditions. It's actually a lot more like 432 MHz. Aircraft scatter is a very good propagation mode, and of course the tropo is as good here as on any of the UHF bands. Meteor scatter is probably out, but there are excellent possibilities for aurora—it remains to be seen. Contacts in the 500-mile range have been made under good tropo conditions, and it is only a matter of time until record QSOs are made in the 1000-plus mile range, as they have been on 23 cm. Normal range with 10 W and a single moderate-sized Yagi seems to be around 150 to 250 miles. As of this writing, six stations—AA2Z, VE3LNX, WB8BKC, W1JR, WB2NPE and VE3CRU—have made VUCC (25 grid squares), and others are getting close.

Most 33-cm activity occurs on the east coast. New England and the eastern Pennsylvania/New Jersey areas have the most activity, while other pockets of activity can be found in western New York, Ohio/Michigan, Texas, Washington/Oregon and Georgia/Florida. Did I miss anyone? Sorry—you guys get to be the DX! ATV activity on 33 cm seems to be spread around in the same areas plus California.

Equipment

A good bit of commercially made equipment is already available for 33-cm. Companies that had tackled the 23-cm problem found little trouble getting the

Table 1

33-cm Equipment and Suppliers

Manufacturer	*Model*	*Notes*
Transverters		
LMW Electronics	902TRV4	4 W, GaAsFET, 144-MHz IF
Microwave Components of Michigan		0.5 W, GaAsFET, 144-MHz IF
SSB Electronics	LT 33S	20 W, GaAsFET, 144- or 28-MHz IF
Transmitters		
PC Electronics	TC33-1	1 W ATV transmitter
Receivers		
ICOM	R7000	25-1300 MHz receiver
Receiving converters		
Hamtronics, Inc (NY)	UHF converter	wired or kit
Preamps		
Frontier Microwave	33LNA	<1dB NF
Hamtronics, Inc (NY)	LNG800-960	<1dB NF
LMW Electronics	902PP1	<1dB NF
Microwave Components	902 MHz preamp	<1 dB NF
SSB Electronics	DX902S	0.6 dB NF
	MV902S-01	1 dB NF, switched
Solid-State Amplifiers		
Down East Microwave	3318PA	1 W in, 18 W out, 13.8 V
	3335PA	8 W in, 35 W out, 13.8 V
Frontier Microwave	902-50C	50 W, class C
Tube-Type Amplifiers		
EME Electronics	PA33200	200 W, pair 7289 tubes
Hi Spec	33G2A	pair 7289 tubes
Antennas		
Down East Microwave	3333LY	33-element loop Yagi
J-Beam	DY20-900	20 elements
Tonna		22-element Yagi

Suppliers:

Down East Microwave, Box 2310 RR1, Troy, ME 04987
Hamtronics, Inc, 65 E Moul Rd, Hilton, NY 14468-9535
Hi Spec, PO Box 387, Jupiter, FL 33468
Microwave Components of Michigan, 11216 Cape Cod, Taylor, MI 48180
PC Electronics, 2522 S Paxson lane, Arcadia, CA 91006
Spectrum International, PO Box 1084, Concord, MA 01742
The PX Shack, 52 Stonewyck Dr, Belle Mead, NJ 08502
Transverters Unlimited, Box 6286 Stn A, Toronto, ON M5W 1P3 Canada
EME Electronics (available through Transverters Unlimited)
Frontier Microwave (available through Down East Microwave)
J-Beam (available through Spectrum International)
LMW Electronics (available through Down East Microwave)
SSB Electronics (available through Transverters Unlimited)
Tonna antennas (available through The PX Shack)

same techniques to work at 33 cm. In some cases, it was just a matter of plugging in new crystals and retuning! Table 1 includes everything I am aware of at this time (but I've probably left something out).

Home Brew, Anyone?

Because of the 33-cm band's proximity to various commercial communications bands, there is a wide variety of parts available both new and surplus for the builder. Most 23-cm home-brew schemes adapt nicely to 33 cm, and most of the parts we use at 23 cm were designed to be used at 33 cm anyway! If you look around, there are inexpensive plastic transistors designed for the land-mobile industry for up to around 2 W; low-noise GaAsFETs designed for UHF TV tuners; doubly balanced mixers specified for use up to 1 GHz; MMICs (of course); and even some relatively inexpensive hybrid amplifiers designed for the mobile bands.

For higher power, you can find mobile power amplifier transistors and their 24-V base-station counterparts (the SGS-Thomson CSF SD1414 and Motorola MRF846 come to mind). For linear power, the NEC 1300 linear series transistors—the NEL1306 and the NEL1320—work fine at 33 cm. There are also devices designed for class-A linear service in the European TV translator bands. Although they are specified for use up to 870 MHz, they should still work well at 902 MHz (they are, however, still a bit pricey).

If you like tubes, the old workhorse 2C39 and 7289 types work very well at 33 cm in cavities very similar to the ones we use at 23 cm. Stripline plate tanks should work quite well at this frequency also—how about a K2RIW-type parallel-tube amplifier using 7289s at 33 cm? The land-mobile industry has given us the 3CX400U7, a coaxial-based cousin to the 8874 designed for continuous output of 300+ W at 900 MHz. Some of these amplifiers have even shown up surplus! The European TV translator service has produced a group of planar triodes that will put out close to a kilowatt at 33 cm. The EIMAC YU129 is one of these tubes, and it is the ultimate at this point. Rumor has it that some of the newer EIMAC 8874-type triodes will work up at 900 MHz. Has anyone tried one? Oh yes—if anyone is lucky enough to have an old RCA 7213 tetrode, or its smaller cousin (the 7650), these tubes work extremely well at 33 cm as long as you resign yourself to dealing with the screen grid.

Summary

There you have it. The 33-cm band is easy to get on, and activity is increasing at an incredible rate. Come on—you must be able to squeeze another antenna on the ol' tower somewhere...

Bits

The First CMOS Switch-Mode Power Supply Controller

The TSC170 and TSC171 are new switch-mode power supply controllers. Both use CMOS technology to decrease system cost, increase power efficiency, reduce heat generation and increase total system reliability compared to existing bipolar ICs. The quiescent supply current is 3.8 mA maximum. Current mode control allows users to parallel two or more power supplies for higher power applications. Control loop stabilization is made easier by eliminating the output inductor pole from the frequency response. The TSC170/171's dual totem pole CMOS outputs have been optimized to directly drive power MOSFETs or bipolar transistors. The components also contain several system protection circuits. A soft-start feature forces the pulse-width modulator outputs to initially operate at a minimum duty cycle.

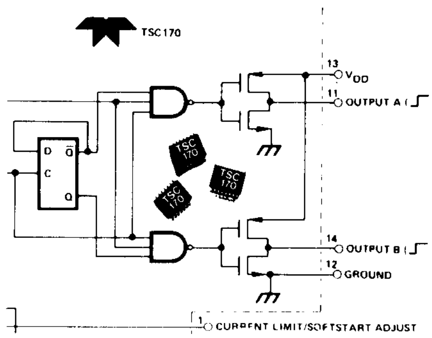

Fig 1—Power supply designers that work with limited board space or a restricted budget benefit by both the size and capabilities of the TSC170/171 . Here the TSC170 sits atop its schematic.

The TSC170/171 are available in a 16-pin plastic DIP, a 16-pin CerDIP and a 16-pin wide-body, small-outline surface-mount (SO) package. In quantities of 100 or more, prices start at $4 each. Surface mount packaged devices are $4.25. For more information on the TSC170/171, contact Teledyne Semiconductor, 1300 Terra Bella Ave, Mountain View, CA 94039-7267, tel 415-968-9241.—*Maureen Thompson, KA1DYZ*

Engineering Software Catalog

California Scientific Software makes available a catalog of software valuable to the electronics engineer who spends much of his or her time in the laboratory. CSS offers a number of engineering programs that include Micro-CSMP—Continuous System Modeling, XPlot—Extended Plotting for any dataset, FILTER—active and digital filter design, LSAP—Linear Systems Analysis, SPICE circuit simulation program and CSS Utilities/Text Processing. Contact CSS at 1159 N Catalina Ave, Pasadena, CA 91104, tel 818-798-1201.—*Maureen Thompson, KA1DYZ*

Board that Accepts Voice Input Returns Real-time Digitized Voice Signal

A small, low bit-rate voice codec™ module is now available that accepts an analog voice input and returns a packetized digital signal at 9600 bits/s for transmission over the private or public telephone network. The card supports 12 real-time voice channels, a mix of voice and synchronous and/or asynchronous data over a single 56-kbit/s DDS circuit, or a DS-O channel in a T1 circuit. It also supports two real-time voice channels and two 1200-bit/s asynchronous data channels through a 19.2-kbit/s voice-band modem. The compression algorithm is based on a combination of time domain harmonic scaling and adaptive predictive coding/dynamic bit allocation. Built-in diagnostics are included to ease system troubleshooting.

Speech digitization has a number of advantages over other techniques used today. Digital speech can be transmitted as a string of bits using the digital network. This allows easy integration of voice with other traffic such as data and FAX. In addition, digital signals can also be regenerated at the intermediate nodes so that comparable quality of service can be offered anywhere in the digital network.

Many products can take advantage of the low bit-rate voice technology: (1) High quality and low cost secure telephone units, (2) software training with voice annotation, (3) personal computerized voice messaging station, (4) voice and data integration over analog private lines, (5) voice and data sub-rate multiplexer, (6) micro-T1 multiplexer, and (7) high capacity T1.

The price of the low bit-rate voice codec module in quantities of 1 to 9 start at $1499. An OEM Evaluation Kit is also available for $2400. For complete information contact Advanced Compression Technology, Inc, 31368 Via Colinas, Suite 104, Westlake Village, CA 91362, tel 818-889-3618.—*Maureen Thompson, KA1DYZ*

VHF+ Technology

By Geoff Krauss, WA2GFP
16 Riviera Drive
Latham, NY 12110

"Amateur" Equipment Responses

In my October 1987 column, I ruminated about the amateur nature of record-breaking QSOs done, all or in part, with equipment not available to most hams. The 11 responses received by December 3 created almost a tie: Five readers said it is okay to use employer-donated equipment to make record-breaking contacts. The best cited example is when Jerry Hinshaw, N6JH, worked Venus bounce with an ICOM IC-502. He also had the use of a NASA-Jet Propulsion Lab station with +87 dBm TX power and 22K RX noise temperature at the feed of a 64-meter dish! Six readers expressed the opinion that record-breaking QSOs *not* done in a totally amateur fashion should not be accepted. The best example in this category is the current DX record (above 300 GHz) set by Steve Noll, WA6EJO. Steve used only amateur gear, and details how he (and you) can accomplish long-distance laser communications in his manual *Amateur Lightwave Communications*. Contact Steve at 1288 Winford Ave, Ventura, CA 93004.

SHF Converters

By using a monolithic frequency converter IC, such as the Avantek MSF-8885, SHF converters may become easier to design and build than in the past. The MSF-8885 is an injection-lockable self-oscillating mixer with more than 8 dB of conversion gain over a 0.5- to 8-GHz RF/LO range. The device presently sells for under $10 in small quantities. Just think: Two GaAsFETs, a few MMICs, a crystal, some chip capacitors and resistors can be turned into a low-cost 5.6-GHz converter with a 1-dB noise figure (NF) and 20-dB conversion gain!

HEMTs

Have you wondered how good the new HEMTs (high-electron mobility transistors) are as low-noise preamplifiers? At about $100 current cost, you might be surprised. My employer is working with HEMTs and I was able to obtain a device that did *not* meet full specifications. In a test jig, the HEMT had a 0.6-dB NF at 4 GHz, with 15 dB gain! Okay, but what would it do at VHF+? Ignoring gain (which was at least 15 dB at all tested frequencies), the measured noise performance was:

Frequency (GHz)	*NF (dB)*
0.220	2.77
0.432	1.46
0.903	1.02
1.296	0.84
2.304	0.67
3.456	0.62

It looks like the HEMT "slides" the low-NF operating range to higher frequencies, with upward movement of both the lower-frequency and higher-frequency roll-offs. In other words, at least this HEMT has lousy VHF/UHF noise figures, because 1/F noise contributions appear well into the 1-GHz region. As HEMTs become more available to amateurs, and more VHF+ers measure actual HEMT-LNAs, I believe this trend will become very noticeable. HEMTs will be used primarily for weak-signal reception in the SHF (3 plus-GHz) region.

State-of-the-Art Equipment for 144 to 148 MHz

This month we continue to look at state-of-the-art equipment in the VHF+ amateur bands. On 2 meters, the amount of SSB activity is almost as large as on 6 meters, and the amount of FM is enormous! This is a band where almost any type of operation is possible and much of the equipment can be homemade by inexperienced operators. Commercially, 2 meters has the largest variety of multi-mode transceivers and an even larger choice of FM-only rigs. While I have seen only one truly hand-held 2-meter SSB transceiver, many FM rigs are small and battery powered. The lack of small SSB transceivers available on the market may be the result of lower demand for such a product and greater production costs (narrow filters and very good frequency stability are both required). The lack of a signal quality threshold effect, as encountered in FM operation, also limits the effective area, for the same output power. Most of my comments about 6-meter equipment are true for 2 meters. While there is a decrease in the number of different tubes available for legal-limit amplifiers on 2 meters, there is an increased variety of equipment available. This may be because of the much larger number of operators on FM and/or SSB, and the almost 3:1 reduction in antenna size for the same gain, making 2 meters the lowest amateur band practical for EME. The number of different available high-gain antennas (most based on NBS designs), add-on receiver preamps and add-on "brick" power amplifiers fulfills almost everyone's needs. Indeed, while it would be expensive, you could purchase the equipment to assemble a 2-meter station for any desired operation, without having to solder a single connection.

Two meters is not the best of all worlds. To obtain the necessary frequency stability and tuning increments, state-of-the-art FM and multi-mode transceivers are tuned using some type of frequency synthesizer (one good extension of the cost-cutting techniques applied a number of years ago to 27-MHz CB transceivers). Some VHF+ers argue that synthesized local oscillators produce too much phase noise for SSB use and, therefore, there is no 2-meter SSB transceiver that is as good for weak-signal work as a combination of an HF radio and a TX transverter/RX converter. Measurements that I have seen and made suggest that this combination is better, by a very small margin, only if the HF radio is a VFO-tuned unit, rather than a synthesized rig. In fact, many 2-meter multi-mode transceivers have better phase-noise characteristics than HF synthesized transceivers for two reasons: (1) Usable 2-meter receiver sensitivity is greater than reception sensitivity at HF, so that less 2-meter phase noise can be well used; and (2) 2-meter transceivers convert down directly to the "major" IF, and use an LO that only has to cover 4 MHz. HF transceivers generally convert up to some VHF first-IF and then convert down to the major IF; they also need an LO that tunes over a 29- or 30-MHz range. In any event, it can be safely said that much of the 2-meter reception problems evident under crowded band conditions are caused by other factors: transmitter distortion (caused by increased nonlinearity in solid-state circuits [with respect to IMD levels in tube mixers and amplifiers]), and, for many of the same reasons, reduced dynamic range in solid-state receivers. While low distortion solid-state transceivers can be built to the same specs as older vacuum-tube units, it is still very expensive. Several major VHF+ contesters still base their 2-meter SSB stations on a hoary old

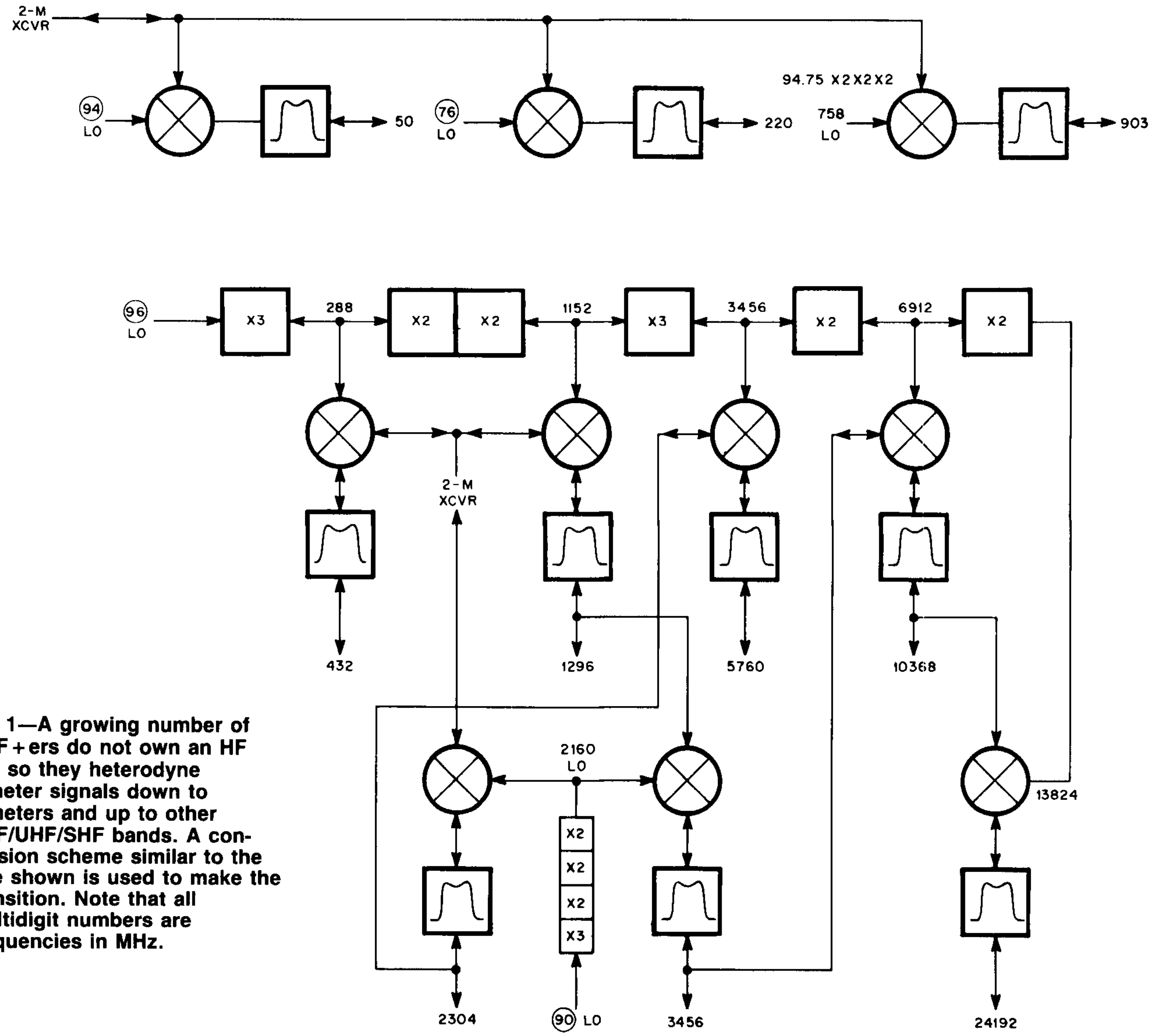

Fig 1—A growing number of VHF+ers do not own an HF rig, so they heterodyne 2-meter signals down to 6 meters and up to other VHF/UHF/SHF bands. A conversion scheme similar to the one shown is used to make the transition. Note that all multidigit numbers are frequencies in MHz.

tube transverter/converter unit (remember the Hallicrafters HA-2?), with added prime-quality GaAsFET preamps and cavity filters to improve weak-signal reception. Their 8877 PAs give 1500 W with good third-order IMD, and reduce crud in their neighboring contestants' receivers.

One reason that so much emphasis is now placed on 2-meter multi-mode transceivers is that a growing number of VHF+ers do not own an HF rig. Instead, they are heterodyning their 2-meter signals down to 6 meters and up to other VHF/UHF/SHF bands. The conversion schemes generally look like that shown in Fig 1. Note that only two additional high-stability LOs are needed for conversion to 432 MHz, and every band from 1296 to 24,192 MHz!

Bits

Suction Cup Mounted Antenna

The VAK-TENNA, manufactured by Electron Processing, Inc, mounts to any smooth surface by the use of suction cups. The antenna is held 1 inch from the surface and can be mounted without tools in areas where drilling holes is not possible. It can be installed or removed without leaving marks, and the antenna can be positioned in a number of configurations.

The VAK-TENNA covers 30 to 500 MHz for receive and 50 to 250 MHz for transmission with up to 50 W. The antenna is constructed so it can be folded easily for storage or transport. A 15-foot 50-Ω RG-58 cable is included. Suggested price is $29.95. For further details about the VAK-TENNA, contact the Sales Dept, Electron Processing, Inc, PO Box 708, Medford, NY 11763, tel 516-764-9798.—*Maureen Thompson, KA1DYZ*

QEX FEBRUARY AD INDEX