QEX 22
December 1983

The ARRL Experimenters' Exchange

QEX Needs Articles

If you have a manuscript describing something of interest to experimenters, now is the time to send it to ARRL Hq for QEX. Do you have a ham-radio-related computer program, a modification to commercial equipment, or a nifty technique to share with your fellow experimenters? Do you want to float an idea past QEX readers? We'd be pleased to consider it in either manuscript or letter form.

Handbook Construction Projects

We're trying to get a number of new construction projects completed in time for the 1985 Radio Amateur's Handbook. The ARRL lab is working on many of them but can't do all the projects in time to meet the 1985 Handbook deadline.

If you have the time, shop skills and writing ability, we'd like to talk to you about building a construction project for the 1985 Handbook. Here's the deal: you do the construction work and a narrative description. The League will pay for the materials and **you keep the equipment** after the lab has validated your design and photographed the item. Fair enough?

Here are three design and construction projects that we'd like volunteers to do:

(1) An adapter that turns a commercial television receiver into a video monitor. This adapter should be usable for either amateur television (ATV) or computer display purposes. The adapter needs to be generic enough to work with many different brands of TV receivers currently available. It is desirable that the adapter be optically isolated to eliminate ac line-frequency pickup and electrical hazards. The deadline is April 15 1984.

(2) A 12-volt battery pack and charger for emergency use. The battery is to consist of gelled-electrolyte cells (e.g., Gel Cells) sized to run a 10-W radio for about 8 hours (with an 80% squelched, 10% receive and 10% transmit duty cycle). The charger should be separate and operate from 115-V ac and fully charge the battery within a minimum time in accordance with the manufacturer's recommendations. The deadline is February 28, 1984.

(3) A phone patch for use with any modern HF SSB transceiver. It should be less expensive to build than the price of commercial phone patches or contain desirable features not seen in those on the market. It must be acoustically coupled, compatible with a telephone-company-provided coupler or work with an FCC Part 68-approved direct-connection device. In other words, it must be legal. The deadline is April 15, 1984.

Prior to the deadline dates mentioned above, we will need to have the working model, a schematic, printed-circuit artwork (if required), and a narrative of how it works with any construction details.

If you are interested and believe that you can make a firm commitment to complete the work by the deadline, please telephone Chuck Hutchinson, K8CH, 302-666-1541, between 8 A.M. and 5 P.M. Monday-Thursday.

NF-105 Manual Needed

Thanks to Fred Larrick, N3FL, we received a donation of a set of antennas for the ARRL lab's NF-105. Now we'd like to make an appeal for either a donated instruction book or information where we could purchase one at reasonable cost.

Season's Greetings

QEX is now two years old. A few of us recently gathered to devour a cake decorated with the letters "QEX." It was homebrewed for the occasion by Libby Karpiej, KA1DTU.

Those of us at ARRL who put QEX together want to thank you for your support. Some of you have sought us out at conventions to say a kind word or two. As many as 500 others have thanked us by ordering single-issue copies to get a computer program. We'd also like to thank QEX authors for sending in your manuscripts and letters.

We wish you "happy holidays." - W4RI & KA1DYZ

Correspondence

More on the Microwave Alignment Probe

I am gratified to learn that my microwave alignment probe design continues to generate interest (QEX, October 1983). I haven't used the design above 1000 MHz, but if more noise output is needed than in the prototype, I would certainly accept this.

I've been told by someone with access to better equipment than mine, that the long-term reliability of the design's measurement is not good. Thus, the suggestion in my third paragraph of calibration in decibels is probably not worth nursing. This design, however, was never intended to be more than an adjustment aid.

LA8AK's suggestion no. 2 in October 1983 QEX, p. 10, is theoretically sound, but not worth the trouble in practice. The delay line effect of the receiver filter would need to be much larger than the suggested 1 ms to make a significant difference to the operation of the alignment aid.

I did not understand LA8AK's suggestion in no. 1. I removed C1, and as expected, the circuit around IC2 overloaded with corresponding loss of accuracy on noise input peaks. Ideally, R4C1 could be replaced with a low-pass network cutting off at about 20 Hz, but the added complexity would be unjustified in terms of improved performance.

Since the circuit was published, I have tried various changes and thought about others. None, however, seem to be a worthwhile improvement. Most have been improvements in the direction of elegance of design rather than of practical usefulness. - J. R. Compton, G4COM, Aysgarth, Beech Corner, Durley, Southampton, Hants, SO3 2AR.

Lookup Table for TNCs

I recently had access to a binder containing a complete set of QEX. They were refreshing to read. For some time, I had been concerned with the drift of Amateur Radio straying away from the technical area. I hope that in time QEX will become a major section in QST.

Through my reading on packet radio, I noticed that because of system overheads and various transmission constraints, the throughput is being held fairly low. I also noticed few attempts to massage information to increase throughput, except in the area of voice.

Digital data throughput could be increased meaningfully by removing unnecessary data before transmission and reinstating it after reception. Why not? We currently do it with cw through internationally accepted abbreviations.

TNC's could be outfitted with a lookup table of frequently used words and a suitable binary search routine at the assembly language level. The table could be based on a sanitized version of the ARRL abbreviations list enhanced with plain language condensible words.

In the sentence above beginning with "Digital data...," 47 characters could be stripped from the total of 135 resulting in a 35% improvement. Depending on the text, 10 to 50% improvements could be expected with an average of 25%. Is this worthwhile?

The average microprocessor in current TNC's should be capable of handling the additional burden at forseeable baud rates while still maintaining its functions. The utility of this scheme would be limited to the technical community for which it is tailored and to the english language. All that is necessary to implement this scheme is for the international packet radio protocol committees to establish the table.

If anyone knows of similar proposals, I would appreciate reading of them in future issues of QEX. - William Dillon, 411 Duplex Ave., 1516, Toronto, Ontario, CANADA M4R 1V2.

Ground Station Antennas for STS-9 Operation

A fixed turnstile-reflector antenna pointed straight up is a poor choice for working STS-9. Why? Ninety-five percent of the time that STS-9 is in operating range, the elevation angle will be less than 30°! STS-9 is to orbit at an altitude of 250 km with an inclination of 57°. The radius of a ground station Ø° elevation circle is 1,756 km, while that of a 30° elevation circle is only 396 km.

What should you use? A 1/4- or 5/8-wavelength ground plane will work fine. /1/ There are slightly better choices, but at this time they haven't appeared in amateur literature. - Condensed from an AMSAT Tech Memo prepared by Martin Davidoff, K2UBC.

/1/ [Editor's Note: You can also tilt a turnstile-reflector array to favor the position of STS-9 on a particular pass.]

BARTG Newsletter

Usually sporting a page length of 40, the Journal of the British Amateur Radio Teleprinter Group consists of columns such as Satellite Scene, AMTOR News, Product Reviews, computer programs and RTTY, of course. Since the tiny publication arrives irregularly at ARRL Hq., it cannot be determined if it is produced monthly or quarterly. If you are interested in any of the mentioned topics, I would suggest writing for subscription information. Though this seemed to be missing from the copy at hand, an address for membership and subscriptions was available. Your inquiries should be addressed to Mrs. T. Crane, "Greta Woods," Bromley Road, Ardleigh, Colchester, Essex CO7 7SF.

"Packet" Meteor Scatter Communications

By Jeffrey W. Moore, * KQ1E

A vast amount of work with meteor scatter (m.s.) communications has been done in the military and commercial world. Up until now Amateur Radio has not benefitted from any of these advances. Hams have been working m.s. the same way for many years -- traditionally using ssb or cw with long schedules on vhf to make short contacts. The information passed is rarely more than call signs, reports and a 73.

The system described here represents a leap to employing current technology in m.s. communications. Although this technique is called "packet" meteor scatter, the only similarity it has with packet radio is the ability to use the same TNC (Terminal Node Controller) hardware. Protocols, algorithms and software are entirely unique.

Meteor Scatter Background

Before discussing this new communication system, it is appropriate to review the fundamentals of m.s. communication and meteors in general.

Billions of meteors enter the earth's atmosphere every day. Because of their extremely small size, less than 1 mm. diameter, these meteors cannot be seen. Several times during the year, major showers occur as the earth intersects a group of particles in space enroute its year long orbit around the sun. During these showers, meteors occur frequently and often are large enough to be seen with the naked eye.

As a meteor enters the earth's atmosphere, it burns up and an ionized trail is produced. The length of this trail and the number of ions it produces is proportional to the size of the meteor. Scientists tend to classify meteors for the purpose of communication into two categories. They either have "under-dense" or "over-dense" ion trails. An under-dense trail will simply "absorb" rf energy and re-radiate it randomly in different directions. This ion trail acts like a mirror to rf and reflects the energy back to earth. Under-dense trails, which occur more frequently in nature, produce signals about 10 dB lower than does an over-dense trail.

In designing a m.s. communications system, it is advantageous to consider using both types of meteor trails. This allows communication not only during meteor showers, but every day of the year.

A set of design guidelines for such a system requires that the system be automatic to send and receive information for long periods of time. It should be able to detect errors and cause retransmission if errors are detected. It must be half duplex; most hams do not have single-band full-duplex capability. A "set" of information must be complete with check sequences in less than 100 milliseconds. It must also be less than 50% duty cycle for transmitting because of the limitations of many amplifiers. It should allow for approximately a one-second transmit to receive turnaround and it must be able to work on all bands from 10 meters to 440 MHz.

Equipment

M.s. communication is a "weak signal" mode of communication and transmitters that produce maximum legal power and low-noise receivers are a must. Antenna requirements are a little different than most weak signal work and gain helps (the more the better). But if an antenna has a small beamwidth in the horizontal plane, fewer meteor trails will be intercepted. A good compromise is an antenna that has greater than 10 degrees beamwidth and more than 15 dBd gain. A single long yagi, collinear or stacked yagis will meet this goal.

In the protocol described below, the following hardware level features are used: Frequency shift keying (fsk), 1200-Hz and 2200-Hz mark and space frequencies (1000 Hz shift), a baud rate of 1200, SDLC-like (Synchronous Data Link Control) synchronous data stream, automatic clock generation and detection in the data stream and SDLC-like bit stuffing with NRZI encoding (to meet the requirements of the automatic clock).

To do all of this you need hardware. A packet-radio TNC with special protocol software works nicely. The TNC output is fed into the microphone input of an ssb transmitter and the receiver output is fed into the TNC audio input. An RS-232 terminal is attached to the TNC to allow text to be entered and displayed.

Although slow, (approximately 100 bytes per hour), you can expect reliable daily communication on 2 meters with the proper equipment. This holds true for a distance of up to 1,500 miles. Data throughput will be higher on 10 and 6 meters, and slower on 440 MHz.

Protocols

Most communication protocols designed to date assume that a channel is frequently available and this works well for a channel behaving that way.

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(continued on next page)

This is clearly not the case with m.s. as a channel is not present most of the time. Because of this fundamental difference, it is not appropriate to use conventional communication protocols for m.s. AMTOR, AX.25, BISYNC, SDLC, and so on, have severe limitations when applied to an m.s. channel. Therefore, it was necessary to develop a new protocol designed for an intermittent, or mostly not present, channel. The program implementing this protocol will be placed in the hardware (EPROMS) of the TNC.

Details

The system described below uses SDLC-like frames for data transmission and verification. This is where the similarity with SDLC ends. Fig. 1 shows a typical m.s. protocol frame.

M.S. Protocol Frame
Fig. 1

FLAG	CNT1	CNT2	IØ	I1	I2	I3	FCS1	FCS2	FLAG	FLAG

At 1200 bauds and with each field representing one octet (8 bits), this frame has a duration of 66.7 milliseconds (80 bits). This meets our design goal of less than 100 milliseconds per information "set." If 128 of these frames were transmitted back to back, the total transmission time would be approximately 8.5 seconds.

If you were to listen in on a typical m.s. contact between two stations, A and B, it would sound like this. Station A would transmit for 8.5 seconds (128 frames) at T = Ø seconds and then turn to the receive mode. Station B would then transmit for 8.5 seconds (128 frames) at T = 10 seconds and turn to the receive mode. This procedure is repeated until all the necessary information is passed. T = 20, 30, etc. in seconds. This allows for a 1.5 second T/R turnaround time, adequate for most setups, and a 50% average for transmitting is maintained. [Note: It is important that both stations in this half-duplex system described be synchronized to WWV for best results.]

If you are wondering what the terms in the m.s. protocol frame mean, here are definitions of the fields in Fig. 1:

FLAG -- FLAGs mark the beginning and end of each frame. This value is a 7E HEX (like SDLC) and are generated automatically on an SDLC controller.

FCS -- FCS is a 16-bit CRC at the end of the frame and it allows frame error checking. As above, an SDLC controller will generate and check these CRCs with minimal software overhead.

IØ - I3 -- These are the four bytes of information being sent. [Note: Subsequent bytes of information are placed in subsequent (Ø - 127) m.s. frames.]

The heart of this protocol resides in the definition of the CONTROL 1 and CONTROL 2 fields. They are described below:

CONTROL 1 -- This is the absolute frame number (or position) within the block of frames and ranges from Ø - 127. The high order bit of this frame is used as an acknowledgement to inform the receiver that we have received his frame with this absolute frame number.

CONTROL 2 -- This is a relative frame number and is associated with the data in the IØ - I3 fields. This starts out the same as CONTROL 1 and changes as acknowledgements are received.

For instance, if A has received an acknowledgement from B for absolute frame number 4, information from a non-acknowledged frame will be repeated and placed in this frame number. The relative frame number (CONTROL 2) is then changed to match the absolute frame number of that information.

The high order bit of this field is set to one on all frames when acknowledgements have been received on each one. This bit is set to Ø after a 1 is received from the other station in QSO. After this occurs, a new block of frames can be started.

In practice, as you enter text, "I" fields start with frame number Ø and continue until the text is finished. If less than 512 bytes (128 x 4) are entered, text is repeated in empty frames and assigned proper relative frame numbers (CONTROL 2 field).

Current Status

Software for this protocol is currently being written and tested. Initial experiments will be conducted on the 10- and 2-meter bands. A VADCG TNC is being used for the controller. All software is written in PL/M-80 and ASM-80 for the 8085 processor.

The author encourages anyone using this mode to conduct experiments to contact KQ1E. Thanks go to Den Conners (KD2S) and Ron Reder (KA1KCU) who assisted me in evaluating this and other protocols and for their moral support.

RFI Conductive Coating

The Miller-Stephenson Chemical Co., Inc. is now marketing a conductive coating that acts as an effective shield against a broad range of RFI/EMI. Known as MS-485 (black), it is applied in a 2-mil coating and becomes functional within minutes. Drying time is approximately 15 minutes.

The coating provides attenuation of 78 dB at 1 MHz and 44 dB at 1000 MHz with a surface resistivity of 0.5 ohm/square at 2-mil thickness. MS-485 is recommended for use on plastics and metals. It is available in 16 oz. aerosol cans and is removable by using MS-114 conformal stripper.

Purchase of MS-485 in quantity of 4 to 11 cans is $7.00 per can with 12 cans per case. A quantity of up to 243 cans sell for $6.25. Further information can be obtained from The Miller Stephenson Chemical Co., Inc., George Washington Highway, Danbury, CT 06810, telephone (203) 743-4447.

A Note on Pi-L Networks

By Elmer Wingfield, * W5FD

While writing BASIC programs for the Pi-L network, I developed additional material. It is given in this article and shown in Fig. 1 which retains the circuit element designations used in the August 1983 QST article, "New and Improved Formulas for the Design of Pi and Pi-L Networks." This article should be referenced for a complete understanding of the subject.

As demonstrated in the QST article, Qo, the Pi-L loaded or operating circuit Q value, is Qpi + QL. QL is fixed in value by R2, the load resistance, and the selected Rm value, $QL = \sqrt{Rm/R2 - 1}$, is the same in any L network where $QL = \sqrt{R1/R2 - 1}$ and R1 > R2. The load end L network provides a purely resistive value equal to the selected Rm value. The input or source end Pi network transforms this Rm value into a purely resistive value, R1. The transformation from R2 to R1 is done while affording a selected overall network Qo value. The design equations for this appear in QST.

Since an L network can transform any R2 value into other R values, it can be used to transform the Rm value to the R1 source end value instead of using a Pi network. If this is done, the resulting circuit shown in Fig. 1 will appear the same as a Pi-L network but will differ in the fact that it is two L networks in tandem. I will call this circuit a "double L" network.

The "double L" is simply two L networks in tandem and the circuit can be represented by Qo = QL1 + QL2, or $Qo = \sqrt{R1/Rm - 1} + \sqrt{Rm/R2 - 1}$. The actual value of Qo obtained for a given R1/R2 in the "double L" is a function of the Rm value selected and will be a minimum when $Rm = \sqrt{R1 \times R2}$.

For a given R1/R2 ratio, Fig. 1 shows the L network having the lowest possible Q for R1/R2 < 9. This is lower than both the Pi and the "double L" network. For R1/R2 = 9, the L and "double L" network will have equal Q. For R1/R2 > 9, the "double L" will have the lower Q value. It is to be noted that the Pi network will always have a higher Q for a given R1/R2 than an L network because a finite value of XC2 is required in the Pi network. For values of R1/R2 < 9, the Pi network can have a lower Qo than does the "double L". The Pi network in this case will have a large but finite XC2 value. In all cases, the "double L" network will have the lower Qo value when R1/R2 > 9.

For all inductance coil elements having equal Q values, Qcoil = XL/Rcoil. The network efficiency is highest when the Qo is lowest. With these assumptions, the "double L" will have lower losses and higher efficiency than the L or Pi network where the transformation ratio R1/R2 is greater than 9. This indicates that more than two L networks in tandem could have still higher efficiency than the "double L" network. It is also true if the R1/R2 transformation is divided between two or more networks. The efficiency could then be greater for a single Pi section.

For the "double L" network to have the lowest Qo possible while transforming a given R1/R2, Rm must equal $\sqrt{R1 \times R2}$, as shown in Fig. 1. To obtain a Qo of 12 in the "double L" circuit where $Rm = \sqrt{R1 \times R2}$, the Fig. 2 "double L" Qo equation shows R1/R2 = 1369. Since high transformation ratios are not present in the case of practical rf amplifier output tank coupling circuits with this minimum Q, a maximum efficiency "double L" circuit is not applicable for tank circuits. It may be of some interest for general R1 to R2 matching purposes where the low operating Qo is not a factor and higher network efficiency is desired.

Four programs in BASIC appear at the end of this article, two for the Pi network and two for the Pi-L network. Each provide the network reactance element values based on the R1 to R2 to be "matched" and the operating Qo desired. The programs are based on the August 1983 QST article formulas and procedures.

I have also devised an errata sheet for the QST article, "New and Improved Formulas for the Design of Pi and Pi-L Networks." This data is given below.

In the first line on page 24, change R1 x R2 to read R1 < R2. In the first sentence of the last paragraph in column one of the same page, it should read: The input circuit is fixed-tuned. Therefore, in order to obtain a broadband response, the Q of the circuit is kept at the lowest level that will just afford an adequate "flywheel effect."

The equations on page 25 should read:

$$Q1 = \sqrt{\frac{Qo\ R1}{XL} - 1} \qquad \text{(Eq. 13)}$$

$$Q2 = \sqrt{\frac{Qo\ R2}{XL} - 1} \qquad \text{(Eq. 14)}$$

On page 26, the correct equation 28 is:

$$Px(A) = \frac{E^2 Xs}{Rs^2 + Xs^2} = Px(B) = \frac{E^2}{Xp} \qquad \text{(Eq. 28)}$$

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(continued on next page)

Also on page 26, correct the Table 1 BASIC program to read:

```
180 :XL=(R1*Qo)/(Q1*Q1+1):
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This adds the left parenthesis in the denominator.

```
220 IF R2/R1 > Qo*Qo+1, THEN...etc.
```

Equation 67 on page 28 should be: Q2 = Qo - Q1. Equations 71 and 72 are:

$$XC1 = \frac{R1XL}{R1 \pm \sqrt{R1R2 - XL^2}} \qquad \text{(Eq. 71)}$$

$$XC2 = \frac{R2XL}{R2 \pm \sqrt{R1R2 - XL^2}} \qquad \text{(Eq. 72)}$$

This returns Everitt's equations to the general form in which he gives them, excepting that the sign of the resultant reactance value has been restricted to the capacitive reactance. This is because only the low pass Pi network arrangement is being considered.

The last paragraph on page 28 correctly states that the XL solution from Eq. 76 derives solutions for XC1 and XC2 from Everitt's equations (Eq. 71 and 72), or from the equations given in Procedure 2 (Eq. 13 and 14). The following will add an explanation of the factors involved when using Everitt's Eq. 71 and 72 to obtain XC1 and XC2 after using Eq. 76 to obtain XL.

Everitt's equations allow for two solution sets when solving for XC1 and XC2. The plus (+) or minus (-) sign is used in the denominator and use of the same sign in both equations should be maintained for each solution pair. That is, if the minus sign is used in one equation, it must be used in the other as well. Of the two solution pairs, only one will be correct. It is usually obtained when the plus sign is used in Eq. 71 and 72. One exception to this rule to obtain sufficient coupling for the R1 to R2 "match" is the selected value of the Qo, used in Eq. 76 to obtain the XL value. When Qo is in the interval between the Q of an L network for the given R1 and R2 and the Q that obtains R1 and R2 for a Pi network when XL is at the maximum value, a minus sign before the radical in the denominator in Eq. 71 and 72 is necessary.

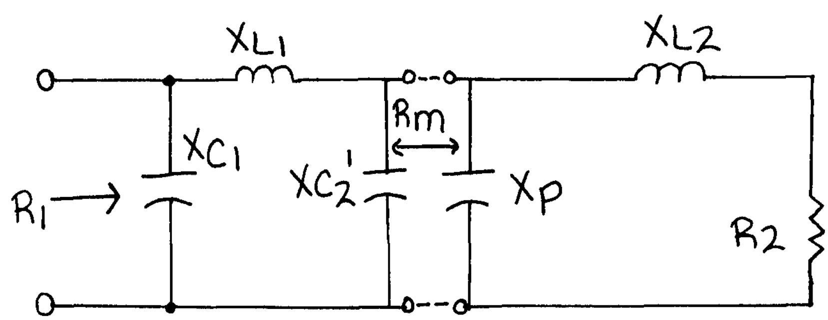
To illustrate my comment above, use the minus sign in both Eq. 71 and 72 when:

$$XL = \sqrt{R1R2 - R2^2}, \quad \sqrt{R1R2}$$

$$Qo = \sqrt{\frac{R1}{R2} - 1}, \quad \frac{R1 + R2}{\sqrt{R1R2}} \qquad R1 > R2 \text{ is assumed.}$$

The lower endpoint of the interval is the XL and Qo of an L network. The upper endpoint is the XL and the Qo when XL is at its maximum value and provides sufficient coupling. I do not include the lower endpoint in the interval because the correspoinding network there is an L, not a Pi network. The sign used at the upper endpoint before the radical is not important because the radical is zero. It is, however, a Pi network at the upper endpoint.

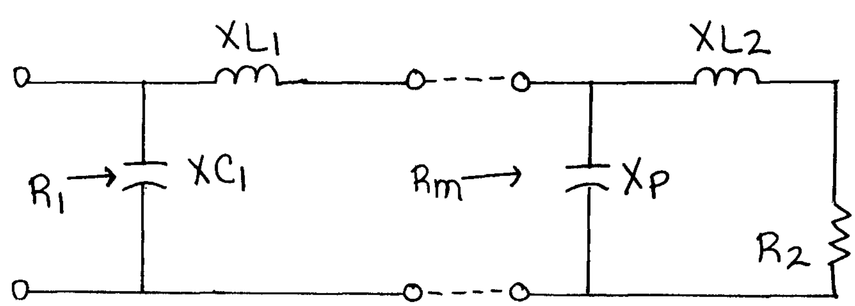
Because of the added complexity introduced by the double-valued Eq. 71 and 72, Eq. 13 and 14 were developed for use in the Procedure 2 Pi-network formula set. Use of Eq. 13 and 14 simplifies manual and computer solution for XC1 and XC2 after obtaining XL from Eq. 76.



R1 > Rm > R2

$$XC2 = \frac{XC2^{1} \times XP}{XC2^{1} + XP}$$

Pi-L Network



"Double L" Network

Fig. 1

(Fig. 1 continued)

For the "Double L":

$$Qo = QL1 + QL2 = \left(\frac{R1}{Rm} - 1\right)^{\frac{1}{2}} + \left(\frac{Rm}{R2} - 1\right)^{\frac{1}{2}} = f(Rm)$$

$$f^{1} = \frac{1}{2}\left(\frac{R1}{Rm} - 1\right)^{-\frac{1}{2}} - \left(\frac{R1}{R2}\right) + \frac{1}{2}\left(\frac{Rm}{R2} - 1\right)^{-\frac{1}{2}} \frac{1}{R2}$$

$f^{1} = \emptyset$ for $Rm = \sqrt{R1 \times R2}$ and this is the minimum for Qo.

Minimum Qo = 2QL1 or 2QL2 in this case.
Further, for "double L", $Rm = \sqrt{R1 \times R2}$:

$$Qo\ (L\text{-}L) = 2\left[\left(\frac{R1}{R2}\right)^{\frac{1}{2}} - 1\right]^{\frac{1}{2}}$$

and for the L net:

$$QL = \left(\frac{R1}{R2} - 1\right)^{\frac{1}{2}}$$

Program 1

```
100 REM PI-NET 9/29/82 LAST REVISED 7/15/83 EAW FILE "PINET4A"(PROC.1 FORMULAS)
110 REM Q BASED FORMULAS PER W5FD FOR CALCULATING PI-NETWORK REACTANCE VALUES
120 INPUT "R1";R1
130 INPUT "R2";R2
140 INPUT "QO";QO
150 IF R1 <=0 OR R2 <=0 OR QO <=0 THEN 160 ELSE 170
160 PRINT:PRINT "INVALID NEGATIVE OR ZERO INPUT":GOTO 350
170 PRINT
180 REM              SPECIAL CASE WHERE R1 = R2
190 IF R1=R2 THEN X1=(2*R1)/QO:X2=(2*R2)/QO:Q1=QO/2:XL=(R1*QO)/(Q1*Q1+1):GOTO 290
200 IF ABS((QO*QO+1)-(R1/R2))<.01 THEN PRINT "L NETWORK":GOTO 350
210 IF ABS((QO*QO+1)-(R2/R1))<.01 THEN PRINT "L NETWORK":GOTO 350
220 IF R1/R2>QO*QO+1 THEN PRINT "NO SOLUTION":GOTO 350
230 IF R2/R1>QO*QO+1 THEN PRINT "NO SOLUTION":GOTO 350
240 Q1=(R1*QO - SQR(R1*R2*(QO*QO) - (R1-R2)*(R1-R2)))/(R1-R2)
250 Q2=QO-Q1
260 X1=R1/Q1
270 X2=R2/Q2
280 XL=(R1*QO)/(Q1*Q1+1)
290 PRINT "R1 = ";R1
300 PRINT "R2 = ";R2
310 PRINT "QO = ";QO
320 PRINT "X1 = ";X1
330 PRINT "X2 = ";X2
340 PRINT "XL = ";XL
350 PRINT:RUN
```

Program 2

```
100 REM PINET 12/27/82  REV 8/2/83 EAW FILE "ELMER3"
110 REM  Program based on W5FD QST Aug 83 Procedure 2 PINET equations.
120 INPUT "R1";R1
130 INPUT "R2";R2
140 INPUT "QO";QO
150 PRINT
160 IF R1 <=0 OR R2 <=0 OR QO <=0 THEN 170 ELSE 180
170 PRINT:PRINT "INVALID NEGATIVE OR ZERO INPUT":GOTO 340
180 IF R1/R2=QO*QO+1 THEN PRINT "L NETWORK":GOTO 340
190 IF R2/R1=QO*QO+1 THEN PRINT "L NETWORK":GOTO 340
200 IF R1/R2>QO*QO+1 THEN PRINT "NO SOLUTION":GOTO 340
210 IF R2/R1>QO*QO+1 THEN PRINT "NO SOLUTION":GOTO 340
220 XL=(QO*(R1+R2)+2*SQR((R1*R2)*(QO*QO+4)-(R1+R2)*(R1+R2)))/(QO*QO+4)
230 Q1=SQR((QO*R1)/XL-1)
240 Q2=QO-Q1
250 X1=R1/Q1
260 X2=R2/Q2
270 PRINT "R1=";R1
280 PRINT "R2=";R2
290 PRINT "QO=";QO
300 PRINT
310 PRINT "X1=";X1
320 PRINT "X2=";X2
330 PRINT "XL=";XL
340 PRINT:RUN
```

Program 3

```
100 'PI-L Net 10-4-83 EAW File "PI-LA"
110 'Program based on W5FD QST Aug 83 Pi-L and Procedure 2 Pinet equations.
120 INPUT "R1";R1
130 INPUT "R2";R2
140 INPUT "QO";QO
150 PRINT
160 RM=SQR(R1*R2) 'This sets Rm value, Line 180 checks for adequate Qo value.
170 QL=SQR(RM/R2-1)
180 IF QO<2*QL THEN PRINT "Invalid, Qo value too low":GOTO 390
190                     'Special case where QO=2QL
200 IF QO=2*QL THEN 210 ELSE 220
210 XC1=R1/QL:XC2=RM/QL:XL1=RM*QL:XL2=R2*QL:GOTO 310
220 XL2=QL*R2
230 XP=RM/QL
240 QP=QO-QL
250 XL1=(QP*(R1+RM)+2*SQR((R1*RM)*(QP*QP+4)-(R1+RM)*(R1+RM)))/(QP*QP+4)
260 Q1=SQR((QP*R1)/XL1-1)
270 Q2=QP-Q1
280 XC1=R1/Q1
290 XCM=RM/Q2
300 XC2=XCM*XP/(XCM+XP)
310 PRINT "R1= "; R1
320 PRINT "R2= "; R2
330 PRINT "QO= "; QO
340 PRINT
350 PRINT "XC1="; XC1
360 PRINT "XC2="; XC2
370 PRINT "XL1="; XL1
380 PRINT "XL2="; XL2
390 PRINT:RUN
```

Program 4

```
100 'PI-L Net 10-4-83 EAW File "PI-LB"
110 'Program based on W5FD QST Aug 83 Pi-L and Procedure 2 Pinet equations.
120 PRINT
130 INPUT "R1";R1          'Line 160 allows you to input a desired Rm value
140 INPUT "R2";R2          'instead of the Rm=SQR(R1*R2) as in the PI-LA program.
150 INPUT "QO";QO          'For a fixed Rm value change:160 RM=300 or as desired.
160 INPUT "RM";RM
170 PRINT
180 QL=SQR(RM/R2-1)
190 QM=SQR(R1/RM-1)
200 IF QO<QL+QM THEN PRINT "Invalid, QO is too low":GOTO 410
210                 'Special low Q case
220 IF QO=QL+QM THEN 230 ELSE 240
230 XC1=R1/QM:XC2=RM/QL:XL1=RM*QM:XL2=R2*QL:GOTO 330
240 XL2=QL*R2
250 XP=RM/QL
260 QP=QO-QL
270 XL1=(QP*(R1+RM)+2*SQR((R1*RM)*(QP*QP+4)-(R1+RM)*(R1+RM)))/(QP*QP+4)
280 Q1=SQR((QP*R1)/XL1-1)
290 Q2=QP-Q1
300 XC1=R1/Q1
310 XCM=RM/Q2
320 XC2=XCM*XP/(XCM+XP)
330 PRINT "R1= "; R1
340 PRINT "R2= "; R2
350 PRINT "QO= "; QO
360 PRINT
370 PRINT "XC1="; XC1
380 PRINT "XC2="; XC2
390 PRINT "XL1="; XL1
400 PRINT "XL2="; XL2
410 PRINT:RUN
```

VHF+ Technology

Conducted by Geoff Krauss, * WA2GFP

24-GHz GUNNPLEXERS: THE Holiday Gift for This Year?

Data has been received from Keith, VE2AQU, of M/A-COM (Canada), and Jay, W1VD, in response to a question in my last column about the Microwave Associates model MA-87820 Gunnplexer for 24 GHz. Both will apparently be a North American sales outlet. This microwave subassembly should be available by the time you read this column.

A copy of the preliminary product specification indicates that a varactor-tuned Gunn oscillator (nominal 24.125-GHz frequency) will have a mechanical tuning range of ±50 MHz and a minimum electronic tuning range of 60 MHz for a 0- to ±15-V dc tuning voltage. The Gunn oscillator will require about 6-V dc at about 0.65 A diode current, delivering about 20 mW of output power through the diode-in-a-waveguide companion mixer.

The entire assembly is under 2 inches long, about 1 inch wide and 2-1/2 inches high. A horn antenna is not shown in the preliminary specification, although W1VD mentions a 30° horn antenna as part of the unit. The cost will be in the $300 range.

While this unit is more expensive than the 10-GHz Gunnplexer with its built-in ferrite isolator that is not present in the 24-GHz model, it is still a competitive price compared to the cost of assembling such a unit from a surplus Ku-band radar oscillator, a 3-port circulator and a Ku-band diode mixer. Assuming almost-standard 30 MHz-IF frequency offsets are used, the present 10-GHz Gunnplexer power-IF units will be adaptable. The adaptation can be performed by switching in a 6-V regulator (LM317 or LM140A) on the Gunn bias line, adding a Zener diode and a few minor components to limit the tuning pot maximum voltage to 15 V instead of the maximum 20 V utilized in the 10-GHz unit.

I have not received word yet whether Microwave Associates will make the 24-GHz mixer available as a separate item. This would be convenient as it could be used with those surplus 24-GHz oscillators a number of VHF+ers acquired over the past few years.

According to VE2AQU's data, there are a half dozen stations in the Montreal area active on the 10-GHz band and additional stations in the equipment-building stages. At least one contact between Mount Royal, Montreal, and Mount Mansfield, VT, has been made over a 76-mile path. The path length is typical of the line-of-sight range for a non-ducting, mountain-top-to-mountain-top contact. Several contacts in the 70 to 80 mile range were made by the W2SZ/1 contest operation. An excellent discussion of the four-thirds radius rule operating in these non-ducting situations is given on pp. 43-48 of the November 1983 QST article, "Tropospheric Scatter Propagation," by G3YGF. See Fig. 3 for some idea of how "low" obstacles can "pop" into a "visually-clear" path.

While IØSNY has proven longer paths are possible in the over-water ducting mode, significantly longer paths in the overland mode will require use of forward-scatter operation. To achieve this method with Gunnplexers, a lower noise figure than 10 to 12 dB and a higher power than 10 to 20 mW is necessary.

To reduce receiver noise figure and increase transmitter output power, external low-noise amplifiers or TWT/Power GaAs FET amplifiers must be used. Commercial 10-GHz LNAs are available with 2- to 3-dB noise figures and sufficient (30 dB) gain for receiving, but the cost is prohibitive. Bob Atkins, KA1GT, exhibited and described a homebrew LNA at the October 1983 Mid-Atlantic VHF Conference. He will, hopefully, publish details in his QST column, "The New Frontier."

TWTs in the 1- to 5-W output range occasionally appear at hamfests. Nothing further will be said about that option as the high-voltage and protection requirements for this type of amplifier limit its use to only those acquiring the tube and information on how to use and "feed" it.

A number of 1+ W power GaAs FETs are presently being advertised. With a cost reduction, it could become practical for amateur 10-GHz use!

The RF switching required to accommodate the added assemblies to a "transceiver" such as the Gunnplexer is not minor, even if a 10-dB noise-figure decrease and 20+ dB power-output increase (30+ dB path loss allowable) is possible with a GaAs FET LNA and a transmit amplifier. Another major improvement obtained by decreasing the signal bandwidth is taking the typical 200-kHz FM signal and reducing it to a 200-Hz CW signal. With an additional 30 dB path loss accommodated, it can be better than 50+ dB when the lack of FM threshold and "aural" human filtering are added.

This requires an extremely stable transmitter and receiver heterodyne oscillators. The chances of locking a 10-GHz oscillator to a stable reference increases with the basic stability of the microwave source being locked. Both the switching and stability requirements may dictate that separate transmitter and receiver modules be used.

A presently available DRO-type GaAs FET transmitter was tested in an earlier QEX article, "10 GHz Signal Sources," April 1982, p. 16. A companion receiver, the Mitsubishi FO-UP11KF, is also available from Applied Invention, RD 2, Rte.

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(continued on next page)

Amplitude Compandored Sideband vs. FM

The Office of Science and Technology has issued a Technical Memorandum (FCC/OST TM 83-7) entitled, "Amplitude Compandored Sideband Compared to Conventional Frequency Modulation for VHF Mobile Radio: Laboratory and Field Testing Results." The Technical Memorandum describes tests conducted by the FCC laboratory relating to the feasibility of integrating a new communications technology, known as Amplitude Compandored Sideband (ACSB), into the existing frequency modulated (fm) two-way radio services.

ACSB communications systems need only 5 or 6 kHz of bandwidth to transmit information, as compared to the 25 or 30 kHz needed by conventional fm two-way systems. Even though less bandwidth is needed for transmission, several questions had to be answered regarding how ACSB might interfere with existing fm systems and the frequency reuse potential of ACSB as compared to fm. Answers to these questions could help in considering how new technologies, such as ACSB, might be introduced into the existing two-way vhf bands with a minimum impact on current radio users and a long-term improvement in spectrum utilization.

The report describes the testing program and provides a tabulation of the results. ACSB has been found to be a viable communications medium that can compare favorably to fm under most conditions. Although the study concluded that ACSB channels could not be intermixed with existing fm channels and remain completely inaudible on fm receivers, the study does provide guidance on how ACSB might be considered on a radio service by radio service basis.

Copies may be purchased through International Transcription Systems, Inc., FCC, 1919 M Street, N.W., Washington, D.C., 20554, Room 248. The price per copy is $5.88.

Five New, Low Cost Portable DMMs Available

The Circuitmate line of digital multimeters, a low-cost line of feature packed portables, is now available from Beckman Instruments, Inc., Instrumentation Products Operations. The DM40 and DM45 DMMs are full-sized portables featuring five dc volt ranges, five ac volt ranges, five or more current ranges, six resistance ranges, diode test, a single rotary switch, recessed display and recessed lead jacks, tilt bale and anti-skid pads.

The suggested retail price for the DM40 is $69.95 and $89.95 for the DM45. For a full-sized DMM packed with features at an affordable price, consider the DM40 with .8% dc voltage accuracy or the 10 amp, .5% dc voltage accuracy DM45.

For a low-cost pocket portable, check Beckman's line of DM15, DM20 or DM25. Smaller than the DM40 and DM45, these meters have their own special function other than their five (2 V to 1000 V) dc, five (2 V to 1000 V) av ranges, multiple ac current ranges and six resistance ranges. The DM15 features separate diode test functions and a .8% basic Vdc accuracy. Its retail price is $59.95. The DM20 features a transistor gain tester, dual voltage resistance test function, conductance measurement capability and separate diode test function. Its price is $64.95.

Some of the DM25 features include capacitance, dual voltage resistance test function, audible continuity checking, separate diode test function and conductance measurement capability. It sells for $79.95.

Circuitmate meters are accompanied with test probes, batteries, extra fuses and a manual. For further information on where to purchase the Circuitmate DMMs, contact Beckman Instruments, Inc., Instrumentation Products Operations, 210 South Ranger Street, Brea, CA 92621; telephone (714) 993-8803.

(VHF+ continued from page 10)
21, Hillsdale, NY 12529 in the $40 range. This receive converter uses the same GaAs FET DRO-stabiized oscillator as the transmitter, but couples the energy to a single-diode mixer having a waveguide-type RF input instead of coupling the oscillator output to a waveguide. This unit still has the same order of noise figure as a Gunnplexer, but is a separate heterodyne converter and can be used independently from a transmit oscillator.

Several approaches are known to be in the experimental stages for increasing the frequency stability of the Mitsubishi transmitter and receiver units. I am aware of VHF+ers working with locking-variation of oscillator frequency by the introduction of optical energy into the oscillator GaAs FET device, by injection-locking the oscillator from the output frequency of a varactor-type multiplier and by varying the oscillator frequency by small variations of the basic +6-V dc supply voltage. The first and third approaches will probably acquire an additional mixer/sampler to derive an error signal, while the second should work directly. Each approach has pros and cons with no clear-cut way apparent to anyone. Much work remains to be done, but at least it has started.

I am sure all VHF+ers would like to know more about similar work being done by others. If you have some results or suggestions, write and I'll include these worthy items in future columns. Till next year, have a happy Holiday Season!

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2) document advanced technical work in the Amateur Radio field, and

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