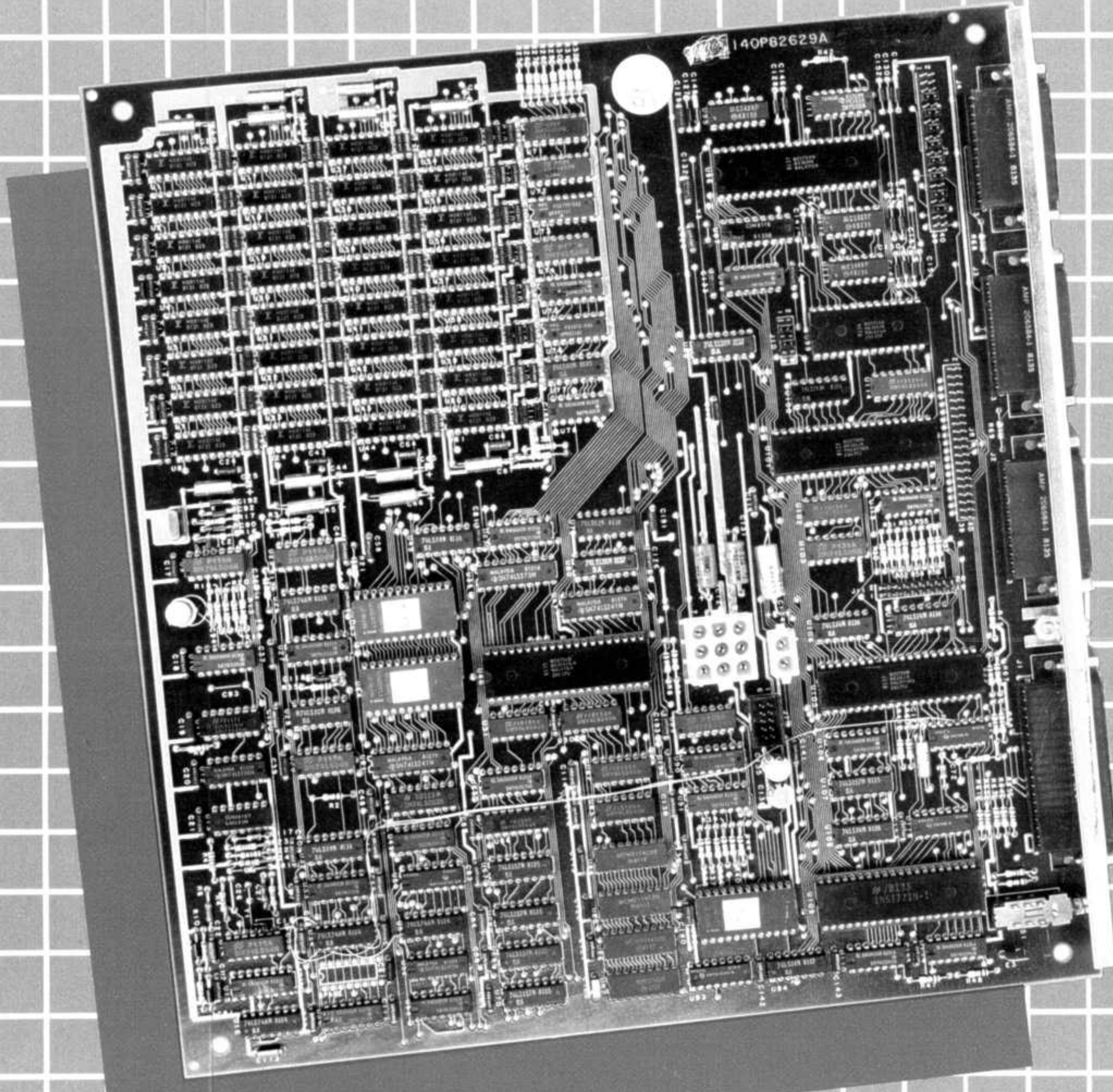
QEX 54

$1.75

AUGUST 1986

The ARRL Experimenter's Exchange



QEX (ISSN: 0886-8093) is published monthly by the American Radio Relay League, Newington, CT USA.

David Sumner, K1ZZ
Publisher

Paul L. Rinaldo, W4RI
Editor

Maureen Thompson, KA1DYZ
Assistant Editor

William Conwell, K2PO
Geoffrey H. Krauss, WA2GFP
Bill Olson, W3HQT
Contributing Editors

Lisa Fuini
QEX Circulation

Michelle Chrisjohn, WB1ENT
Production Supervisor

Deborah Sandler
Typesetting and Layout

Sue Fagan
Graphic Design Supervisor

David Pingree
Technical Illustrator

Lee Aurick, W1SE
Advertising Manager

Sandy Gerli, AC1Y
Deputy Advertising Manager

Technical Department
Charles L. Hutchinson, K8CH
Manager
Gerald L. Hall, K1TD
Deputy Manager
Paul Pagel, N1FB, Mark Wilson, AA2Z
Senior Assistant Technical Editors
Bruce O. Williams, WA6IVC
Assistant Technical Editor

Production Department
E. Laird Campbell, W1CUT, *Manager*
Joel P. Kleinman, N1BKE, *Deputy Manager*

Circulation Department
Lorry Evans, KA1KQY, *Manager*
Debra Chapor, *Deputy Manager*

Offices

225 Main St, Newington, CT 06111 USA
Telephone: 203-666-1541
Telex: 650215-5052 MCI
Electronic Mail: MCI MAIL ID:215-5052
(user name ARRL)

Subscription rate for 12 issues:
In the US by Third Class Mail:
ARRL Member $6, nonmember $12;
US by First Class Mail:
ARRL Member $11, nonmember $17;
Elsewhere by Airmail:
ARRL Member $21, nonmember $27.

QEX subscription orders, changes of address, and reports of missing or damaged copies may be marked: *QEX* Circulation.

Members are asked to include their membership control number or a label from their *QST* wrapper when applying.

TABLE OF CONTENTS

COLUMNS

ABOUT THE COVER

The Xerox 820-1 board is popular among packet radio users. This single-board computer is available to amateurs through the surplus market. More on its theory of operation can be found on page 14.

Purposes of *QEX*:

1) provide a medium for the exchange of ideas and information between Amateur Radio experimenters

2) document advanced technical work in the Amateur Radio Field

3) support efforts to advance the state of the Amateur Radio art.

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

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

Empirically Speaking. . .

To Construct, or Not to Construct: That is the Question

In the 1500s, you could have overheard a sergeant say to his troops: "Alright mens. By the grace of our company commander, thous hast been granted leave to forage for sticks, flat rocks, catgut and feathers from which thous willst build thine own M1A1 crossbow and arrows. Thous willst love it!" Technology is leading us to a day, not too far off, when the briefing of the troops might go like this: "Alright mens. Yous have been issued your very own M37XL keyboard-operated, computer-controlled, laser-aimed, TV-guided, shoulder-mounted tactical missile launcher. Yous will love it! However, in the unlikely event of a malfunction, yous are required to ship it to your nearest warranty service center and are prohibited by law from trying to repair it in the field." Is this what the old-timers are telling us about the direction Amateur Radio equipment will take? Maybe so. But it's a distorted and incomplete picture.

There was a day, so the story goes, when hams home-brewed their own radio equipment—all of it! Well, maybe not quite all of it, as the coil form's earlier incarnation was as an oatmeal box, the cotton-covered wire was store-bought, etc. Nevertheless, there was a need to educate oneself on the options, make a design choice, select the components, assemble and test same, and experiment with it until it works. Then came kits. Suddenly it was acceptable to buy a kit of parts, assemble and test same, and debug it until it works. Oh, yes. A few rich hams bought commercially manufactured equipment, usually just the receiver because they were harder to build. But still, real hams built their own transmitters, or at least their own kilowatt amplifiers. Antennas too.

Now we're in the era of what some have dubbed the "appliance operator." It is heard so much these days that it no longer carries the element of dishonor it did when first coined. Every year manufacturers tantalize us with amazingly small, feature-packed new radios with lots of buttons, improved specs, computer-control options, and all for much less than the price of a new car. And as if that's not enough, for the not-so-well-financed ham, there are used equipment in Ham-Ads and flea markets that made everyone salivate just a few years ago.

One might conclude that no one is building anything as there is no longer any need. For a lot of hams, that's largely true in the sense that they buy their equipment. But there is still the education as to the options, the searching for the right gear, the system engineering, and station integration. What we've seen is an evolution of what hams home-brew from the circuit level to the box level. In a sense, the average ham has progressed from a circuit engineer to a station architect.

The handwringers among us usually forget to mention another quiet revolution in hams building things: cooperative design projects. Design and construction used to be mostly a solitary pastime. . . one ham one project. Quite often the design was a modification of one out of a magazine, but the actual construction was usually done by one person. Starting in the 1960s, it became apparent that some projects were too complex for one person to tackle. Project OSCAR was a team effort to design, build, test, launch and operate amateur satellites. At first, the team was small, then it grew under AMSAT to a sizeable number of specialists in many countries of the world. In the 1980s, we saw packet radio take off as a team effort. Doug Lockhart, VE7APU, started things in Vanouver, BC; the First ARRL Amateur Radio Computer Networking Conference got about 80 people fired up; and the Tucson Amateur Packet Radio club did the group design that multiplied and went forth (ultimately through commercial manufacturers) to most of today's 18,000 or so packeteers. It's too early to tell, but amplitude-compandored single sideband (ACSSB) and spread spectrum could go the same route.

Both the amateur-satellite and packet-radio experiences have taught us the power of synergistic teamwork. After all, we are fortunate to have in our ranks electronic engineers, microwave engineers, propulsion engineers, thermal engineers, protocol analysts, software writers, technical writers, *and* the technical management brains to make everything come together. Moreover, we are endowed with a national Amateur Radio organization, instant communications, funding mechanisms, and other resources needed to tackle almost any project we set our minds on.—W4RI

A PSK Demodulator for the JAS-1 Satellite

**By Fujio Yamashita, JS1UKR, JARL, Sugamo 1-14-2
Toshima-Ku, Tokyo, 170 JAPAN**

Introduction

The digital transponder on the JAS-1 satellite is designed to transmit its downlink signal by PSK modulation. Therefore, reception of the downlink signal requires a PSK demodulator. Several circuits are available, but this article introduces another recently developed.

A PSK signal can be thought of as carrier-suppressed double sideband (DSB). To demodulate the signal, a carrier signal identical in frequency and phase as the received PSK signal is required. The key to demodulation is knowing how to regenerate a carrier coherent to the received PSK signal. An SSB receiver is only used as the linear frequency converter and does not work for PSK demodulation.

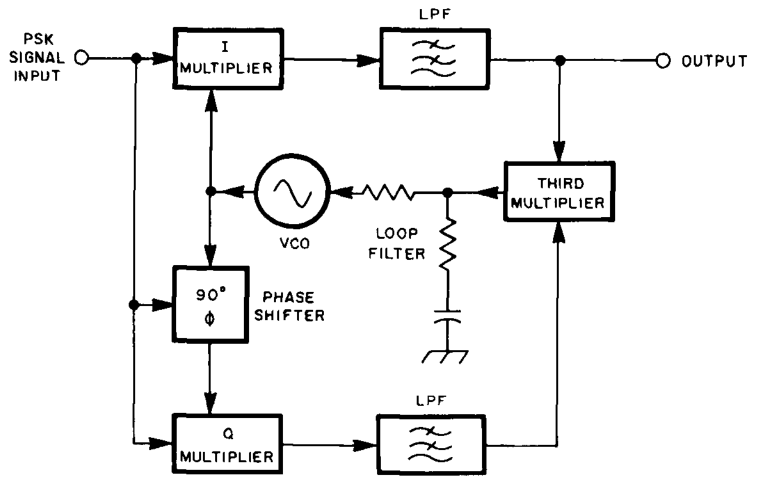


Fig 1—Basic diagram of a Costas loop.

The carrier frequency of a down-converted PSK signal is chosen to be around 1600 Hz so the spectrum of the signal falls within ± 600 Hz. There are several reasons why a frequency of 1600 Hz is chosen. Here, the signal can pass through the flat part of the passband of a conventional amateur SSB receiver, capable of receiving voice communications up to 3 kHz. Because the rate of information is 1200 bits/s, it is better for the carrier frequency to differ by 1200 Hz, considering carrier suppression.

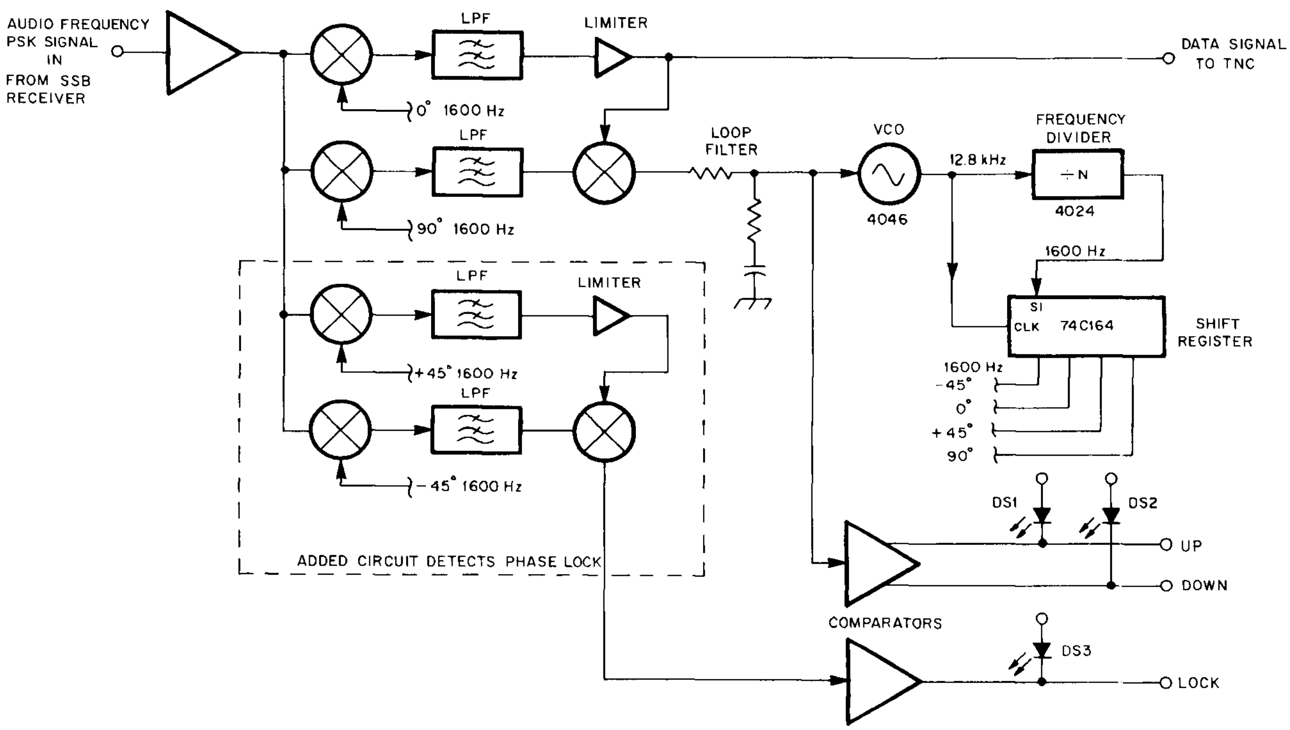


Fig 2—Block diagram of the demodulator circuit.

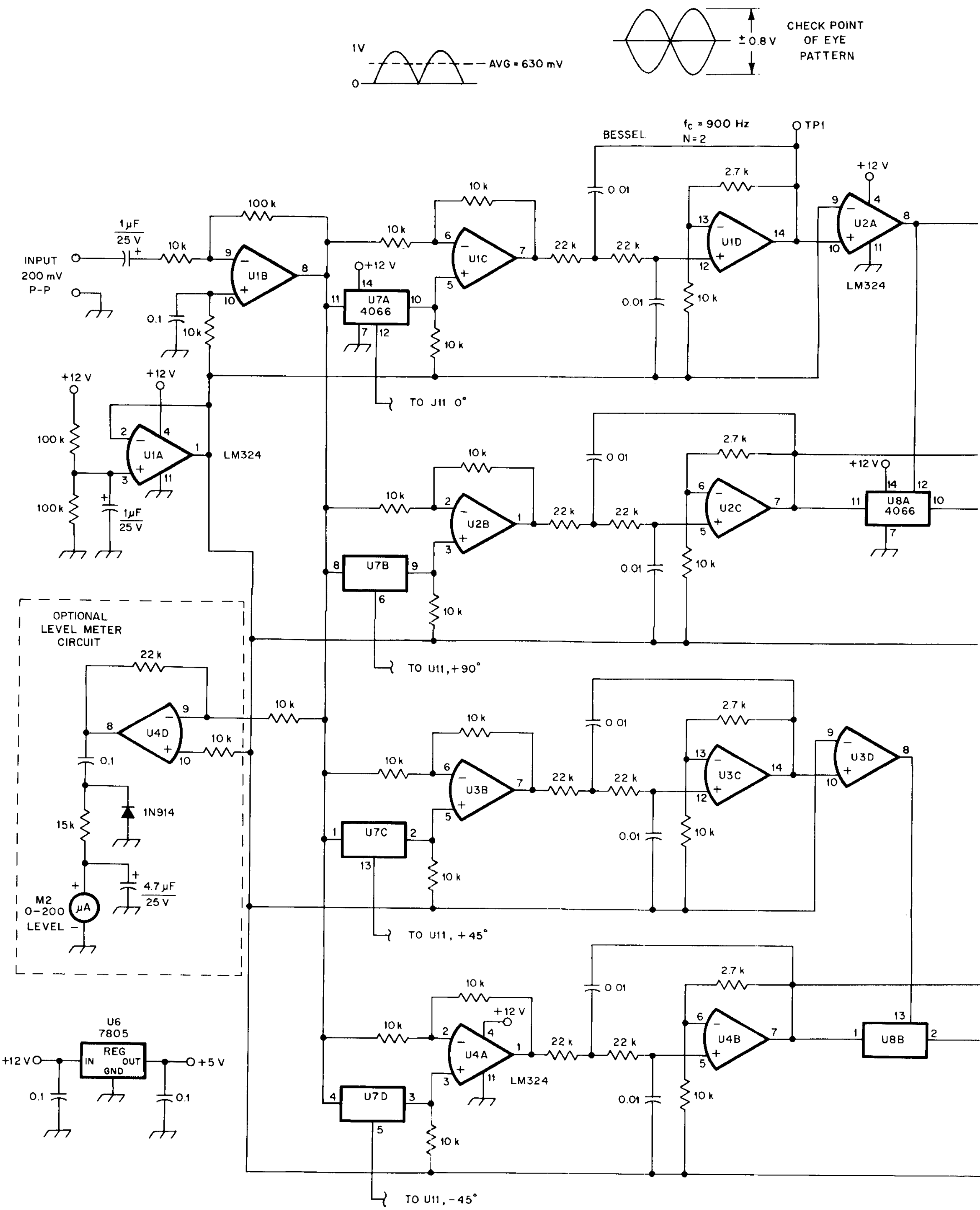
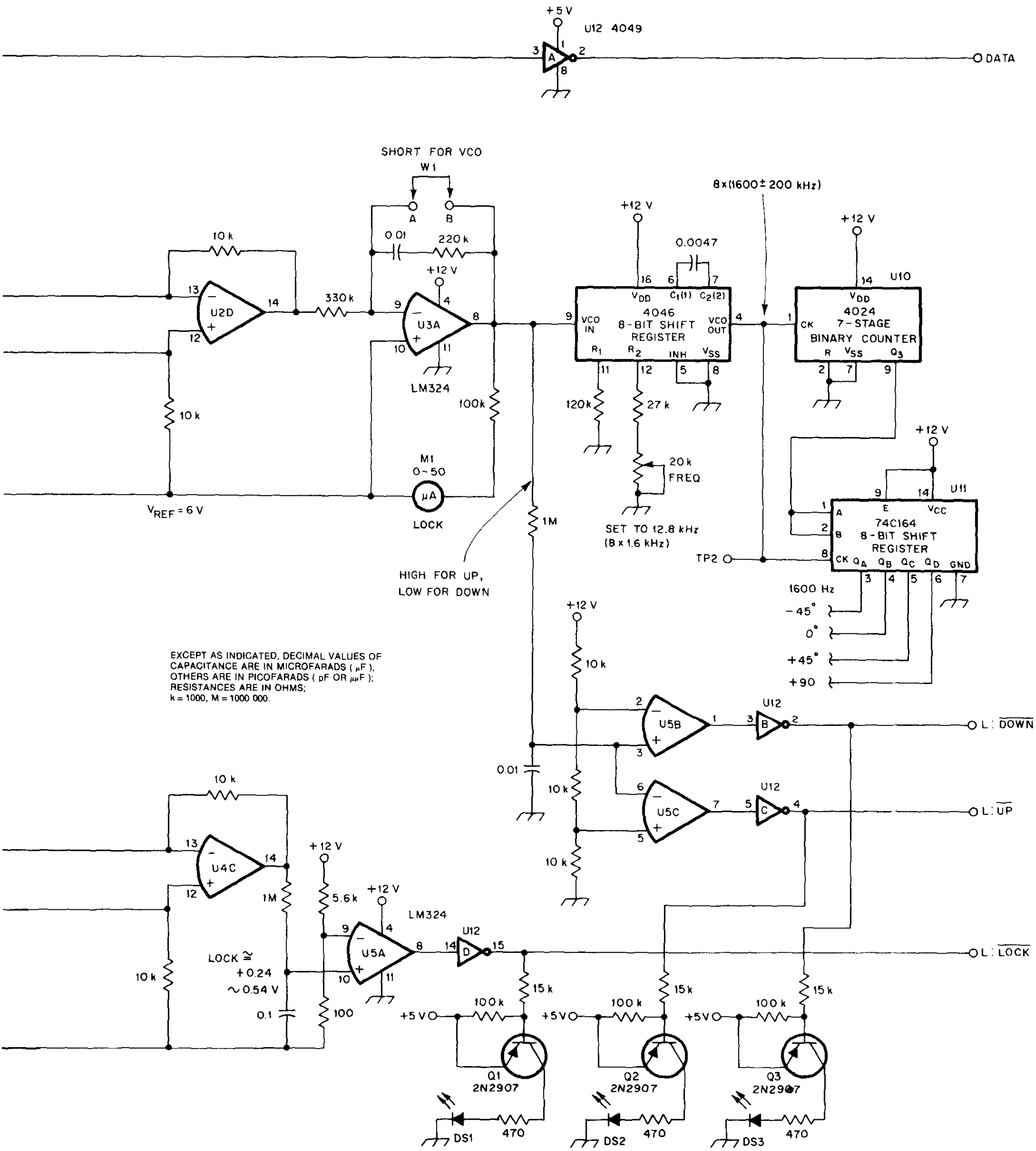


Fig 3—Schematic diagram of the PSK demodulator.


+5 V
U12 4049
DATA
SHORT FOR VCO
W1
0.01
220 k
10 k
330 k
+12 V
U2D
U3A
LM324
100k
M1
0–50
LOCK
V REF = 6 V
4046
8-BIT SHIFT REGISTER
VCO IN
VCO OUT
INH
0.0047
8x(1600 ± 200 kHz)
120k
27 k
20 k
FREQ.
SET TO 12.8 kHz
(8 x 1.6 kHz)
1M
HIGH FOR UP,
LOW FOR DOWN
U10
4024
7-STAGE
BINARY COUNTER
U11
74C164
8-BIT SHIFT
REGISTER
TP2
1600 Hz
−45°
0°
+45°
+90
EXCEPT AS INDICATED, DECIMAL VALUES OF CAPACITANCE ARE IN MICROFARADS (μF), OTHERS ARE IN PICOFARADS (pF OR μμF); RESISTANCES ARE IN OHMS; k = 1000, M = 1000 000.
U5B
U5C
L : DOWN
L : UP
U4C
LOCK ≅
+0.24
∼0.54 V
5.6 k
U5A
100
L : LOCK
15 k
100 k
+5 V
Q1
2N2907
Q2
2N2907
Q3
2N2907
470
DS1
DS2
DS3

Circuit Description

The circuit presented is an adaptation of the Costas loop. Its merits include:

- A frequency lock range up to ±200 Hz
- A lock indicator
- A sense indicator of the received frequency shift
- Output of the sense indicator drives the receiver VCO (if an input port is available) to automatically track the received signal

Fig 1 shows a block diagram of the Costas loop. The multipliers labeled I-, Q- and third form a phase lock loop (PLL) circuit. A carrier signal is applied to the I- and Q-multiplier with a phase difference of 90° to each other. The two outputs connect through the low-pass filters and are introduced to the third multiplier. Its output is then applied to the variable crystal oscillator (VCO) through the loop filter. The data signal to the terminal node controller (TNC) is obtained from the I-multiplier.

It is necessary to receive some indication that the PLL is in a lock condition. While the Costas loop's output does not contain signal amplitude information, the main loop circuit should be designed to include a PLL indicator. The modified circuit operates with applied carrier signals showing a phase difference of ±45°.

The Circuit

Fig 2 shows a block diagram of the demodulator circuit and Fig 3 is the schematic diagram. The multipliers consist of an LM324 op amp (U1) and a 4066 analog switch (U8). The 4046 VCO generates a frequency eight times that of the carrier. This signal frequency is divided by eight and applied to the shift register (U11) to obtain the phase differences of 45° each.

Once the circuit wiring is complete, place a jumper (W1) between points A and B; this makes U9 a voltage follower. Adjust the VCO frequency to read 12.8 kHz, keeping its input reference voltage at 6 volts.

VCO Indicator

If your receiver has the means of driving the VCO from an external source, the following process will go easily.

When the received frequency get higher than the 1600-Hz carrier, the sig nal indicator (DOWN) shows its status an delivers a corresponding output signa voltage. This allows control of the RI receiving frequency and UP signal. Bot of the signals (UP and DOWN) appear o the indicator panel when the frequenc deviates over ±100 Hz. When the receiv ing frequency is correct, the LOCK LEI shows this.

UP and DOWN indicate the deviatio sense only of the input signal frequenc of the demodulator and not of the receive frequency. UP and DOWN will invert ac cording to the sideband being used.

The meter (M1) at U9 is a lock indica tor and is important for frequency tuning Scale this within ±5 volts.

A level indicator aids in setting a prope receiver audio level. Because the Dopple shift of JAS-1 is larger than the lock rang of the circuit, this indicator might b necessary. Any indicator such as an LEI will suffice.

It is better for the UP, DOWN and LOC signals to be arranged for an RS-232-(format. The 12-V power supply should b

---

The Flight of JAS-1
By Shozo Hara, JA1AN
c/o JARL

Project JAS-1 has been in the works since 1983. Flight Models FM-1 and FM-2 were completed in March and November of 1985, respectively, for the August 1 flight. Both models were prepared for launch in the chambers of the NEC Corp near Tokyo.

On June 21, a vehicle with air-suspended wheels transported FM-2 to Tanegashima. Various test and measuring equipment accompanied the satellite on its journey.

The island of Tanegashima is located in southern Japan and is historically famous to the Japanese as the place the matchlock was introduced by drifted Portuguese people more than 400 years ago. In 1986, it was the launch site of JAS-1.

The Japanese National Space Agency launch vehicle, the NASDA H-1, consisted of a two-stage rocket. The propellant of the second stage rocket, that which carried JAS-1 into orbit, was liquid oxygen and hydrogen. The booster is capable of launching 3,968 pounds to an altitude of 932 miles with an inclination of 50°.

Instead of sending a dummy payload on the first H-1 test flight, three missions were onboard: EGP, the experimental geodetic payload, JAS-1 and the magnetic bearing flywheel experiment. About one hour after launch, the second stage rocket flew over South America, where two payloads separated from the rocket sequentially.

The satellite's power supply was activated at the moment of separation from the rocket. The University of Chile agreed to provide assistance and was the first to receive the satellite's signals. About 20 minutes later, JAS-1 flew northward over England. There, the staff at the University of Surrey waited to check the health of the newborn satellite.

JAS-1 transmits its telemetry in CW using the analog transponder, Mode JA. During the initial period, the solar condition of the satellite will be examined. It is requested that listeners do nothing more than this until the operating schedule is announced.

Major Specifications of the Satellite

Orbit: Circular, 1500 km altitude
Period: 116 minutes
Inclination: 50°
Life expectancy: 3 years
Weight: 110.23 lbs
Configuration: Polyhedron of 26 faces covered by solar cells
Size: 15.75 inches (diam) × 18.50 inches (height)
Power generation: 8 W initially

Transponders

Analog (JA—linear)

Input: 145.9 to 146.0 MHz (100-kHz bandwidth)
Output: 435.9 to 435.8 MHz (inverted sideband)
Required uplink EIRP: 100 W
Transponder EIRP: 2-W P-P

Digital (JD)

Input: Four channels—145.85, 145.87, 145.89, 145.91 MHz
Output: 435.91 MHz (one channel)
Required uplink EIRP: 100 W
Transponder EIRP: 1-W RMS
Signal format: 1200-baud PSK, store and forward

Beacon and Telemetry

JA beacon: 435.795 MHz, 100 mW CW or PSK
JD telemetry: 435.910 MHz, 1 W PSK

Orbit Parameters

Epoch: 1986-07-31, 21h 32m 07.20s UT
Semimajor axis: 7879.562 km
Eccentricity: 0.000140656
Inclination: 50.0039′
RA of ascending node: 237.456′
Argument of perigee: 2.155′
Mean Anomaly: 330.246′

well regulated. Current drain is less than 30 mA.

This circuit is small enough (no larger than a standard postcard) to fit inside a TNC. If this is where the circuit will reside, add a switch to the modem to select PSK or FSK.

Automatic Tracking

Perfect auto-tracking of the received signal will be impossible in a band full of interference and noise. First, capture the PSK signal manually. The auto-tracking system can take over once the Doppler shift is noticeable. When the circuit unlocks, try to manually access the satellite one more time. This is a good exercise to determine sensing—whether the frequency shift during lock is going to be up or down. Remember, the circuit has no searching function.

Testing the Circuit

If you own a TNC, construct a PSK signal generator that works with your equipment. A PSK-modulated signal can be generated by the circuit shown in Fig 4. Here, the audio frequency PSK signal is obtained by applying a 1600-Hz carrier signal to the Manchester encoder of the circuit. The PSK signal is used to examine the demodulator at audio frequencies, and the signal can also be applied to the mic terminal of a transceiver to check the PSK demodulator at RF.

Mode selection is easy if you are familiar with your TNC. Work with your system further by using test tapes.

Further development of the PSK demodulator circuit is expected. For additional information contact JAS-1 Committee, c/o Technical Institute, JARL, Sugamo 1-14-2, Toshima-ku, Tokyo, 170 Japan.

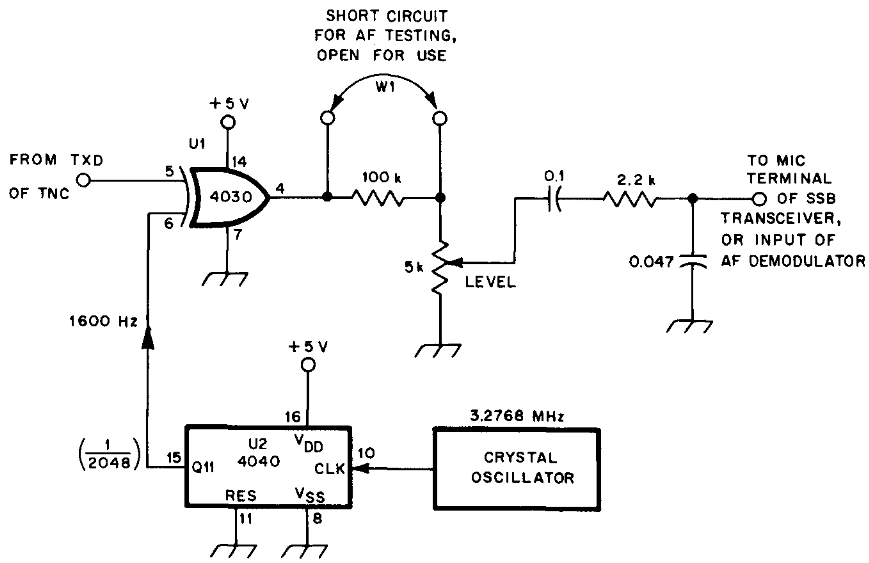


Fig 4—Audio frequency PSK modulation circuit for testing the PSK demodulator.

Bits

Call for Papers

The Fifth International Ionospheric Effects Symposium will be held at the Springfield Hilton in Springfield, VA during May 5-7, 1987. The Symposium is sponsored jointly by the Naval Research Laboratory, Washington, DC, the Air Force Geophysics Laboratory, Hanscom AFB, MA, the US Army Center for Communication Systems, Ft Monmouth, NJ and the Office of Naval Research, Arlington, VA, in cooperation with the Defense Nuclear Agency, the Defense Communications Agency and the Institute for Telecommunication Sciences.

Topics to be covered under the effects on various space and terrestrial systems include communications and direction finding techniques; the topics of ionospheric sounding and probing schemes, ionospheric scatter and meteor burst schemes, adaptive techniques and robust system design will be discussed during the conference on techniques for prediction assessment and mitigation. Phenomena subjects include angle-of-arrival variations, group-path delay, nuclear and EMP effects and absorption and scatter.

Abstracts are to be limited to 500 words or less and should be submitted on or before October 1, 1986. Full papers must be submitted by March 1, 1987—a full preprint document will be given to each attendee. Address all abstracts, correspondence and papers to: Ionospheric Effects Symposium Coordinator, Code 4180, Naval Research Laboratory, Washington, DC 20375-5000.—*KA1DYZ*

Satellite Course Offered

The John Hopkins University Columbia Center in Columbia, MD, will be holding a course on engineering methods and system variations on October 20-23, 1986. The course contents and emphasis is placed on the advantages and disadvantages of communication with satellites. Topics include deep space telecommunications systems and technology, satellite and earth station antennas, coding and cryptology, spread spectrum applications, military and commercial satellite systems and much more.

Enrollment is limited and advanced registration is required. For further information write or call Continuing Education in Engineering, University Extension, University of California, 2223 Fulton St, Berkeley, CA 94720; tel 415-642-4151.

Forthcoming programs for the 1986-1987 season are:

- Advanced CMOS/VLSI, October, Santa Clara
- Digital Telephony and Network Integration, October, San Francisco
- Software Engineering Management, October 6-7, Santa Clara
- Barrier Materials for Semiconductor Fabrication and Packaging, January, Palo Alto
- Designing with Bit-Slice Microprocessors, February, Santa Clara

For detailed announcements of these programs, telephone the Continuing Education in Engineering Office.—*KA1DYZ*

Community Access Stations

By James Eagleson, WB6JNN
15 Valdez Lane
Watsonville CA 95076

[This article was written prior to the report of OSCAR 10's ill health. The satellite is referenced only as an example of the potential that such a communications system as this possesses.—Ed.]

Many potential users of the OSCAR Phase III and Phase IV satellites are unable to communicate through the spacecraft for various reasons. These reasons include budget restrictions, or a lack of technical knowledge or equipment.

It should be remembered that many competent, active VHF/UHF operators began their activities with a Heath Twoer and a coat hanger Yagi! Not exactly what you would call high tech or demonstrative of an overabundant enthusiasm for VHF!

VHF, UHF and OSCARs all have a tendency to generate their *own* enthusiasm when people discover them. The proposal discussed in this article allows amateurs to gather at a common operating site and introduces the amateur space program to those who would not otherwise participate in it. Called a *community access station* (CAS), it consists of a primary operating position for amateurs to use solely for the purpose of accessing the OSCAR satellites.

The Simplest Approach

Fig 1 shows a pictorial of the most basic CAS—a receive only system (CASROS). Let's say we receive a significant portion of the OSCAR 10 passband (145.910-145.930 MHz). This frequency range is chosen because part of the satellite subband, and the 2-m band, offers the best access and exposure to a CASROS. As with a repeater, an elevated station location is important. It allows CASROS to transmit its signals over a greater vicinity, receivable even when mobile.

Once the satellite's signal is ready for retransmit, a 1- to 10-watt transmitter sends OSCAR's signals lower into the 2-m OSCAR space band. A good antenna system includes automatic or remotely adjustable tracking capabilities.

Separation of the transmit and receive sites allows for the required 300- to 400-kHz input/output split. Optimum placement of CASROS is in a quiet, QRM-free location where a large 2-m array won't be subjected to mountain-top weather extremes.

Care must be taken to ensure that the power level radiated from the CASROS is the lowest required for coverage of the area. This helps to reduce interference in the 145.8- to 145.975-MHz band.

Use of the 145.5- to 145.7-MHz segment also allows for use of the CASROS as a *terrestrial* linear translator (LT) during periods when the satellite is accessible. The 145.5- to 145.7-MHz portion of

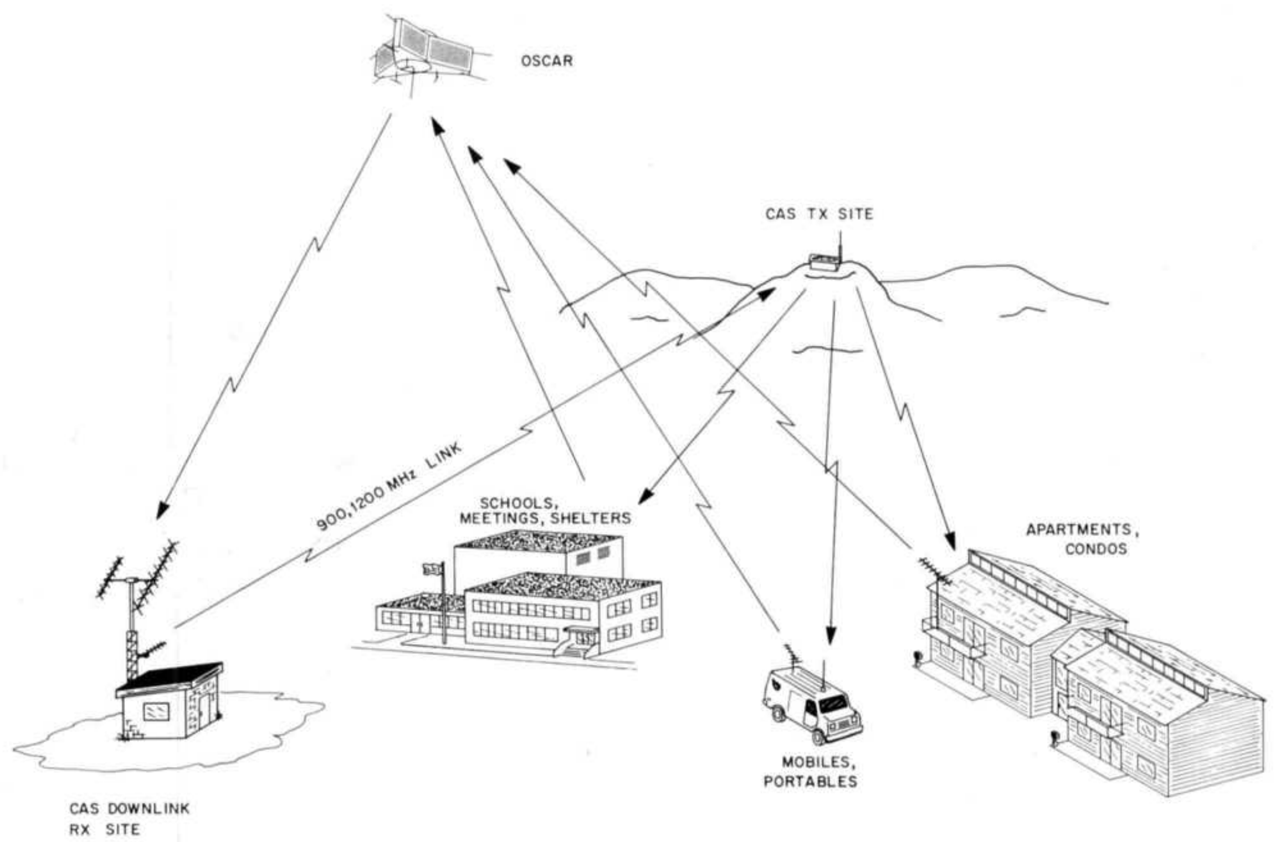


Fig 1—A pictorial of a community access system receive only system.

the satellite band can be paired with 144.9 to 145.1 MHz for this purpose. There should be no conflict between the two uses of the same spectrum; the CASROS is the primary purpose of the system.

Area packet radio coordinators should consider assigning at least one 20-kHz wide channel in the 144.9- to 145.1-MHz spectrum in each region for CASROS activity. This is the only frequency spectrum available for use in the lower end of the space band for in-band linear translators associated with current and future satellites.

CAS Receive Only Uses

The most efficient use of a receive-only CAS is to provide a stronger signal for stations now barely able to hear OSCAR 10. Many Phase III users are presently receiving about a 10- to 15-dB SNR (signal-to-noise ratio). The satellite actually has a 2.4-kHz SNR relative to its own internal noise and is at least 22-26 dB. . . often as much as 30 dB! OSCAR 10 was designed to have a 17-dB SNR across the passband (150-kHz noise bandwidth). Thus, the SNR possible for a given signal is somewhere around 17 + 10 log 150/2.4 or 34 dB below the PEP output of the satellite. Some of this 34 dB is lost because of power sharing, internal intermodulation in the satellite, and so forth, but the actual transmitted SNR of a typical station relayed by OSCAR 10 is at least 20 dB (more likely 25 dB) above the satellite's noise output.

Obviously, then, a typical user hearing only the top 10-15 dB of the satellite's signals is, at the same time, missing the bottom 5-10 dB of usable signals. Signals arriving 10 dB or more over the satellite's own internal noise are lost because the operator does not have enough downlink antenna gain and/or a high noise level present at the reception site. Those operators not hearing a 20- to 25-dB SNR on stronger signals are not hearing weaker, 10-W stations.

If a typical user upgraded from a single KLM 14C antenna (or equivalent) on the downlink to 3 to 6 dB more gain (stacked 14 or 22Cs, for example), more stations could be heard. When I ran 12 watts with a KLM 18C, I often heard myself poorly on my KLM 16C (similar to the 14C), but yet my signals were heard clearly by users of KLM 22Cs or stacked 14Cs! Obviously, 13 to 15 dBc is a good downlink antenna goal and 10 to 12 dBc is marginal.

Stated another way, adding 3 to 6 dB to a signal only 3 to 6 dB above the noise (marginal by anyone's standards) yields a 6- to 12-dB SNR—significantly better reception. That same 3 to 6 dB added to the 10 to 15 dB already achieved when listening to 50- to 100-watt stations yields 13 to 21 dB. This is not as significant as the weak signal case, but places us into a good reception category.

CASROS Enhancement

CASROS provides several benefits for both users and non-users of Phase III satellites:

- The station rebroadcasts the satellite's signal as received at a good location with a good antenna system so that *anyone* can hear the downlink signal with simple equipment. This allows beginners, mobile stations, amateurs residing in antenna restricted zones or noisy locations to use OSCAR.
- It provides the OSCAR user with a known downlink signal which can be used to evaluate one's own site and equipment performance by direct comparison.
- The CASROS accommodates satellite users when the bird is in an inaccessible position.
- Operators using Phase III for gateway (digital) or educational purposes will also find the CASROS useful. Attention can be directed to uplink access rather than both uplink and downlink. Equipment used for demonstrations would consist of a relatively small antenna (eg, KLM 18C) required for uplink, and a receiver with a 2-m antenna. Thought would not have to be given to the location of the demonstration—is it free from QRM?
- The CASROS is its own demonstration. It is active for a large period of time whenever the satellite is visible so that anyone having a 2-m multi-mode radio can tune in the Phase III signals without need of an az-el or circular antenna. A 2-m omnidirectional antenna would only be necessary.

A mobile station within the coverage area of the CASROS can listen to OSCAR 10. Enterprising amateurs have access to the satellite while mobile, using a 3- to 6-dB uplink antenna gain and 100 watts on 435 MHz with the assistance of the CAROS downlink for reception!

Building A CASROS

A basic CASROS consists of a modified 2-m SSB receiver (ie, an old Echo II or an IC-101) that has a 20- to 30-kHz IF crystal filter replacing the 2.4- or 2.7-kHz SSB filter. The BFO crystal must be changed to move the BFO to the lower edge of the new IF filter.

Modify the audio section to pass the entire 300-20,300 Hz (or 30,300 Hz) video output from the product detector. This audio can be sent to the remote transmitter site using 900 or 1200 MHz. Wideband FM is legal at these frequencies. Audio over a range of 20-30 kHz could be passed over a standard 450-MHz channel if a very low modulation index was used with no pre-emphasis. This is not recommended, however. Another alternative would be a 10-GHz Gunnplexer system.

At the CASROS transmit site, the video signal is reconverted to SSB using a doubly balanced mixer, then the signal is passed through an appropriate crystal filter having a 20- to 30-kHz bandwidth. The resulting signal is upconverted to the desired output frequency by a modified 2-m transmit converter. (This could be the transmit section from the unit taken apart for use in the receive portion of the CASROS or it could be a commercial or homemade transverter.) An output of 1 to 3 watts should be sufficient for most sites at high elevations. Up to 10 watts could be used, but higher power should be avoided to prevent potential QRM to direct satellite reception.

Setting up the downlink receiver can be accomplished by feeding its output to a spectrum analyzer or a general coverage receiver at 10.7 MHz (or whatever IF you use). Within the IF bandwidth you should be able to tune any of the several signals present in that portion of the corresponding satellite passband. This provides a good example of the AGC and intermodulation performance achieved.

Ideally, OSCAR Phase III satellites transmit a constant level reference as their beacon frequency. BPSK and RTTY, as currently used on OSCAR 10, provide a constant level, but the standard on-off CW beacon would modulate any AGC developed to use the beacon to eliminate spin modulation.

If the ideal beacon were available, a separate IF tuned only to the beacon using a 1- to 1.5-kHz bandwidth could be used as an AGC channel. This might reduce, if not eliminate, most downlink spin modulation from the CASROS bandpass. The noise bandwidth of a 1- to 1.5-kHz wide AGC IF/detector would allow its sensitivity to be set at about 10 dB better than one acting on the entire passband, and would be able to handle up to about 10 fades per second. This is three times faster than the 3-Hz spin rate of OSCAR 10. Unfortunately, the CW beacon exists for a number of minutes each hour so that any AGC rapid enough to eliminate the spin-fading would also modulate all the signals in the passband with the Morse code signal!

If Phase III C was to have the CW beacon modified to utilize a 1-kHz FSK format, instead of the current on-off format, the beacon could be used for CASROS or CAS-LT AGC purposes. The 1-kHz shift would also provide enough spread to allow zero beating the space carrier for normal CW reception. In other words, tuning the FSK'd CW signal for a beat note between 500-900 Hz would place the non-keyed carrier outside the receiver's passband.

The suggestion to set up the CW in this fashion was passed on to AMSAT. I don't know, however, if it is practical in Phase IIIC preparation and whether it can be implemented with current hardware and software.

Other CAS Systems

There exist other kinds of community access stations. They include CAS-LTs (linear translators) and CAS-MSTs (multiple source translators). One such LT system is currently in service by John Yurek, K3PGP. Development of each system follows logically from the other, but they both possess different strengths and weaknesses.

Community Access Station-Linear Translator

It would not take much to convert a CASROS into a full-fledged community access station-linear translator (CAS-LT). Such a system could provide not only enhanced reception capability, but uplink access to the satellite as well. Thus, low-powered and mobile stations could uplink to Phase III satellites if they are located near a CAS-LT. Fig 2 shows a block diagram of the CAS-LT receiver, an alternative system and a downlink site receiver. Fig 3 shows what a CAS transmitting setup would look like.

Access to OSCAR should be crossband between 2-meters (downlink) and either 220 or 435 MHz (uplink), but that it be outside the 435-MHz satellite uplink band, perhaps at 432.5-433 MHz. ACSSB operation is possible at 220 MHz, but is not the ideal choice because of lack of equipment.

A crossband linear translator would allow users to maintain full duplex operation without the need for a complete OSCAR station. Furthermore, a CAS-LT would require its users to obtain almost half of the equipment needed to directly access Phase III satellites. A basic station requires a 2-m receiver, a 432-MHz transmitter and a small two-meter and 70-cm antenna (perhaps only verticals).

To upgrade to direct OSCAR access, a 435-MHz beam, a 2-m beam (both circular), an az-el rotator system and a 435-MHz 30- to 60-W amplifier is needed.

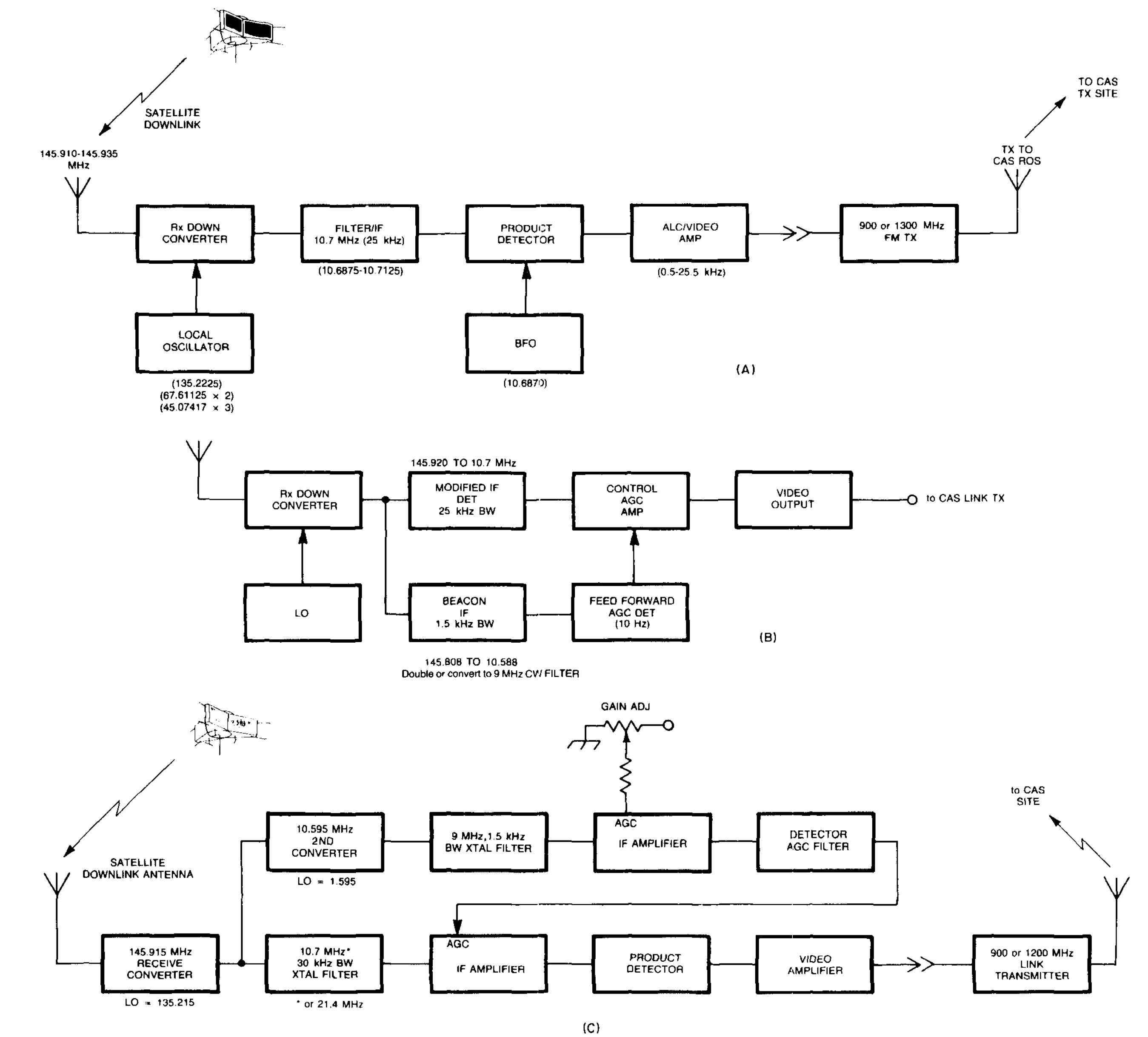


Fig 2—A shows a block diagram of CASROS or the CAS-LT receiver. The block diagram in B shows an alternate CAS receiver. If the beacon equals a 10-dB SNR in a 2.4-kHz bandwidth receiver, it will be about 12-dB SNR at the AGC detector. Further, SNR improvement is obtained from the AGC detector's low-pass filter. Such a beacon-derived AGC should be able to give an 8- to 12-dB AGC control range at 10-dB input SNR. This value will increase with a better input SNR. C is a block diagram of a downlink site receiver.

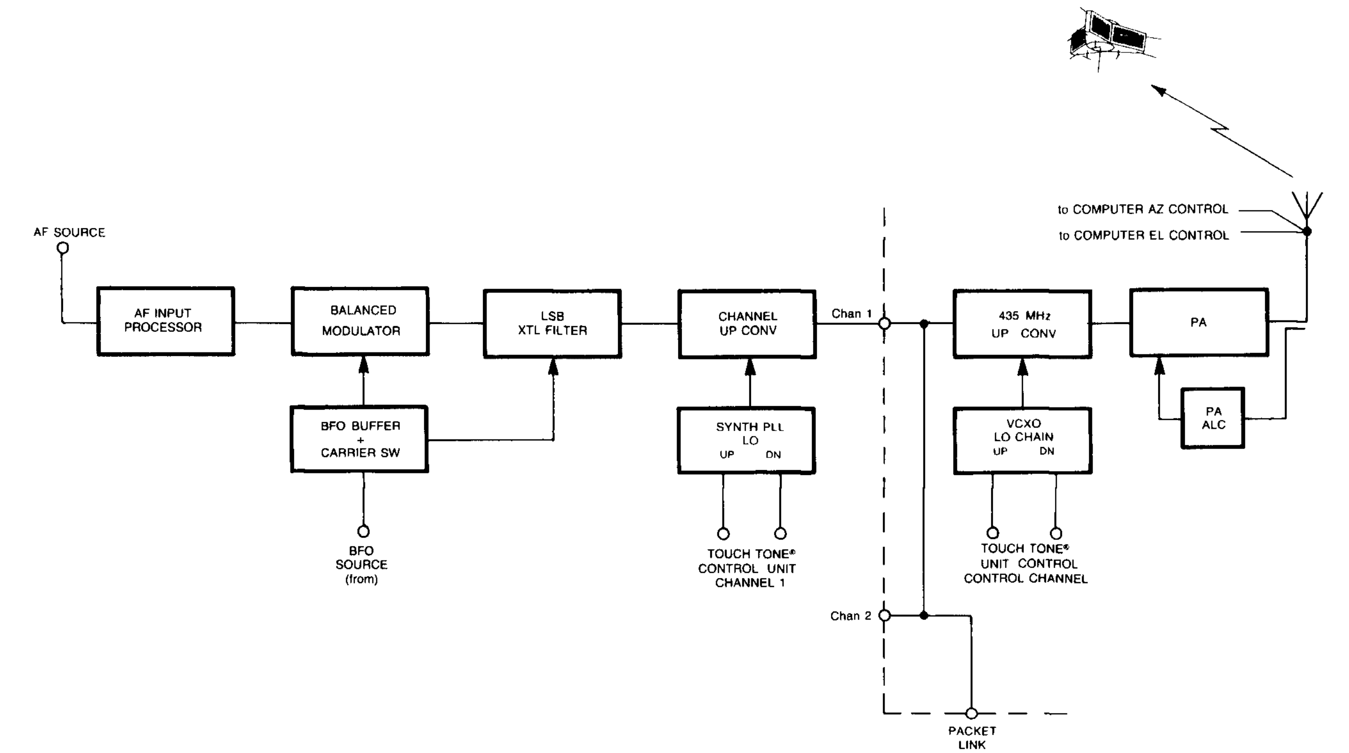


Fig 3—A block diagram of the CAS uplink transmitting station.

Obviously, the cost to try out the satellite through the CAS-LT would be minimal. Two meters is easily accessible and the cost of small antennas for 435 and 146 MHz is moderate. The highest expense would be the 435-MHz transmitter, but this has uses other than OSCAR. Az-el, circular antennas, and the like are much more satellite specific even though circular-polarized beams can also be used with terrestrial systems. The cost increment from a CAS-LT user to a complete OSCAR station is approximately several hundred dollars. Fig 4 points out the needed hardware to operate various stages of the CAS-LT system.

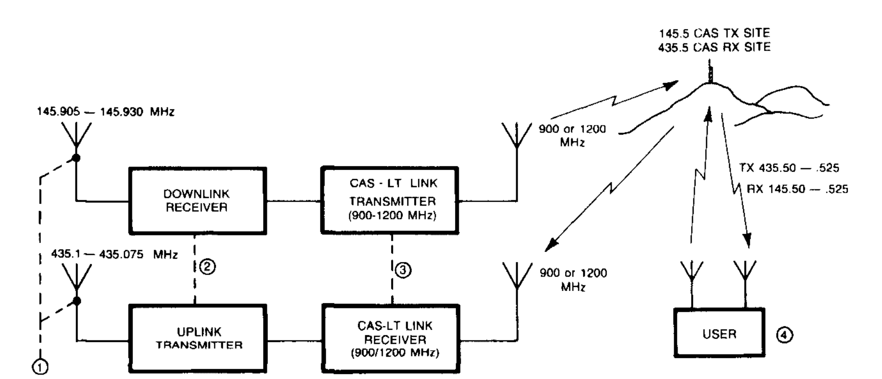


Fig 4—The CAS-LT block diagram. At location 1, the required hardware for az-el tracking includes a 2-m and/or 70-cm beams, az-el rotators, and a computer or remote controller. Location 2 features frequency tracking. The system should be remotely or automatically adjusted to perform its responsibilities. A link system is shown at location 3. It consists of two channels, a separate transmitter and receiver and separate antennas or diplexed.

CAS-LT Design Requirements

The following criteria apply to the uplink and downlink requirements for a CAS-LT. Assume an uplink antenna is equivalent in gain to the KLM 40C (about 13-14 dBd). Each station using the uplink should be budgeted an uplink power of about 25-30 watts. For four stations, the likely maximum for a single CAS-LT, requires an amplifier having a PEP capability of N^2 times 25 W or 400 watts (25 W × (4 × 4) = 25 × 16 = 400 W) where N is the number of stations.

An uplink station supporting three stations could use an amplifier of about 200-250 watts ($N^2 \times 25$ W = $3^2 \times 25$ W = 9 × 25 W = 225 W). A two station system would require only 100 W.

Since the station's speech patterns would not be totally synchronized, some lowering of the PEP requirements can be expected. A two-station system could probably use a 60- to 80-W amplifier. Three stations could share a 150- to 200-W amplifier. Our maximum four-station system could get by with 250-350 W. Care should be taken to use ALC or otherwise limit the PEP to reduce any intermodulation products within the passband to at least -30 dB below PEP levels. This suggests a two-tone third-order IMD capability of at least 24 dB below each tone (30 dB below PEP) at the ALC set point. Thus, an amplifier using 28-V devices, or a tube amplifier of a known low-distortion design, is recommended.

To ensure that no adverse effects are observed on the Phase III satellite, the noise floor of the CAS-LT should be kept to about 35 dB below each 25-W output. Restated, the gain of the LT must be set so that the noise output with or without signals present never radiates enough power to be heard by the OSCAR satellite.

This 35 dB should be referenced to 25 W, not PEP, however, since the SNR *at the satellite* is typically about 20-30 dB for any given station when measured relative to noise in a 2400-Hz bandwidth. The 35-dB figure provides us with a 5- to 10-dB margin of safety to handle spin modulation peaks.

Since the SNR is read on a power meter, the suggested SNR specification must be corrected to allow for the full LT noise bandwidth. Unless output filtering of the IF has been used in the LT, the measuring instrument will see the LT's noise output over the *entire* IF amplifier output bandwidth regardless of its input filter bandwidth (typically 200-kHz wide at 10.7 MHz). The actual bandwidth can be checked by tuning across the IF's output with a receiver or spectrum analyzer to find where the noise drops 6 to 10 dB.

The actual level to measure is 10 log Bo/Br where Bo = IF noise bandwidth (output) and Br = receiver bandwidth (normalized at 2.4 kHz). At a 200-kHz IF noise bandwidth, this is 10 log 200/2.4 = 19.2 dB or, 19.2 dB higher than our 35-dB SNR goal.

Thus, we read a noise output level which is 35 dB − 19.2 dB = 15.8 dB below our 25-W reference level. This would be + 44 dBm − 15.8 dBm = 28.2 dBm or about 650 mW. Any value below this would be acceptable for a 200-kHz noise bandwidth IF.

If the IF amplifier uses output filtering (it should be used), you must take this into account when determining what noise level your power meter will read by using the above formula. For example, if the IF noise output is limited by placing a 30-kHz ceramic or crystal filter between it and the up converter, the amount of noise seen by the wattmeter will be 10 log 30/2.4 = 11 dB above our 35-dB goal.

Thus, our wattmeter reading will be 35 dB − 11 dB or 24 dB below 25 W (+44 dBm). This is 44 − 24 − 20 dBm or 100 mW.

This typical output-to-noise-output level requirement tends to limit the utility of a multi-station LT. Weaker stations are not necessarily going to achieve a full 25-W output from the LT, and they may also arrive at the satellite weaker than other LT users.

There is no way to prevent a single station from uplinking the entire 200-400 watts if no other stations are using the CAS-LT! No AGC/ALC can distinguish between single and multiple stations. During slack periods of satellite use through the CAS-LT, users would be entrusted to lower their power output to avoid excessive uplink power.

Though the CAS-LT features "user transparency" and provides the closest performance to direct satellite access, it has serious drawbacks in terms of protecting the satellite from overpowered uplinks. Only by limiting the system to 100 to 150 watts can we provide adequate control and this would only support two or three stations at a time. In many locations, only two or three stations may use the system at one time. Thus, a CAS-LT in the 100-W range is practical for these areas.

Table 1

Power Output v Antenna Gain
(OSCAR 10 observed under typical conditions)

	Marginal	Average	High Limit	Too High
10W	14dBc	17dBc	20dBc	—
25W	10dBc	13dBc	16dBc	>18dBc
40W	8dBc	11dBc	14dBc	>16dBc
100W	4dBc	7dBc	10dBc	>12dBc
200W	1dBc	4dBc	7dBc	> 9dBc

A CAS-LT is also limited in use by mobile stations and others poorly located relative to the CAS-LT site. Because of the requirement to keep the noise floor at a minimum to prevent uplinking noise to the satellite, note that not all signals will be uplinked at the same power share. Futhermore, a shared IF/AGC prevents use of an AGC specifically designed to reduce flutter on mobiles since it will also affect other stations in the passband.

Viewing the CAS system in these respects, it is not much different than the OSCAR transponders, themselves. One goal of the system is to *optimize* access to the satellite. The CAS-LT has serious drawbacks, but K3PGP's experiments through OSCAR 10 demonstrate that it can be useful.

Using A CAS-LT

Using a CAS-LT is similar to using OSCAR 10. Tune in a signal and transmit on the CAS-LT input at a frequency correlated to the frequency of which you are listening. The desired station is zero beated by listening to your return signal, while transmitting into the CAS-LT.

This makes absolute frequency tracking unnecessary between the CAS-LT input and output passband. These can be kept synchronized using an adjustable VCXO.

Any drift is handled by zero beating your signal. On the other hand, working on the passband edges can be tough because of the satellite's Doppler shift. If left uncorrected, the uplink transmitter passband and the downlink receiver passband experiences several kilohertz of offset. Use of a remote settable VCXO allows correcting this offset problem by the command station.

CASROS Experiments

Project OSCAR is putting together a CASROS system as described in this article. Anyone interested in pursuing a similar system is welcome to write or call me regarding the project. Anyone desiring to donate hardware, software, time, energy or suggestions is also encouraged to make themselves known. Write to James Eagleson, WB6JNN, President, Project OSCAR, 15 Valdez Lane, Watsonville, CA 95076; tel (W) 408-427-2248 (IDX); (H) 408-724-2032 (6-9:30 PM).

Bits

Teledyne Semiconductor Offers Op Amp Design Kit

An op amp design kit that gives designers hands-on experience and in-depth information on a full line of high performance, chopper stabilized op amps is available from Teledyne Semiconductor (TSC). The kit contains the TSC's *Op Amp Handbook*, membership in the Design Support Group which includes no-cost consultation with TSC design engineers, updates on the company's new product developments, free evaluation samples of new TSC products and a full set of application notes.

The kit costs $25 and can be ordered directly from Teledyne Semiconductor, 1300 Terra Bella Ave, Mountain View, CA 94039-7267; tel 415-968-9241.—*KA1DYZ*

Panasonic—An Energy Source

From rechargeables to throw aways, Panasonic is an endless source of energy. Their latest bulletin on batteries consists of many specification sheets that tell the whole story. What application would you use a lithium battery for? What are the features of an alkaline button battery? For these answers and more, write to Panasonic Hq, Battery Sales Div, PO Box 1511, Secaucus, NJ 07094; tel 201-348-5266.—*KA1DYZ*

A High-Resolution Potentiometer

By Albert E. Weller, WD8KBW
1325 Cambridge Blvd,
Columbus, OH 43212

Occasionally, amateur projects require fine adjustments of voltage over a considerable range of voltages. For adjustment over small voltage ranges, a conventional potentiometer padded with series resistors can be used. For large voltage ranges, use a multiturn potentiometer.

An alternative to the multiturn potentiometer can be constructed from a dual- and single-gang potentiometer. Resolutions even greater than with a precision multiturn potentiometer can be obtained.

Fig 1 shows the high-resolution potentiometer circuit. The output voltage is given by:

$$V_{out} = \left(\frac{1 + K}{1 + 2K}Y + \frac{K}{1 + 2K}X\right)V_{in} \quad \text{(Eq 1)}$$

where y and x are the fractional settings of the dual and single potentiometers. If k is small compared to unity, the single potentiometer covers a range of about k times that of the dual potentiometer, and the total range is that of the input voltage.

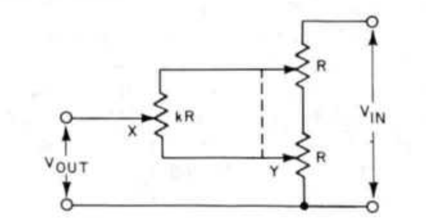


Fig 1—High-resolution potentiometer circuit.

If k is 1/9, the range of the single potentiometer is 1/10 of that of the dual potentiometer. There is no special advantage to such a ratio, however. For the greatest possible resolution, the range of the single potentiometer should be somewhat larger than the resolution of the dual potentiometer. Adjustment of a conventional potentiometer to better than one part in a hundred is difficult. Hence, a value for k of about 1/50 is reasonable. This allows adjustment of the output to about one part in 5000—better than can be done with a 10-turn potentiometer adjusted to one one hundredth of a turn.

The worst-case output resistance of the cascaded potentiometers is $R(1 + k)/4$. The input resistance is constant and equal to $R(1 + k)/(1 + 2k)$.

The scheme can be extended by cascading another dual potentiometer, giving a possible resolution of one part in 250,000. Or, the single potentiometer can be replaced with a 10-turn potentiometer, giving a resolution of about one part in 50,000.

Bits

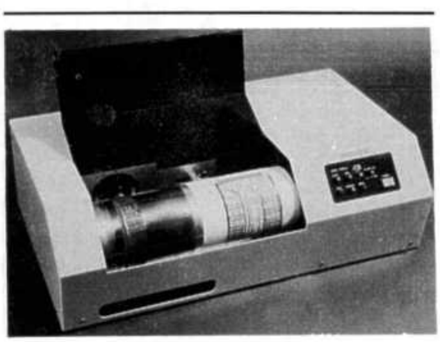
Create Your Own Circuits With PROTOFLEX-III

Girard Electronics of Afton, MN has marketed a system that allows professionals to generate their own PC boards. PROTOFLEX-III produces double-sided PC boards, multilayer circuits and single-sided circuits from 1 oz copper sheeting on a flexible polyimide base. Boards can be prepared for standard or surface mount components.

The machine, shown in the photo, uses a drum to create its circuits. Prepared circuit artwork is afixed on the right side of the drum, while the copper sheeting is mounted to the left. Using an optical scanning system, PROTOFLEX-III eliminates the messy and sometimes hazardous chemicals associated with acid etching systems.

The machine is sold with a computer-aided drafting (CAD) interface which allows the circuit designer to proceed directly from schematic capture to printed board. PROTOFLEX-III is capable of handling material measuring 7 × 16 inches, and machines flexible circuits in 140 minutes or less.

For further information on the PROTOFLEX-III system, contact Girard Electronics, Inc, 13914 Oakgreen Circle South, Afton, MN 55001; tel 612-436-1167.—*KA1DYZ*



(Photo courtesy of Girard Electronics)

JAS-1 Publication Available

Project OSCAR is pleased to announce the availability of *The JAS-1 Satellite Handbook*. Originally available only in Japanese from JAMSAT, this book has been translated into English, and includes all of the important diagrams and information contained in the original book.

The JAS-1 Satellite Handbook is the most detailed publication available concerning the history of the Japanese Amateur satellite program, how to use the JAS-1 satellite, and information about decoding JAS-1 telemetry. For those interested in packet, the schematic diagram to interface with JAS-1, along with alignment instructions, are presented. Information about conducting QSOs on JAS-1 using the analog and digital transponders is included.

Cost of *The JAS-1 Satellite Handbook* is $10; this includes postage and handling. To obtain your copy, send a check made out to Project OSCAR, Inc, and send it to *The JAS-1 Satellite Handbook*, Project OSCAR, Inc, PO Box 1136, Los Altos, CA 94023-1136.—*Ross Forbes, WB6GFJ, PO Box 1, Los Altos, CA 94023-0001.*

Xerox 820-1 Compendium—Part 3

By David W. Borden, K8MMO
c/o AMRAD, PO Drawer 6148
McLean VA 22106-6148

Xerox 820-1 Again

Many AMRAD members purchased the Xerox 820-1 board in 1985 from the Xerox Outlet store in Texas (item now out of stock). Since that time, AMRAD has decided that the computer is another standard model capable of withstanding experimental assignments.

Using software written by Phil Karn, KA9Q, and modified by G. J. van der Grinten, PAØGRI, and myself, I have been transmitting and receiving packets with the Xerox 820-1 single board computer. The software required attention, but before discussing that, let's recall that the Xerox 820-1 board consists of a floppy disk controller and an SIO.

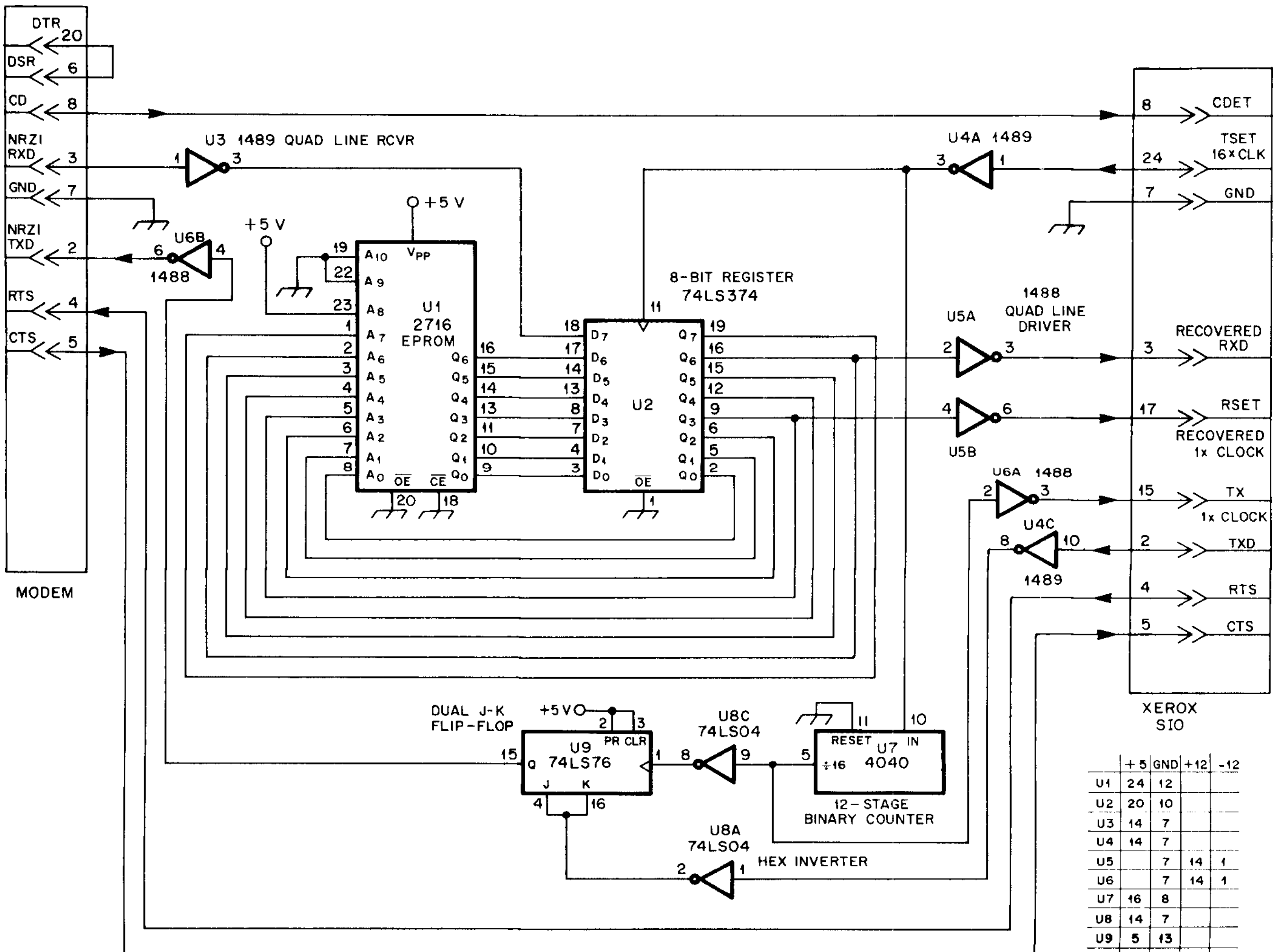
Once I received my package of hardware from the dealer, my immediate task was to find a parallel keyboard to connect to. I used an Apple II keyboard; they are inexpensive and easy to use. One drawback is that the Apple has no curly braces or brackets. This cramped my C coding style and I knew I'd have to find something else.

My disk drives are 5¼ inch Panasonic double-sided drives. They can be obtained from vendors advertising in the back of computer journals (or the *Computer Shopper*[26]). For packet operation, only a single-sided drive is necessary. With a fabricated connector cable, the drives should easily plug into the Xerox 820-1. A DB-37 male connector is available from Electronic Equipment Bank.[27]

Interface Board Receive

The packet device on the Xerox 820-1 is the Zilog SIO. It does not speak NRZI, nor listen to it, thus, an interface board that goes between the Xerox 820-1 and the modem is necessary. NRZI data must be transmitted to the modem and radio, and then received via the same route.

Notes appear on page 16.



	+5	GND	+12	-12
U1	24	12		
U2	20	10		
U3	14	7		
U4	14	7		
U5		7	14	1
U6		7	14	1
U7	16	8		
U8	14	7		
U9	5	13		

Fig 1—The Zilog SIO on the Xerox 820-1 does not understand NRZI code, thus it is necessary for this interface board to be connected between the Xerox board and modem.

Also, it is necessary to recover clock from the incoming data in true synchronous fashion. In the old asynchronous days, the clocks had start and stop bits to synchronize on. In the synchronous world, there are no start and stop bits.

The interface board is shown in Fig 1 and has a varied history. Jon Bloom, KE3Z, built the first in March of 1983. At that time, AMRAD had purchased the ATT Blue/Green Box STD bus computers. They used an SIO, also. Jon built a repeater using these boxes and it is from this work that the receive side was developed—a state-machine decoder. The PROM and latch combination act as a programmed device to extract data clock and normal data from the incoming NRZI data stream.

Interface Board Transmit

A simple circuit for generating NRZI data was found in The FADCA's newsletter.[28] Designed by Sumner Hansen, WB6YMH, the circuit uses an inverter (added by Howard Goldstein, N2WX) and a JK flip-flop to generate the NRZI data from the normal data produced by the Xerox 820-1 SIO. I later added a 4040 divider to obtain 1x TX clock, which the SIO requires. The board uses nine chips that cost about $20. A slight modification of the Xerox board is required to obtain a 16x clock output and power for the board.

Adding Little Wires to Xerox

I wanted to use the SIO on the Xerox board with as little hassle as possible, so I added RS-232-C interface chips to the interface board. To do this, turn the Xerox board over and connect a wire from pin 29 of J9 to the DB-25 SIO connector, pin 24. This is the 16x clock that KE3Z points out as TSET on the schematic.

While you are working on the Xerox board, bring out the +12, −12 and 5-volt lines to the DB-25 SIO connector to power the interface board. This is not required, however. You can purchase an inexpensive board from Radio Shack and steal power from the Xerox board. This interface draws practically no power. Next, pull all jumper plugs on the Xerox board from J9 and place them as follows: 33-34 (1x RX Clock), 37-38 (1x TX Clock), 7-8 (TX Data), 11-12 (RX Data), 15-16 (RTS), 19-20 (CTS) and 27-28 (DCD).

The Prom

The heart of the KE3Z state machine is the PROM. To program your own 2716, burn in the code shown in Table 1.

Table 1
Code for Programming a 2716 PROM

41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	40
03	04	05	06	06	07	08	08	09	09	0A	0B	0B	0C	0D	0E
21	22	23	24	25	26	27	28	29	2A	2B	2C	2D	2E	2F	00
23	24	25	26	26	27	28	28	29	29	2A	2B	2B	2C	2D	2E
41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	40
43	44	45	46	46	47	48	48	49	49	4A	4B	4B	4C	4D	4E
61	62	63	64	65	66	67	68	69	6A	6B	6C	6D	6E	6F	00
63	64	65	66	66	67	68	68	69	69	6A	6B	6B	6C	6D	6E
13	14	15	16	16	17	18	18	19	19	1A	1B	1B	1C	1D	1E
11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	30
33	34	35	36	36	37	38	38	39	39	3A	3B	3B	3C	3D	3E
31	32	33	34	35	36	37	38	39	3A	3B	3C	3D	3E	3F	70
53	54	55	56	56	57	58	58	59	59	5A	5B	5B	5C	5D	5E
51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	30
73	74	75	76	76	77	78	78	79	79	7A	7B	7B	7C	7D	7E
71	72	73	74	75	76	77	78	79	7A	7B	7C	7D	7E	7F	70
FF	FF	FF	FF	FF	FF	FF	FF	FF	(the rest of the PROM is FF)						

Alternatives

There are other ways to design the interface board, but it might not be cost effective. The FADCA designed a small daughterboard containing the 8530, a super chip that is described in the next installment.

Why did I do all this? I want to go fast. Users will discover that fat computer generated packets do not compete well with skinny packets on the same channel. Two channels is not the answer. There are only so many repeaters to link the East Net chain. Bulletin boards are not the answer. The answer is the Level Three Network! That requires speed, at least 49 to 56 kilobaud. Hal Feinstein, N2WX, has done some work on the state machine and believes 44 kilobaud is possible. I intend to use it with spread spectrum on the radio. Alas, it is mostly software that makes the data world go round.

Xerox 820-1 Packet Software

The software runs on a Xerox 820-1 board that has been augmented by the hardware board. The packets are generated by the Zilog SIO residing on the Xerox 820-1. The add-on board generates the NRZI encoding on transmit and recovers clock and data on receive. This is not the only approach to Xerox 820-1 packets. TAPR sells a board which uses the more modern Zilog 8530 SCC and Terry Fox, WB4JFI, is developing software for it.[29] To install the TAPR board, remove the PIO from the 820-1 and plug the daughterboard in place of the PIO.

Here is a description of the code, written by Phil Karn, KA9Q:

"Description of AX.25 'C' Code

Overview

The code currently implements AX.25 Level 2 as defined in the Version 2.0 document (as released by the ARRL Ad Hoc Digital Communication Committee). This code contains a number of extensions to AX.25 which are new to Version 2.0 and, to my knowledge, is the first AX.25 implementation to do so. These include:

- Idle link keep-alive polls (timer T3)
- Acknowledgement delay (timer T1)
- "C" bits and correct P/F bit usage according to LAPB (link-access-protocol, balanced)

Item three is upward compatible in that it is not used whenever the software detects an "old" (ie, pre-Version 2.0) implementation of AX.25 (which includes all other AX.25 implementations). The keep-alive polls require proper use of the P/F bit and will not be sent to an old implementation.

This code also supports multiple simultaneous logical links. This is an implementation rather than a protocol issue;

it involves keeping individual "link descriptors" for each station, and uses a hash lookup algorithm to find the appropriate link descriptor whenever a frame is received. Support is also provided for multiple physical HDLC ports so that more than one channel can be used.

These extensions required me to separate and classify the commands and parameters (from a unit like the TAPR TNC) into groups that are applied on a per-link, -line or -terminal basis as appropriate.

Digipeating works, but repeats a frame only on the physical link on which it was received. With relatively little work, it would be possible to do cross-channel digipeating, although with the work underway to define and implement higher level protocols, it is not clear this is a "clean" thing to do.

A number of things in the TAPR TNC are not here. Some of them, such as CW identification and the Vancouver protocol haven't been implemented."

Software Description

General

All I/O is interrupt driven. Full use is made of the 820-1's interrupt capability; queues are emptied or filled with characters going to and from the terminal and SIO. A top-level loop in main.c executes higher-level functions which operate on the "other ends" of the interrupt queues. The CTC timer ticks at a 10-Hz rate and provides all real-time functions. A halt instruction at the end of the main loop causes the CPU to wait until an interrupt occurs; this might help reduce RFI and/or power consumption on a CMOS version of the Z80. It also makes possible the use of a "CPU speedometer" which monitors the HALT line from the CPU and indicates the amount of real time being used by the software.

Review of Software

Phil's description, only partly reproduced above, also speaks of each routine and how it works. In the software trade, we call this a three-banana program: 1) the coding is finished, 2) the program works and 3) it is documented. I find the program a joy to use. At first, I experienced trouble with bugs. I received a finished version of the program, but not before it was tested. I found that it would not send full packets. The last three characters were trashed as the RTS line was lowered and output ceased. Phil later visited AMRAD and brought a fixed version that worked properly.

Vancouver Code

I ran a wire across the room and placed Bell 202 modems at both ends. A Xerox 820-1 was connected at one end and a Vancouver board (with an AMRAD daughterboard attached) was at the other end. What a test! In a quick summation, the Vancouver board does not handle the new version 2.0 AX.25 protocol SSID field or P/F bit. KA9Q added two quick fixes to allow for communication with the Vancouver boards. I then moved the clip leads from the Xerox 820-1 modem to the radio interface and fired up on 145.01 MHz.

On-The-Air Testing

I connected with several operators on 145.01 MHz. Phil's code worked swell. The software allowed a full trace of what was happening on the channel. Both outgoing and incoming frames were traced (as desired) and each frame type was announced along with desired bits broken out so you can see if the other station was sending the right stuff.

Multiple Connections

Multiple connections is required for networking and it would be neat for network servers to use them too (allowing data base access or download to multiple users). I connected with two packet users at one time and tried to carry on two conversations. The software worked well. I went into the command mode and ordered the software to "convers WB4JFI-2," then I typed data to Terry. Later, I typed a control-C followed by a carriage return to go back to the command mode. I entered "convers AJ9X-0" and transmitted information to Mike. The software enabled me to type to Mike and faithfully receive frames from Terry, simultaneously. When I got back to Terry, the frames flooded the screen.

The Zilog has two channels and Phil's code addresses both. I said we could have multiple connects on channel A, well, channel B is there also. How about receiving a file in the transparent mode on channel B while discussing the file on channel A with the file server, when you are also connected to another user on channel A? How much can your brain handle? There is more. How many modems and radios do you have?

There is something else you could do with channel B that is addressed in the description above. Take in all the packets from 147.21 MHz and put them out on 145.01 MHz, and vice versa. That is a packet switch! As Phil points out, this is cheating. We need AX.25 Level 3 or another protocol. However, remember both channel A and B could have multiple connections. The mind boggles.

[Dave Borden, K8MMO, continues to share his enthusiasm about the Xerox 820-1 board in Part 4 of the Compendium. K8MMO presents an ICOM IC-2AT connection and Terry Fox, WB4JFI, talks about a FAD and a modem.]

Notes

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

[27]Electronic Equipment Bank, 516 Mill St, NE, Vienna, VA 22180, tel 1-800-368-3270, VA residents only 703-938-3350.

[28]*The Beacon*, Mar 1984, The Florida Amateur Digital Communications Association, Gwen Reedy, 812 Childers Loop, Brandon, FL 32511.

[29]TAPR, PO Box 22888, Tucson, AZ 85734.

Bits

FCC Cracks Down on Illegal Microcomputer Operations

If you have recently purchased a clone of your favorite computer, or are planning to, there is one thing you should know: Federal law prohibits computers and other electronic devices from emitting transient radio waves that interfere with radio and television reception. This is a four-year old ruling that many manufacturers choose to ignore!

If your purchase does not exhibit an FCC label, you have the right to return the computer to your dealer and ask for a replacement. It is not only illegal to manufacture and sell these interference-causing appliances, but the user can be fined or imprisoned if an interference complaint is involved.

Thus far, the FCC has been shaking illegal manufacturers out of the trees. Many small-based operations, including mail-order firms, can't afford to pay the price once they're found out—afford FCC approved parts or $5,000 and the two months it takes to test the machine for FCC approval.

Cautious buyers should check the physical appearance of the computer before purchase. Are the mating surfaces flush, tight and clean of paint? Is the case metal or metal shielded with no holes? The cables should be shielded and the cable connectors flush, tight and shielded. The internal electrical connections should be clean, tight and paint free. The microprocessor should also be shielded. These are only some of the steps manufacturers may take to eliminate microcomputer radio interference.

You can fool some of the people all of the time, and all of the people some of the time. By exposing sales schemes such as these to potential buyers, we can only hope to revise the sentence to read. . . you cannot fool all of the people all of the time!—*Maureen Thompson, KA1DYZ*

[Some of this information was excerpted from J. Forbes, "FCC Cracks Down on Micro Emissions," *InfoWorld*, May 12, 1986, Vol 8, Issue 19, p 1, and P. Chabal, "FCC Warns Owners of Illegal Micros," *InfoWorld*, May 19, 1986, Vol 8, Issue 20, p 5.]

By Bill Olson, W3HQT
Box 1655A, RFD 1
Burnham, ME 04922

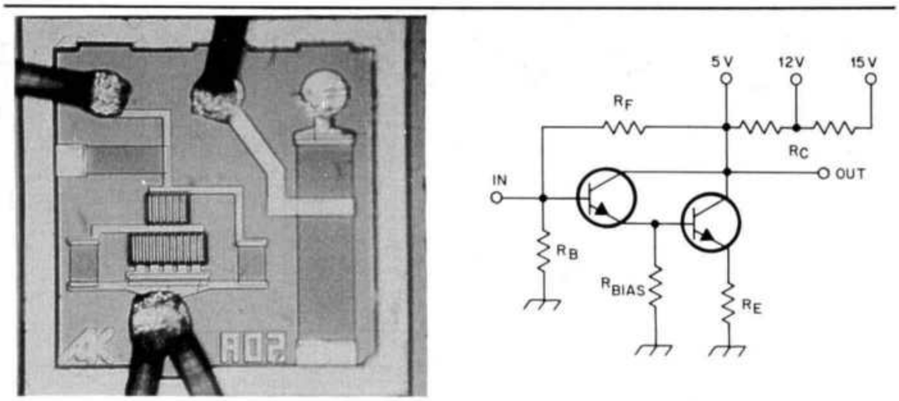
MMICs: Gain Blocks for Modern Equipment

Last month I finished a discussion on RF transistors. Before going on to other areas of interest to VHFers, there is one other semiconductor that warrants some discussion. In a few short years this device has made an enormous impact on the RF and microwave electronics industry. The *monolithic microwave integrated circuit*, or *MMIC*, has qualities so impressive that they were only imagined 10 years ago. Imagine a packaged device that has the following specs:

1) Usable broadband, linear gain to more than 3 GHz.
2) Single-voltage power supply.
3) Linear power output to 50 mW.
4) Resistant to RF input overload, bias voltage overload, bias polarity reversal and electrostatic discharge.
5) 50-ohm input and output impedance.
6) Stable over a wide range of input and output impedances and therefore cascadable.
7) Small size.
8) Priced under $3 and available!

The Avantek MSA0104 through MSA0404 "Modamps" are such devices and are an RF designer's dream. These silicon RF ICs are basically RF Darlington pairs with resistive negative feedback, all processed on a single chip and packaged in a plastic micro-x package.

Pick up any of the microwave or RF trade journals these days and you'll read about MMICs. They're the wave of the future. There are silicon and GaAs MMICs by a number of manufacturers, factories that specialize in custom MMIC fabrication, special computer software for designing MMICs—you get the idea. The first such device that I can recall came out in early 1982, manufactured by CTC in their last months of existence. Known as the MPA-201 "Unit Amplifier," this device was packaged in a 0.4-inch-square microwave flange package. It consisted of a Darlington pair of devices similar to the CTC 2001 2-GHz transistor. Capable of putting out around half a watt from dc to 500 MHz, it was the forerunner of things to come. In late 1982 Avantek announced their MMIC and the race was on. Silicon devices are now available from Avantek and NEC, and GaAs devices are available from NEC, Siemens (MSC) and others. While the GaAs devices have inherently lower noise figures, they are more expensive. The silicon devices definitely have the most "bang for the buck."



(A) (B)

Fig 1—The photograph at A shows a 0.010-inch-square MMIC chip. The input bond is at the top left. The double bond near the bottom is ground. The output/collector is the back of the chip, which is also connected to the metallization around the top of the chip. The schematic diagram at B shows the circuit for an Avantek MMIC. R_F is a negative feedback resistor and R_C is an on-chip decoupling resistor for optional 12- or 15-V operation. The other resistors form the bias network.

What is It?

Fig 1 shows a microphotograph of an Avantek MMIC chip and the associated schematic diagram. Besides the Darlington coupled transistors, the chip contains thin-film feedback and bias resistors all on a 0.010-inch-square chip! The resistor values and transistor parameters have been computer designed to provide stable gain that is constant with frequency (up to the point that chip and package parasitics start to cause a smooth rolloff), and 50-ohm input and output impedances. Not bad for a little chunk of sand, eh? It looks very simple, but keep in mind that it took the latest high frequency processing techniques and the latest computer transistor modeling tools to make such a "simple" device possible.

Where Do We Use It?

Since the negative feedback makes the noise figure of a MMIC quite high—compared to modern standards anyway—the most obvious use is in low-level transmitter stages. For receiving gain stages where high noise figure is not a problem, such as in front of passive mixers and filters, MMICs do a fine job. See Figs 2 and 3.

A less obvious use is to get back gain sacrificed in "cleaning up" a signal. For example, since a doubly balanced mixer likes to be terminated on all ports with 50 ohms for best linearity, we can terminate the mixer ports with 50-ohm pads and get the gain back with MMICs as shown in Fig 4. We could also filter a local oscillator with a very sharp (and probably lossy) filter for a nice clean LO and make up for the filter loss with a stage of MMIC amplification!

Remember the old microwave signal sources? Old handbooks show a low-

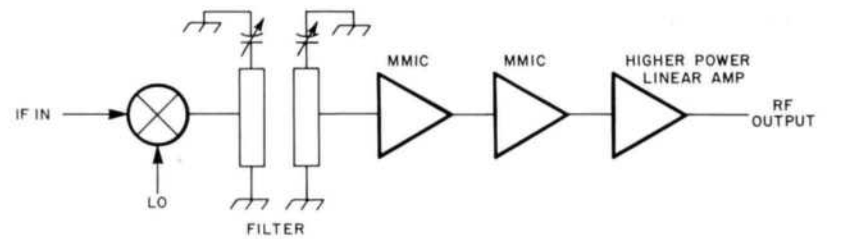


Fig 2—A natural MMIC application is in low-level transmitting amplifiers.

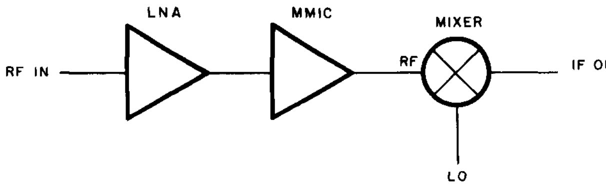


Fig 3—Although MMICs have relatively high noise figures, they can be used as receiver gain stages after a low-noise front end.

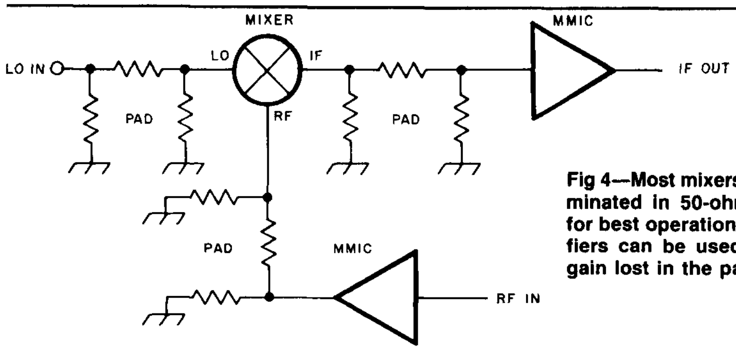


Fig 4—Most mixers like to be terminated in 50-ohms, resistive, for best operation. MMIC amplifiers can be used to make up gain lost in the pads.

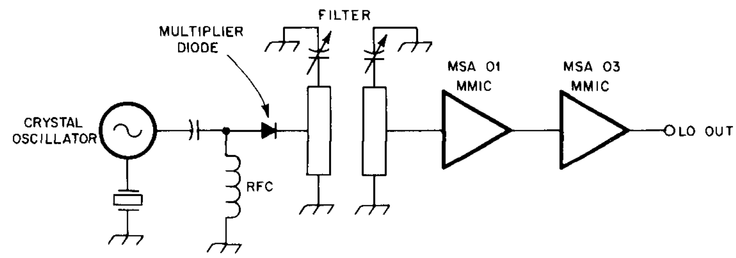


Fig 5—MMICs can be used to simplify microwave local oscillator construction. Just build a low-frequency oscillator (50-100 MHz), hit an inexpensive multiplier diode, filter all unwanted harmonics and use MMICs to bring the level of the desired signal up to something useful. This approach eliminates all tuned multiplier stages.

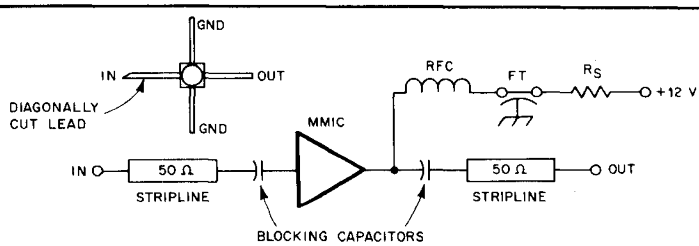


Fig 6—Typical MMIC application. Use the shortest leads possible, especially for the ground leads. The RFC should be approximately series resonant. Some values that work are 4T for 1.3 GHz, 2T for 2.3 GHz and 1T for 3.4 GHz. All RFCs are no. 30 enam wire close wound and are 0.10 inch ID. R_s should be adjusted for proper quiescent current. Starting values for Avantek MMICs (12-V operation) are:

Device	*R_s (Ohms)*	*Device*	*R_s (Ohms)*
MSA01	**390**	**MSA02**	**270**
MSA03	**180**	**MSA04**	**120**
MSA08	**220**		

Table 1
Avantek MMIC Characteristics

Type (MSA-)	*Package Style*	*Gain @ 100 MHz (dB)*	*50-ohm Noise Figure (dB)*	*Max Usable Freq (GHz)*	*Pout @ 500 MHz 1-dB Gain Comp (dBm)*
0135-21	Micro-X	19	5	3	1.5
0235-21	Micro-X	12.5	5	3	4
0335-21	Micro-X	12.5	5	3	10
0435	Micro-X	8.5	5	3	13
0104	Macro-X	19	5	3	1.5
0204	Macro-X	13	6	3	4
0304	Macro-X	13	6	3	10
0404	Macro-X	8.5	6	3	13
0835	Micro-X	30	3	6	13

frequency oscillator (around 50-100 MHz) driving a cheap diode (1N34 or 1N914), fed into a high-Q troughline or stripline filter. What came out was adequate to use as a receiving signal source and not much more—a couple of microwatts.

With a couple stages of MMIC amplification after the filter, *bingo* we have a clean LO. See Fig 5. In my experience, one of the trickiest things to get working in any ham gear is an active multiplier. The triplers double, the doublers quadruple, and so on. Now you just have to pull your hair out getting the oscillator running—there are *no* active multiplier stages. The frequency is determined by the oscillator frequency and the mechanical dimensions of the filter.

Remember, MMICs are almost unconditionally stable and are 50 ohms in and out. Just line up as many as you need to get the signal to the desired level. It really is that simple!

Tips for Using MMICs

Avantek silicon MMICs come in several different packages and package configurations. The basic package types are the 70-mil-square ceramic package; the micro-x, fourlead, low-cost ceramic package; and the newest macro-x, molded plastic, four-lead package. The ceramic versions have higher gain and broader bandwidth, but are more costly.

The typical MMIC application configuration is shown in Fig 6. The devices most suitable for amateur use have two ground leads. They require around 5 V to operate and will run off a 12-V supply through a decoupling RF choke and a dropping resistor. The dropping resistor also adds some temperature stability. There is a version with only one ground lead and a separate 12-V supply lead. These MMICs can be used with no external choke and dropping resistor, but they have lower gain and bandwidth. Table 1 shows performance of several different Avantek device types.

Whereas new, state-of-the-art devices have in the past been around for many years before they were affordable to hams, the silicon MMIC seems to have gone from a laboratory curiosity to a high-volume, low cost device almost overnight. Undoubtedly the GaAs MMICs will follow in this trend. The Siemens CGY-40 looks promising as a relatively low-noise, high-gain amplifier for up to 3 or 4 GHz.

It staggers the imagination to think about what might be next. There is already a next generation of MMICs with local oscillator, mixer and RF and IF GaAs FET amplifiers all on a single chip. Imagine a complete 3.4- or 10-GHz receiving converter in the same package style as an MRF901 transistor! It's really not that far fetched!

Next month I'll get down to some *serious nuts and bolts stuff. Until then, keep those cards and letters coming!*

Intellectual Properties

By Bill Conwell, K2PO
16th Floor, Willamette Center,
121 SW Salmon St,
Portland, OR 97204

Trademarks

Given the choice, which would you buy: a Rockwell Collins transceiver, or a similarly equipped, similarly priced unit by Acme Manufacturing Industries? How about a choice between a Bird wattmeter or a comparably priced unit by Amalgamated Trading Co?

Other factors being equal, your decisions would likely be influenced heavily by the brand names of the products. This is not an irrational response. Certain characteristics, such as quality, performance and reliability, are often associated with particular product brand names. As such, brand names, or "trademarks," provide useful information to consumers making purchasing decisions.

Because of their importance in purchasing decisions, a trademark can be a company's most valuable asset. Consider the case of Tektronix, the test equipment manufacturer. If all of Tektronix's manufacturing facilities burned down tomorrow, it could doubtless borrow money from a bank to rebuild based solely on the consumer goodwill associated with its name. If, on the other hand, Tektronix were ordered to cease use of the mark "Tektronix," the company would be cast among all the other no-name manufacturers in the competitive test equipment market and might not ever recover.

For the merely curious consumer, this month's column will answer some of the frequently asked questions about trademarks. For the garage shop entrepreneur, it will point out some of the common pitfalls and misconceptions.

Choosing A Trademark

A trademark can be any word, name, symbol or feature used by a company to identify its products and distinguish them from the products of others. Corporate names, such as Tektronix and Larsen, are often used as trademarks. Conventional words (Argonaut, Grandmaster), made-up words (Kulrod) and alphanumeric combinations (QST, FT101, TH6DXX) are also often used. Some companies have adopted different types of trademarks, such as the three-tone NBC chime and the well-known Chevron stripes. All of these devices serve to identify the origin of the products or services with which they are used.

For new businesses selecting trademarks, a common mistake is to base the selection on the trademark's appeal alone, without regard to potential conflicts with other marks. One of the corallaries of Murphy's Law is that if you think a particular word would be a good mark for a product, someone else has probably beat you to it. The costs of changing marks after a product has been introduced can be high, both in terms of money and opportunity cost. Changing names in midstream can sometimes be fatal to start-up companies in rapidly developing markets.

Another common mistake is in confusing the registration of a corporate name by the state government with the aquisition of trademark rights. Merely because the state accepts a registration of a company name does not mean that the company can use that name on its products. For example, here in Oregon, there is not presently a company registered under the name Yaseu, so it would be a simple matter for me to incorporate a business under this name. However, Yaseu Musen Corp would likely take a dim view of me marketing amateur radio equipment under that name and would very likely seek to stop such activity.

In choosing trademarks, then, the first rule is to avoid all marks already used by others for the same goods. This alone, however, is not enough. Also to be avoided are non-identical marks that might be confused with the trademarks of other companies used on the same or similar goods or services. For example, some years ago a company decided to sell electronic control panels under the mark Tek Associates. Tektronix understandably was concerned about customer confusion and succeeded in preventing registration of the phrase Tek Associates as a trademark at the US Patent and Trademark Office.

Sometimes the owner of a trademark loses its bid to prevent others from using arguably similar marks. Several years ago, Fisher Radio Corp tried to prevent Bird Electronics Corp from registering an illustration of a flying bird as a trademark for use on wattmeters. Fisher was using a logo of a flying bird carrying a musical note in its beak as a trademark on its hi-fi equipment, and was concerned that Bird's use of a bird illustration on its electrical equipment might cause customer confusion. The Patent and Trademark Office decided that customer confusion would be unlikely and allowed Bird to register its trademark over Fisher's protests.

Sometimes, a mark can be adopted for a product even if the identical mark is already in use by someone else, provided the products offered by the two companies are sufficiently different. For example, Quick Service Textiles, Inc of Chicago, Il adopted and federally registered the mark "QST" for use on textile fabrics in 1971 without objection from the ARRL. Similarly, the use of "TR7" by Drake on transceivers and "TR7" by British Leyland on sports cars is sufficiently different as to avoid the likelihood of customer confusion.

Choosing a mark that does not conflict with existing marks requires considerable research. Most companies hire trademark attorneys to research potential marks and steer them clear of trouble. The trademark attorney usually checks the marks by commissioning a search of one of several private trademark libraries. Such libraries typically include trademarks registered by the Patent and Trademark Office, trademarks registered by each of the states, selected Yellow Pages telephone listings nationwide, large collections of industry, trade and advertising indexes, and proprietary trademark databases. The trademark attorney then evaluates the search results for possible conflicts. Although this search procedure is not infallible, it provides a good basis on which to make a trademark selection.

Registration

Rights in a trademark begin immediately with proper use. Registration with the state or federal government is not required. There are, however, several advantages to such registration.

Registration at the state level is quickly accomplished by filing the necessary documents with state authorities. Once registered, the mark will show up in trademark data bases and can discourage others from choosing a similar mark. In some states, a state registration can enable the registrant to collect attorneys' fees and enhanced damages from infringers.

Several further benefits are provided by registering a mark at the federal level. A federal registration serves to notify everyone, nationwide, of the registrant's claim to ownership in the mark. It also gives the registrant extensive remedies against infringers which can, in some cases, include the destruction of infringing goods and the recovery of the infringers profits and the registrant's losses. These monetary awards can be tripled in some instances.

Obtaining a federal registration can be somewhat complex. Since the grant of a federal registration is akin to a limited monopoly on the use of a word in connection with certain products, the Patent and Trademark Office has a number of strict requirements. One such requirement is that the mark not be descriptive of the product generally. For example, several years ago Kellogg's sought to register "Raisin Bran" for its bran cereal with raisins. The Patent and Trademark Office refused, not wanting to remove these common words in their common usage from the language and dedicate them to Kellogg's exclusive trademark use.

Applications for federal registration can be rejected on a number of other grounds. Some of these include: likelihood of confusion with an existing mark, the mark being deceptive, the mark being the name of a living person whose consent is not of record, improper use of a mark, failure to comply with applicable government regulations such as FDA labeling requirements, and so on.

More than 90% of all federal trademark applications are rejected initially. The applicant's trademark attorney then argues back and forth with the Trademark Office until the mark is approved or finally rejected. If approved, the Trademark Office publishes the mark in the Trademark Gazette for opposition. The public then has 30 days within which to object before the registration issues. Assuming only minor difficulties are encountered, the federal registration process generally takes about a year.

Maintaining Trademark Rights

Rights in a trademark persist as long as the trademark is properly used. Some marks, such as Crosse and Blackwell for packaged food products, have endured for centuries.

A mark can be abandoned by nonuse, or lost by misuse. Misuse of a mark generally consists of widespread public use as a noun, rather than as an adjective. The use of "a xerox" to refer to a photocopy is an example of such misuse. Used as a noun, a trademark no longer serves to identify the origin of a product, but rather serves as the name of the product. Examples of marks lost by widespread misuse include the now generic words: escalator, yo-yo, dry ice, kerosene and aspirin. (Aspirin is still a valid trademark of Bayer for acetylsalicyclic acid in some foreign countries.)

Some familiar trademarks are presently flirting with loss by misuse. Examples include Kleenex for Kimberly Clark's brand of facial tissue, Xerox for Xerox Corp's brand of copying machines and Band-Aid for Johnson & Johnson's brand of adhesive bandages. These companies are very careful to use their marks exclusively as adjectives in advertising and product packaging in an effort to encourage proper use by the public.

To highlight the trademark status of a word, many companies denote the word when printed as being a trademark. If the mark is not registered anywhere, but the owner wants to indicate a claim of trademark status, the mark can be labelled with a "TM" or with a footnote stating that the word is a trademark. If the mark has been registed in a state, it can be labeled with a "TM" or with a footnote stating that the word is a registered trademark. If the mark is federally registered, the mark can be labeled with an ® in a circle or with a footnote stating that the word is registered at the US Patent and Trademark Office. In addition to these measures, the first letter of a trademark should always be capitalized to designate its status as a proper, rather than a common, adjective.

The above discussion, of course, only barely scratches the surface of the trademark topic. It may, however, provide some insight into the inconspicuous ® that pervades our hobby and our society.

Bits

FCC Trying to Accommodate ACSSB Users

Almost one year after the FCC officially recognized ACSSB in Docket No. 84-279, the technology continues to evolve less rapidly than anticipated. The level of interest and use of ACSSB continues to grow each month, but according to marketing, not fast enough for profits.

One reason for this sluggish growth is that manufacturers have not been promoting the advantages of using ACSSB. Most ACSSB equipment remains physically bulky and expensive. Manufacturers of conventional radio systems use the newest technology available to minimize size and reduce the production cost of their product. Also, the technology must compete against a 50-year old widely accepted mode of communication—FM.

The first Notice of Proposed Rulemaking reviewed by the FCC set aside spectrum space in the 150-MHz band for ACSSB. According to several officials of land mobile communication industries, ACSSB in the 150-MHz band won't work. Most land mobile communications takes place at a high frequency, but there congestion and interference frequently exists. No amount of frequency monitoring, filtering or any other technical solution can smooth the ACSSB signal in such a hostile environment. The FCC needs to assign spectrum space solely for ACSSB! Field tests and experiments have proven that an ACSSB system, operating at its full potential in a free, uncongested area, is among the superior type of land mobile communication system available. More coverage is achieved with less power.

On May 13, 1985, the FCC added a petition to the Public Notice concerning an ACSSB reallocation of 4 MHz of the 216- to 220-MHz band to the Private Land Mobile Services. Industry, thus far, has come forth to support and comment on the FCC's ruling. As individuals in the FCC, industry and the public reeducate themselves about the benefits ACSSB has to offer, its popularity is certain to increase.—*Maureen Thompson, KA1DYZ* [The above information was excerpted from L. Testa and P. Murray, "ACSB Still Fighting for Acceptance One Year After Official FCC Recognition," *Radio Communications Report*, June 1, 1986, vol 5, no. 11, p 46.]

Static in the Workplace

Static charges in the work environment has ruined more projects than one can imagine. In the electronics industry alone, it is a fact that static electricity generated through a human body damages certain microcomponents. How, then, can you protect your devices from that devastating blow? The Static Control Systems Division of 3M offers an annual catalog that lists numerous products designed to control static charge. Special protective floor and table mats, tapes, shipping packages and even educational materials are available. For your copy of *Total Control of the Static in Your Business*, contact the Static Control Systems Division/3M, 225-4S, 3M Center, St. Paul, MN 55144.—*KA1DYZ*