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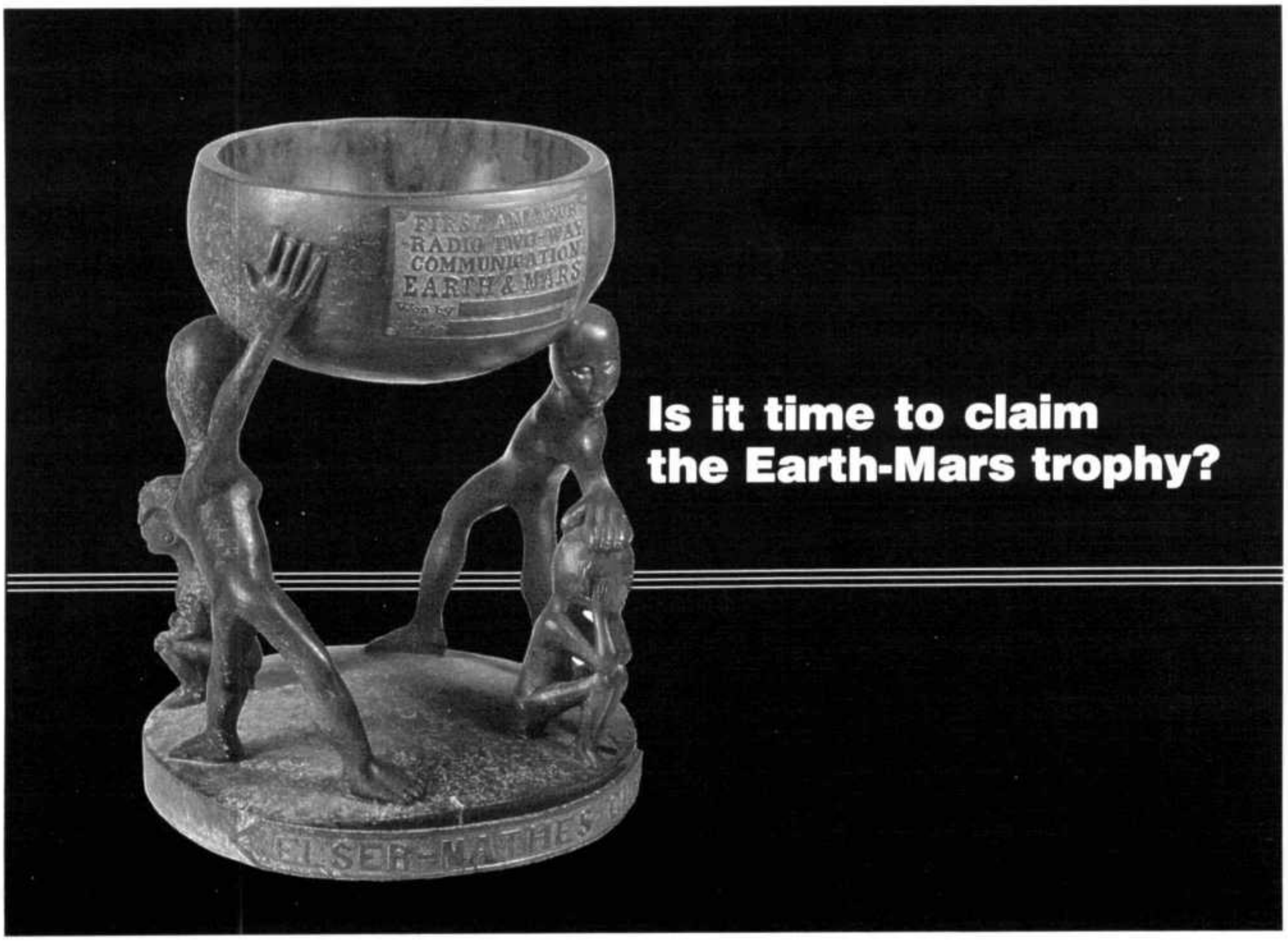
SEPTEMBER 1991



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COLUMNS

On the cover:
The cover photo is the Elser Mathes Cup conceived by Col Fred Elser, K3AA, and Lt Col Stanley Mathes, K1CY, while stationed in the Philippine Islands in 1928, for the first two-way amateur communications between Earth and Mars. See page 2 of this issue for a possible way of winning this cup.

SEPTEMBER 1991 QEX ADVERTISING INDEX

THE AMERICAN RADIO RELAY LEAGUE, INC

The American Radio Relay League, Inc, is a noncommercial association of radio amateurs, organized for the promotion of interest in Amateur Radio communication and experimentation, for the establishment of networks to provide communications in the event of disasters or other emergencies, for the advancement of the radio art and of the public welfare, for the representation of the radio amateur in legislative matters, and for the maintenance of fraternalism and a high standard of conduct.

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

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

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

Empirically Speaking. . .

AMSAT-UK Colloquium—The Sixth

Too bad, if you missed this event in Guildford, England at the University of Surrey. The irrepressible Ron Broadbent, G3AAJ, pulled together this group of 135-odd people (I know, some odder than others) from all over planet Earth.

The UoSAT gang had recently given birth to a new satellite, UO-22, which had been fully commissioned by Colloquium time. But for those who think only in futuristic terms, there was plenty to talk about. Karl Meinzer, DJ4ZC, outlined some objectives for the design of the Phase 3D elliptical satellite system:

- Launch around 1995 on Ariane 5
- A 16-hour orbit to give same-time-of-day coverage to the heavily populated areas, ie, North America, Europe and East Asia
- 10 dB better gain to reduce earth station antenna requirements
- 60-degree inclination, probably
- elimination of the need to reorient solar panels by making them 15% larger
- doughnut shaped to fit around the launch cone
- matrix for receivers and transmitters on various bands
- a beeper to tell "alligators" when they're alligating (running too much power)—if they still don't get the message, a notcher will descend on them to reduce their power

Then Karl talked about something far out—an amateur mission to Mars. The inside of the launch cone mentioned above is empty and big enough to hold another spacecraft. It appears that earlier Phase 3 spacecraft designs could be used as a starting point for modification to go to Mars. Karl said that the weight, size, power, propulsion system and link power budget look practicable. The main problems are money and people because Phase 3D already has the funds and design team fully committed.

What could a Mars spacecraft actually do? The most likely use would be a packet relay. The link power budget and propagation delay would dictate a digital system. An earth station configured for Earth-Moon-Earth communication would experience about a 10 dB improvement in reception from the active Mars spacecraft compared to passive reflection from the moon. The data rate could be on

Snaps at the AMSAT-UK Colloquium '91

RSGB Council Member "Smudge" Lundegard, G3GJW, gave the keynote address on how amateur satellite organizations, national societies and IARU must work together.

Doug Loughmiller, K05I, and Jeff Ward, GØ/K8KA, paused between sessions at the Colloquium.

Hans van de Groenendaal, ZS6AKV, soaked up as much knowledge as possible to apply to South African satellite projects.

Continued on page 17.

Correspondence

38,400 bit/s Packet Radio Comments

I read with great interest the article about the YU3 high speed packet-radio transceiver project in the June 1991 issue of *QEX*. In the past, I too have thought about using FM broadcast 10.7-MHz IF filters for higher speeds than is possible with a standard FM voice communication bandwidth. I would like to add the following thoughts on the subject.

The long multiplier chains are a great concern because they can be a constant source of spurs and unwanted crystal multiples. These spurs can be very temperature dependent, thus compounding the problem at unheated mountaintop sites. A better approach is to utilize a phase-locked loop (PLL) as a fixed ratio multiplier and share the loop between transmit and receive functions.

I am not referring to a full synthesizer as in a design that can generate individual channel increments. What is needed is a (× 128) or (× 256) fixed ratio multiplication loop. Thereby, a pair of crystal oscillators, one for the receiver and the second for the transmitter, would be multiplied by the PLL to either the receiver LO frequency or the transmit frequency. Selection of either the receive or transmit frequency would be accomplished by switching between the outputs of the respective crystal oscillator. With a reasonable amount of shielding, both oscillators could be continuously powered, thus eliminating the frequency chirp of the transmitter upon key-up.

The crystal oscillators in the 4-10 MHz range, generate the reference frequency for the phase detector, while the feedback signal to the phase detector is counted down from L band via a divide-by-128 or divide-by-256, fixed ratio, prescaler IC for TV synthesizers. The high reference frequency of the PLL (the crystal frequency) enables the use of a wide loop bandwidth, thus allowing the loop to follow both the FSK modulation of the transmit crystal oscillator and rapid transmit-receive switching. An HC 4046 IC could function as the phase detector, while the VCO could be printed on the PCB using microstrip techniques.

The VCO in the PLL can supply enough power to directly drive a hybrid PA module, which would constitute the rest of the transmitter. The 10 or 20 watts of power that currently available amplifier modules generate will help compensate for the losses in the demodulator.

A single conversion receiver is probably good enough for the current band utilization, as the image frequency most likely will be unused, if chosen to fall within the Amateur Radio band.

When the transceiver is to be used for a dedicated point-to-point link, a single crystal oscillator can supply both the receiver LO and transmit signal by split frequency operation. Alternatively, when using a pair of rocks, the receive and transmit crystals may be swapped, to move from an interfering signal.

For the near future, the market for these high-speed data transceivers will be limited to node operators. By limiting the amount of RF and microwave circuitry and the alignment thereof, the chance of success in an amateur assembling the unit is greatly improved.

Finally, a common PCB design could support both a 902-928 MHz and 1240-1300 MHz design.—*John Papson, WB2CIK* @ N1DCS

PK-232 Telemetry Reception Modification

I have seen the way W6SHP modified his PK-232 to receive transmissions from UO-11 (Correspondence "Telemetry Reception with the PK-232," page 16, January 1991 *QEX*). The same modification can be made without cutting any circuit board trace. This is what I did:

1) Solder a jumper wire between U15's pins 1 and 6.
2) Unplug the jumper from JP4 and reinsert it only on one pin (no pins must be jumped).
3) Connect the central contact of an SPDT switch to the inner pin of JP4.
4) Connect the other contacts of the switch as indicated by W6SHP (to U15-6 and U15-2, respectively).
5) Make the switch connecting wires long enough: the switch can be mounted on a small L-shaped bracket fastened by one of the enclosure screws to the rear of the PK-232 cabinet. The wires can come out from the RS-232 connector window.

This modification does not decrease the PK-232 resale value.—*Piero Moroni, I5TDJ, V. Emanuele, 43, 50134 Firenze, Italy*

Some Interesting Power Supply Chips

Harris SP306, SP600 and SP601. The SP306 is a 30-amp, 60-V MOSFET, ideal for switching high currents in a 12-V automotive storage battery supply and which contains a number of additional internal components for all kinds of switching circuitry. The SP600 and SP601 are ideal for use in very efficient half-bridge switching power supplies.

Another exciting device is the (Harris) RFP3055RLE. This device is ideal for 12-V applications. A pair of these could give 20-40 watts output in a push-pull broad band circuit 3.5 to 15 MHz and lower output, to beyond 30 MHz. The device has both input and output Zeners. The output Zener is an addition to the inherent but slower parasitic diodes that all MOSFETs have. This fast Zener will give very good protection against both positive and negative transients, unlike the parasitic diode. Note it takes only 5 volts to drive this to a full 12 amperes. The only precaution in using this is to make certain that either the gate drive cannot exceed the rated Zener voltage or use a limiting resistor. The price, in quantities of 1 to 24, is 63¢ each and comes in standard packages of 20 pieces.—*Earl H. Hornbostel, Crystalsem, Inc., 216 Ortega Street, San Jaun, Metro Manila 1500, Philippines*

An Audio CW Notch Filter for Home Brewing

By Yoshiharu Mita, JH1XEO
4-6-11 Komazawa, Setagaya-Ku
Tokyo 154 Japan

Preface

QRM signals seem to crop up now and then creating the need for a notch filter. Most commercial state-of-the-art transceivers are equipped with an IF notch filter, which is useful for reducing the offending signal. However, the provision of another filter in addition to the transceiver is desirable to ensure satisfactory QRM rejection. It is preferable that the additional filter be a little superior in performance to that of the transceiver[1].

The apparatus described here is essentially a "biquad" active audio filter. As shown in Fig 1, it employs four operational amplifiers designed for both BEF (band-eliminating filter) output for notching and BPF (band-pass filter) output for peaking[2]. It contains the following features.

Principal Features

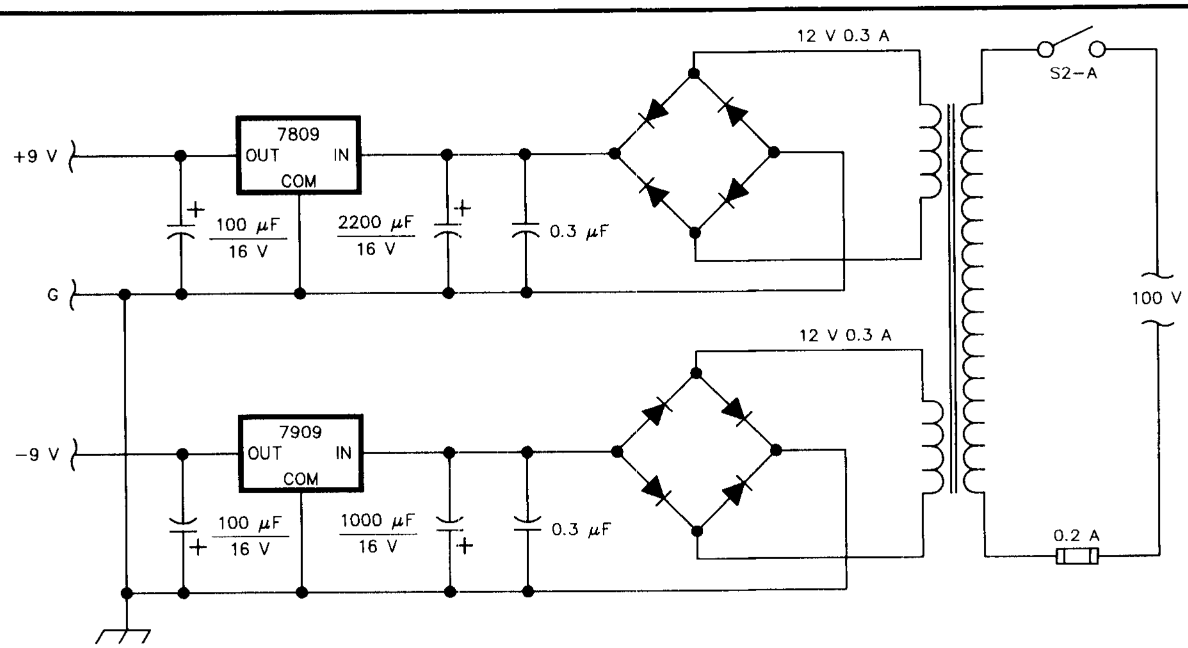
The resonant frequency f_0 is continuously variable in the range of 100 to 4000 Hz by two-gang LED-CdS photo-coupled variable resistors (R12 &R13), not by a conventional carbon-wiping type.[3] The frequency adjustment can be made more smoothly and less critically than compared with the carbon type. Fig 3 shows the relationship between the rotation angle of R8 and f_0. The BEF output for notching is obtained from U1 and provides remarkable notch depth (more than 30 dB), but more attenuation is desirable. In order to secure the notching down to 55 dB or more, the circuit is arranged to further eliminate the small residual amount of the resonant signal. The relationship between the input and output of U1 is 180° out of phase when a sine-wave signal is applied and the frequency is at resonance. Therefore, the addition of the two small equal signals, one from the input to U1 through R2, R3 & R4, and the other from the output of U1 through R5, can cancel out the residual amount almost completely.

[1]Notes appear on page 7.

LED-CdS Photo-Coupler

Because of the rarity of commercially produced LED-CdS photo couplers, this device is home-brewed. It contains two sets of LEDs and CdS photo-cells in a small dark box, each LED and CdS being fixed as a pair (Fig 4). The CdS is 5-mm diameter and the LED is a high-luminous type (V_F 1.77 V, I_F 20 mA, Stanley ER-700-L). Each LED bulb is supported with one of its lead legs so that the level setting of light against the CdS as well as the balance fixing of the two CdS resistance variations (R12 & R13) can be made by simply bending the supporting lead leg (via adjusting the LED-CdS distance) gradually. In this device, a variation of the LED brightness causes CdS resistance and brightness control is made by R8, which varies the LED current i_{LED} so as to adjust f_0 consequently. The relationships i_{LED} vs R12 or R13 and f_0 vs R12 or R13 are shown in Figs 5 and 6, respectively, and the particular curvature in Fig 3 is a result of such an arrangement.

Fig 2



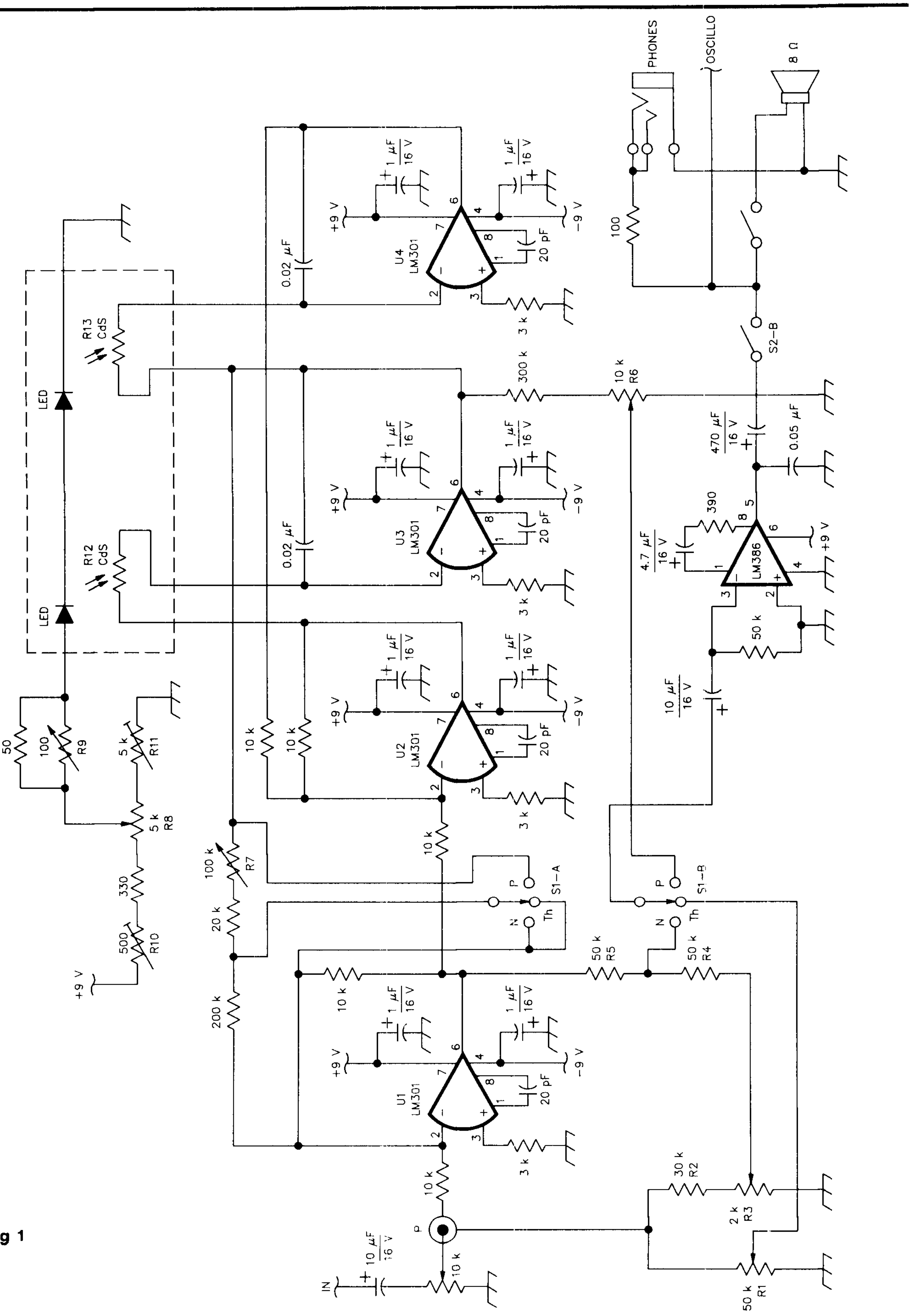

PHONES
OSCILLO
8 Ω
LED
R13 CdS
R12 CdS
U1 LM301
U2 LM301
U3 LM301
U4 LM301
LM386
S1-A
S1-B
S2-B
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
IN

Fig 1

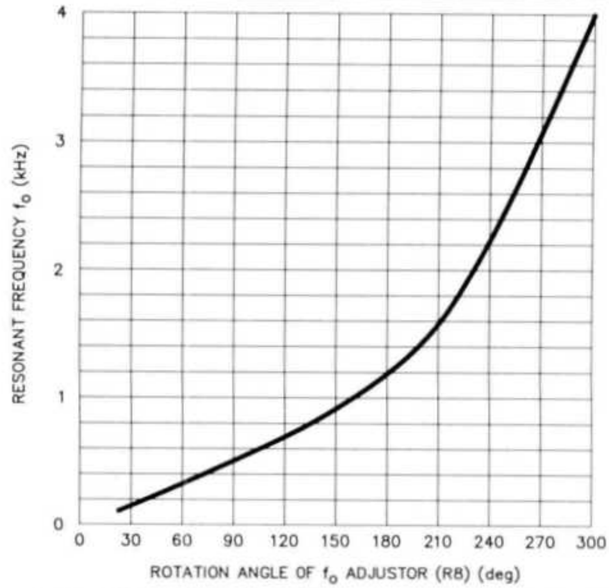
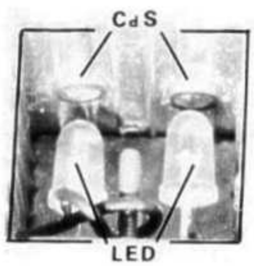


Fig 3

Fig 4



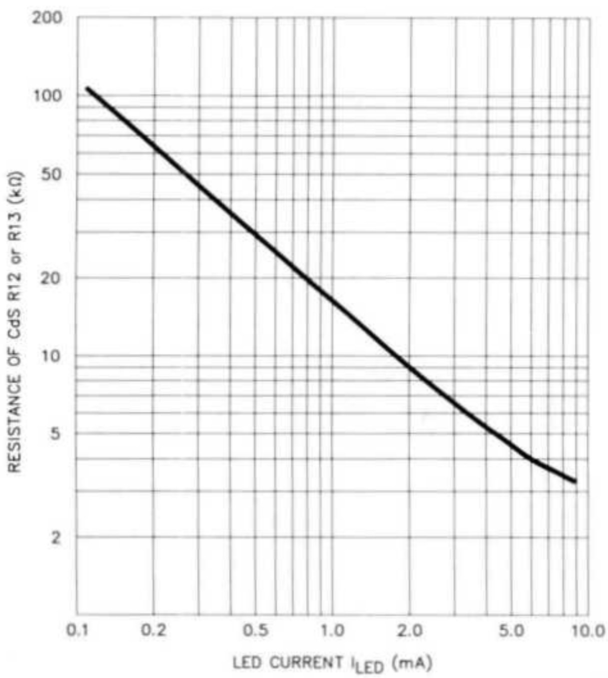


Fig 5

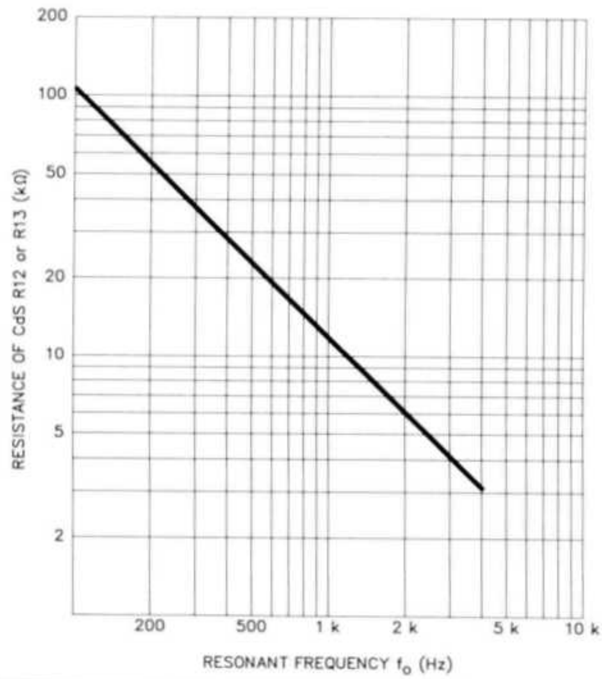


Fig 6

Cancellation of BEF Residue and Fine Adjustment

As for U1, the output level (at the 6th pin) is approximately equal to that of input (at point P) when it is out of resonance. Estimating the criterion of the notch depth to be 30 dB, a voltage e_o which is about 1/32 of the input is applied through R4 for the cancellation of the BEF notch residue, which is phase reversed. A slight variation in the notch depth takes place as f_o or the Q of the filter changes, and a subsequent fine adjustment of e_o is necessary for perfect notching. The fine adjustment of e_o is made by R3. Once it is set at an appropriate position, however, the use of R3 is dispensable because the residue is so small that it disappears into the noise in practice.

Adjustment of f_o and Q

The resonant frequency f_o is mainly adjusted by a carbon-slide potentiometer, R8, which control the current to the two LEDs in series connection to vary the CdS resistances (R12 & R13) as explained earlier. The larger circumference of the potentiometer slide ensures better resistance resolution, and a 30-mm diameter 5-kΩ linear trace potentiometer with 6:1 vernier drive is used in the present circuit. R9 is for fine adjustment of f_o, to be used in conjunction with the setting of e_o by R3. In practice, a satisfactory adjustment is achieved merely by adjusting R8 with the vernier drive. R10 and R11 are used for presetting the f_o frequency range. R10 sets the higher frequency end and R11 the lower end. The Q of the filter is variable approximately from 4 to 14 in the case of notching, and it is fixed at about 16 for peaking. If the offending signal is very close to the desired signal's frequency, an increase in the Q value is needed to improve the notch selectivity, but when this is not the case, a decrease to an appropriate value will make the f_o adjustment less critical. The adjustment of Q is made by R7 and is independent of f_o.

Selection of Notch/Through/Peak

Switch S1 is provided for selecting one of the operation modes: NOTCH, THROUGH or PEAK. The BPF output for peaking is obtained from U3. To those who may have difficulty finding f_0 for the offending signal in the notch mode, I recommend you use the peak mode for adjustment of f_0 because our hearing is more sensitive to peaking than notching. Switching over to the notch mode leaves f_0 unchanged. The peak mode or APF provides a remarkable improvement in noise reduction as well as overall selectivity. R1 is for presetting the output level for THROUGH and R6 for PEAK.

Summary

Audio input signal is obtained from the transceiver phone jack and should be kept below 300 mV_{P-P} (at point P). A schematic of the power supply is given in Fig 2. Figs 7 and 8 show the panel arrangement and the interior view of the filter, respectively.

The use of another filter in addition to a transceiver equipped with an IF notch offers not only an improvement in the notch depth but also a capability of rejecting two offending signals. Another, and yet another, in combination with APF would erase several QRM signals simultaneously. Use of a mechanical iris device for controlling the LED brightness against the CdS may be of interest. It may enable us to develop an improved f_0 adjustment with higher resolution.

References

[1]J. Devoldere, ON4AU, "Notch Filter," *Low-Band DXing* (ARRL), p IV-6.

[2]D.A. Tong, G4GMQ, "Audio Filters as an Aid to Reception," *Radio Communication*, February 1978.

[3]CdS photocells can be obtained from: Hosfelt Electronics, Inc, 2700 Sunset Blvd, Steubenville, OH 43952, tel: 614-264-6464, 800-524-6464.

Fig 7

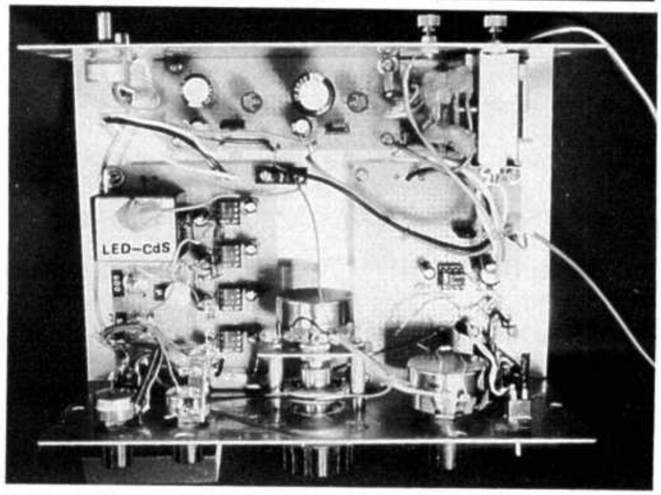


Fig 8

Bits

CALL FOR PAPERS FOR AMSAT-NA TECHNICAL SYMPOSIUM AND EDUCATIONAL WORKSHOP

Papers are invited for the 1991 AMSAT Technical Symposium sponsored by the Radio Amateur Satellite Corporation-North America (AMSAT-NA) to be held November 9-10 in Los Angeles, California. Topics of interest include but are not limited to Phase 3D, SAREX, Microsat applications, AMSAT-OSCAR 21, UoSAT-OSCAR 22, RS-12/13, digital signal processing, and Earth-moon-Earth communications. The deadline for submission of camera-ready papers is **October 1, 1991** to the American Radio Relay League (ARRL), 225 Main Street, Newington, CT 06111 USA, Attn: Lori Weinberg.

Papers are also invited for a joint AMSAT/ARRL Educational Workshop to be held on November 8 at the same location. The theme of this workshop is "Uses of Amateur Radio Satellites in Education." Topics of interest include: using satellites to teach other subjects such as physics, geography, computers, language arts, etc.; ways to use satellites in grades kindergarten through college; designing a school science room including Amateur Radio and satellites; and, how to use satelites as a drawing card for recruiting new hams. The deadline for submission pf papers is the same as above.

Papers submitted by the deadline will appear in printed proceedings which will be available at the Workshop and Symposium, and can be purchased by mail from either AMSAT-NA or ARRL.

For author's kit or further information, please contact Lori Weinberg at ARRL HQ, telephone 1 203 666-1541 or fax 1 203 665-7531.

Measuring the Mass of the Earth: The Ultimate Moonbounce Experiment

By H. Paul Shuch, N6TX
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Williamsport, PA 17701

Abstract

Radio amateurs have been successfully bouncing VHF, UHF and microwave signals off the surface of the moon, and receiving their echoes, for nearly forty years. EME (Earth-moon-Earth) activities have enhanced the teaching of disciplines as diverse as electronics, astronomy, and physics, with several generations of students having now used measured echoes to determine the distance to, and orbital parameters of, the moon. Penn College students have recently had an opportunity to apply these measurements on a truly grand scale, using EME signals to measure the mass of the Earth. Their results differ from the currently accepted figure by about one percent.

STATEMENT OF THE PROBLEM

Give me a lever long enough, and I'll move the world. Give me a scale big enough, and I'll weigh it. This is essentially the problem posed to Electronics students at the Pennsylvania College of Technology in the Spring of 1991. Their innovative solution to weighing their home planet is worthy not only of the best scientific minds, but of the spirit of innovation with which the Amateur Radio Service has always prided itself.

The measurement procedure which they derived is based upon a Newtonian solution to the two-body orbital problem. The forces which hold a satellite in orbit around its primary are gravity (a force pulling in) and inertia (a force pulling out). To achieve a stable orbit, these two forces must of course be in equilibrium. Gravity varies directly with the mass of both objects; inertia, directly with the mass of only the satellite. Thus in setting the forces of gravity and inertia equal, the mass of the satellite cancels, leaving an expression for the orbit of the satellite which involves only the mass of the primary (plus a constant which Newton threw in for dimensional consistency).

The orbital characteristics of our natural satellite, the moon, are determined through a combination of visual observation and radio ranging. From them, we determine the velocity of the moon as it orbits the Earth. Applying Newton's Laws, we can then calculate the planetary mass required to produce the observed orbital velocity.

ESTABLISHING A MATHEMATICAL BASIS

As has been noted, a stable orbit requires that the forces of gravity and inertia be equal. Newton's famous Inverse Square Law shows the force of the gravitational attraction between any two bodies to equal a fudge factor (the Universal Gravitational Constant), times the product of their masses, divided by the square of the distance between their centers of mass. Mathematically,

$$F = \frac{GMm}{r^2} \qquad \text{(Eq 1)}$$

where M is the mass of the primary (planet),
m is the mass of the secondary (satellite),
r is the distance between them (the orbital radius),

and $G = \dfrac{6.673 \times 10^{-11}\ \text{Nt m}^2}{\text{kg}^2}$

Newton's Universal Gravitational Constant.

We now consider the force of inertia pulling a satellite out, which (again according to Newton) equals:

$$F = mA \qquad \text{[Eq 2]}$$

where m represents the mass of the satellite,
and A is its acceleration, which in a circular orbit is found from:

$$A = \frac{v^2}{r} \qquad \text{(Eq 3)}$$

with v representing the velocity of the satellite,
and r the orbital radius, as defined above.

Combining Eqs [2] and [3] gives us:

$$F = \frac{m\,v^2}{r} \qquad \text{(Eq 4)}$$

from which we can determine the inertial force acting on the moon, if we know its orbital velocity. It is this latter item which we will derive from our EME experiment.

Since the moon appears to be in a stable orbit, we set Equations [1] and [4] equal to each other, and then simplify:

$$\frac{GMm}{r^2} = \frac{m\,v^2}{r} \qquad \text{(Eq 5)}$$

$$\frac{GM}{r} = v^2$$

$$M = \frac{v^2\,r}{G} \qquad \text{(Eq 6)}$$

and all that remains is to measure orbital radius, calculate velocity, and solve for the mass of the Earth.

DETERMINING THE ORBITAL PERIOD OF THE MOON

This is perhaps the easiest part of the experiment. The orbital period of the moon is readily measured by eye, given the proper precision laboratory apparatus: a calendar. To the untrained observer, the elapsed time between two successive full (or new) moons appears to be on the order of about twenty-eight days. To the skilled scientist, on the other hand, the measurement comes out more like four weeks.

How long does it take the moon to orbit the Earth? Where do you think the word "month" comes from? (OK, by rights it should be "moonth," but my students will tell you I seldom take off for spelling). If we assume an orbital period of 28 days, and apply a bit of dimensional analysis, we get:

$$P = (28 \text{ days}) \times (24 \text{ hours/day}) \times (60 \text{ min/h}) \times (60 \text{ s/min});$$

$$P = 2{,}419{,}200 \text{ seconds, or:}$$

$$P = 2.42 \times 10^6 \text{ s}$$

We will employ this figure shortly, in computing the moon's orbital velocity.

FINDING THE ORBITAL RADIUS

Remember that the radius of an orbit is measured as the distance between the centers of mass of the two bodies. If we assume the centers of mass of the Earth and the moon to each be at the objects' physical center, then the orbital radius becomes the sum of the respective radii, plus the shortest distance between the surfaces of the two bodies. The radii we can calculate; it is the physical separation which we measure next.

(A) Distance from Earth to Moon

Those hundreds of radio amateurs who have experienced the thrill of hearing their own lunar echoes know that the elapsed time between transmission and reception is on the order of two and a half seconds. What we require here is a more precise estimate of echo time, measured when the moon is directly above the observer.

Unfortunately, the moon's orbit is aligned more or less with the Earth's equatorial plane, so the moon never passes directly over Penn College. There is about a twenty degree tilt to the lunar orbital plane, so when the moon is at maximum northern declination, and as its hour angle approaches local longitude, it appears *nearly* overhead from much of North America. Still, to minimize measurement error, the distance should properly be measured with the moon at zenith, and with a declination equal to local latitude. The present experiment utilized audio tapes of EME echoes made from a more southern locale, with the moon directly overhead, to determine minimum echo time.

You can get a fair estimate of round-trip propagation time by starting a stopwatch when you key your transmitter, and stopping it when you hear the echo. If you're working from audio tapes, start your clock on the transmitter's sidetone, and stop it on the received echo audio tone. For greater accuracy, my students chose to apply the tones to an oscilloscope, and use its calibrated timebase to measure the echo time, which came to 2.55 seconds.

We know radio waves to be propagating at the speed of light, $c = 2.998 \times 10^8$ meters per second. Multiplying speed by time yields distance: 7.645×10^8 meters round trip, 3.83×10^8 meters one-way, or about 238,000 miles.

(B) Radius of the Earth

Here we turn to the ancients for guidance. One of the earliest accurate measurements of the Earth's size involved observing that, on the day of the Equinox at local noon in Alexandria (which is near the equator), a stick placed vertically in the ground cast no shadow. However a stick similarly positioned in Athens (some known distance to the north) cast at the same time a shadow of appreciable length. Applying a bit of trigonometry, the Greeks computed the size of the Earth rather precisely.

We could readily duplicate their experiment. Or accept its result on faith. Either way, we have a dimension for the Earth's radius which falls rather close to the currently accepted "exact" value of 6.37×10^6 meters, which we will employ in the computations which follow.

(C) Radius of the Moon

Now I'm not going to suggest that we measure the lengths of shadows cast by sticks on the lunar surface (although one of my students did suggest that would make for an interesting field trip). Rather, we can observe the moon from Earth, and estimate its radius through trigonometry.

Any number of simple optical instruments tell us that, as viewed from Earth, the moon subtends an angle of about a half a degree. Given a quarter-degree "half angle" from the moon's center to its limb, and the length of the adjacent side (computed from our EME echoes), the tangent function gives us the opposite side of a right triangle (that is, the lunar radius) as:

$$\tan(1/4°) \times d = r_m$$

$$\tan(1/4°) \times 3.83 \times 10^8 \text{ meters} = r_m$$

$$r_m = 1.67 \times 10^6 \text{ meters}$$

or about a quarter of the radius of the Earth.

(D) It All Adds Up

The moon's orbital radius is now found simply by adding the one-way EME path length, the radius of the Earth, and the radius of the moon:

$$r = 383 \times 10^6 + 6.37 \times 10^6 + 1.67 \times 10^6 \text{ meters}$$

$$r = 391 \times 10^6 \text{ meters, or about 243,000 miles.}$$

CALCULATING THE LUNAR ORBITAL VELOCITY

Since distance always equals velocity times time, we can find the orbital velocity of the moon by dividing the distance it travels in one orbit, by the time it takes to complete one orbit. The distance traveled in an orbit is of course orbital circumference, which is found by multiplying orbital radius by 2 pi (the number of radians in a circle). The corresponding time is simply the orbital period (one "moonth"). Computing velocity:

$$v = d / t$$

$$v = C / P$$

$$v = \frac{(2 \times \pi \times 391 \times 10^6 \text{ meters})}{(2.42 \times 10^6 \text{ s})}$$

$$v = 1015 \text{ meters per second}$$

SOLVING FOR THE EARTH'S MASS

Stick around, class, we're almost done. Inserting the orbital radius and velocity into Eq 6, we get:

$$M = \frac{v^2 r}{G} \qquad \text{(Eq 6)}$$

$$M = \frac{(1015\ \text{m/s})^2 \times (391 \times 10^6\ \text{m})}{(6.673 \times 10^{-11}\ \text{Nt m}^2/\text{kg}^2)}$$

$M = 6.037 \times 10^{24}$ kg, which is a heavy planet indeed!

EVALUATING OUR RESULT

Any astronomy textbook will reveal multiple measurement errors for each of the intermediate values which we used to estimate the mass of the Earth. For example, the actual period of the lunar orbit is about two percent less than we estimated through our rather crude calendar technique. The lunar radius is in fact nearly four percent greater than we estimated through visual observation and simple trigonometry. And the radius of the moon's orbit turns out to be about a percent and a half less than we calculated from our echo measurements.

With all the above measurement errors, one might expect our experimental result (the computed mass of the Earth) to be significantly in error. It turns out otherwise. As is often the case in computations based upon multiple independent measurements of unrelated phenomena, our various errors tend to cancel out, yielding a result which would do Pythagoras proud.

Well, how close is our final result? The published value for the mass of the Earth is: 5.975×10^{24} kg, so we see we're rather close. To determine the percentage of error between observed and theoretical values, subtract the theoretical from the observed, divide by the observed, and then (in order to convert ratio to percentage), multiply by a hundred. In our case:

$$\%\ \text{Error} = 100 \times \left[(6.037 \times 10^{24}) - \frac{(5.975 \times 10^{24})}{(5.975 \times 10^{24})}\right]$$

$\%$ Error = 1.03%

Isn't it amazing how accurate we can be, using direct observation and strictly amateur techniques?

CONCLUSIONS

The EME challenge has been successfully met by hundreds, perhaps thousands of radio amateurs eager to expand their communications horizons. It also provides us with a mechanism for training the next generation of engineers and technicians. More important, it serves as a source of motivation and inspiration for those whom society will ask to develop technology to cope with the challenges of the future. Weighing the earth may appear frivolous, but certainly not mundane. It demonstrates to students the diverse applications of the radio art, and provides them with a verifiable problem of truly cosmic proportions, against which to weigh themselves. Once they've held the Earth in their hands, how can they not be moved?

Our students are our future. Of course, we on the campuses will help them to acquire knowledge, and to master skills. But we must not stop there. EME (the Earth Mass Experiment) and similar experiences can provide them with something far more precious: motivation. Give them a lever long enough, and they will move the world!

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ACKNOWLEDGEMENT

This paper was originally presented at the *25th Conference of the Central States VHF Society*, July 27, 1991, Cedar Rapids, IA.

ABOUT THE AUTHOR

H. Paul Shuch began his microwave experiments in the 1960s, using APX-6 transponders at 1215 MHz. He heard his first EME echo in 1973 and has not been the same since. He has operated on all 19 ham bands between 1.8 MHz and 10 GHz. Paul holds a PhD in Engineering from the University of California, Berkeley, has taught for nearly twenty years, has published half a hundred technical articles in engineering and scholarly journals, and was a coauthor of the *ARRL UHF/Microwave Experimenter's Manual*.

Conducted by: Stan Horzepa, WA1LOU
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Wolcott, CT 06716-2702

UO-22 LAUNCHED

UoSAT-F was launched from Kourou, French Guyana, on July 17. After activation of the satellite, it became known as UO-22 on the Amateur Radio frequencies and UO-5 on nonamateur frequencies. Modulation and data formats will be the same used by UO-14, ie, AX.25 data using 9600-bit/s FSK. The frequency plan (as on UO-14 and the MicroSats) is Mode B, ie, uplink on 2 meters and downlink on 70 cm. Stations already equipped for UO-14 operation will be able to receive UO-22 with the software and hardware they already use.

UO-22 will transmit telemetry, status messages, and files in the pattern typical of UO-14. Telemetry and status messages will be in the same format as that on UO-14. Files will be transmitted using the PACSAT Broadcast Protocol already in use on PACSAT, LUSAT and UO-14. These broadcasts can be received by PE1CHL's *NET.EXE* program or the GØ/K8KA's *PB.EXE* program.

The satellite's primary nonamateur mission is to provide store-and-forward communications for SatelLife, an organization formed by 1985 Nobel Prize winner Dr. Bernard Lown. SatelLife will use UO-5 for a nonprofit electronic mail network for health professionals. Initially, five African medical schools will use "HealthNet" to exchange electronic mail and receive up-to-date medical literature. Some of the HealthNet stations have already been commissioned and demonstrated on UO-14. HealthNet is a direct application of store-and-forward satellite communications techniques developed within the amateur-satellite service and demonstrated on several amateur satellites.

UO-22's role in the amateur-satellite service will be similar to that of UO-9, UO-11 and WEBERSAT. Instead of providing a two-way communication service, it will transmit experimental data and telemetry. The most exciting aspect of this mission will be the charge-coupled device (CCD) camera. UO-22's CCD camera design incorporates all of the lessons learned from previous UoSAT CCD experiments. It has a 110-degree wide-angle lens providing a field of view only slightly smaller than the satellite's footprint. Images will measure 994 by 1119 miles, making identification of ground features much easier than with previous OSCAR cameras. The image array measures 578 by 576 pixels, which provides ground resolution on the order of 1.25 miles. Each pixel is eight bits, resulting in a black-and-white image with 256 levels of grey. With a full array of attitude determination sensors (sun-angle sensor, Earth-horizon sensor and magnetometer). UO-22's gravity-gradient and magnetorquer attitude control system should provide a stable platform for reliable Earth imaging.

The two transputer microprocessors in the CCD camera module will take the image and send it over an on-board network to the main 80C186 on-board computer (OBC186). The OBC186 will put the image into a file with a 256-byte preamble and a standard PACSAT file header. UO-22 will broadcast the CCD image files routinely using the standard PACSAT Broadcast Protocol.

For those interested in writing their own display programs, complete technical details of the image file contents will be published and a display program for IBM PC compatible computers will be released. The program will be available as a broadcast file on UO-14 and UO-22, so any station equipped to receive the images will immediately be able to get a copy of the display program. This on-the-air bootstrapping and updating of earth station software is a regular feature of the new PACSAT satellites.

Stations active on UO-14 are already equipped for UO-22. New users will need a 70-cm FM receiver, FSK demodulator and KISS TNC. Over 150 stations have been heard on UO-14 and 114 are regularly active. Although the 9600-bit/s modems are more difficult to hook up than 1200-baud PSK modems, a growing number of experienced users are available to lend assistance to newcomers. If UO-14 is anything to go by, signals from UO-22 should support stations with simple omnidirectional antennas.

The first software you need is *PB.EXE* or *NET.EXE* to receive the PACSAT Broadcast Protocol files. Using that you will be able to receive a copy of the image display program when it is released.

Any program which displays UO-14 telemetry will display UO-22 telemetry. AMSAT-UK has developed *DTLM.EXE*, which displays and logs telemetry from UO-11, UO-14, PACSAT, LUSAT, WEBERSAT and UO-22. Another program from AMSAT-UK, *SPLOT.EXE*, is a general purpose data graphing program. *SPLOT* graphs output from DTLM, WOD files from UO-14 and UO-22, radiation experiment data from UO-14 and solar cell experiment data from UO-22.

The UO-22 frequency plan follows.

Downlink
435.120 MHz
9600 bit/s FSK
1200 bit/s AFSK (backup)
5 W or 2 W

Uplink
145.900 MHz
9600 bit/s FSK
1200 bit/s AFSK (backup)

Note that this channel will be used by groundstations transmitting "hole lists" for the PACSAT

Broadcast Protocol. There should be little interference with the MicroSat uplink on the same frequency.

—from Jeff Ward, G0K8KA, Ron Long, W8GUS, and AMSAT News Service

NORWAY PACKET-RADIO STATUS REPORT

LA Packet Radio Group (LAPRG) was formed in 1985 to coordinate planning and implementation of the Norwegian AX.25 network. Early in the planning process, LAPRG proposed a network architecture with user access points to the network on VHF and transmission links between nodes on UHF. LAPRG also coordinated establishment of the AX.25 network. Another task was planning of PBBS mail-forwarding procedures. LAPRG, Norwegian Radio Relay League (NRRL) and the manager for digital communication in NRRL contributed to the IARU Region 1 frequency allocation conference in 1987. This conference made the first recommendation for an AX.25 frequency plan in Europe on VHF and UHF.

LAPRG now has 250 members and approximately 10% of Norwegian radio amateurs are active on packet radio. The network has approximately 50 official nodes with a combination of VHF access points and UHF links. There are 10 official PBBS installations. The main network stretches from Kristiansand in the southern part of Norway up to Trondheim in the middle of the country. There are links to the western part of Norway to connect nodes in the major cities Stavanger and Bergen to the main network. North of the Polar Circle, a subnetwork links Bodx via Harstad to Tromsx. This subnetwork has no direct connection to the main network and uses HF gateways for mail-forwarding.

The traffic in the main network has increased considerably. The main links were upgraded by using 9600-baud radios and modems to handle the large volume of traffic. These links use a two-frequency scheme (the RU14 and RU15 repeater channels for AX.25 UHF links) that reduces the packet collision probability and considerably improves the throughput on the UHF links. LAPRG also has experimented with links on the 23-cm band.

From the start, LAPRG has contributed to the success of packet radio in Norway. Not only through coordinated network establishment, but also financial support for the establishment of nodes in areas with low activity on packet. Experience has shown that this is a good strategy for introducing other radio amateurs to packet radio.

—from Nils Tolleshaug, LA5DI, Manager Digital Communication, NRRL Errundveien 24, 0588 Oslo 5, Norway

AEA RELEASES PK-232 AND *PC-PAKRATT II* UPGRADES

AEA recently announced upgrades of the firmware for their PK-232MBX controller and *PC-Pakratt II* packet-radio terminal software.

Enhancements of the PK-232MBX include:

AMTOR Maildrop that operates the same as the PakMail system. It is more reliable on HF and allows the user to send and receive messages while away from the controller.

Packet Lite is a new, more efficient type of AX.25 backwards compatible packet that reduces overhead to provide greater reliability and throughput.

PakMail now has a "You Have Mail" message for the user who has mail addressed to the user's call sign when connecting to the maildrop.

New SAMPLE command allows user analysis of many signals previously identified as "Synchronous" or "Unknown" by SIAM. Note that this will not provide readable text. It is up to the user to write a program to analyze the data further and extract any usable information.

XBAUD command for nonstandard RTTY baud rates.

Enhancements of the *PC-Pakratt II* include:

Built-in text editor. The user still has the option of using his or her own word processing program.

Binary File Transfer routine for packet radio that is compatible with YAPP.

Support for new PK-232 commands (including AMTOR mailbox and Packet Lite).

Replaced the CBELL command with the CONALARM command that toggles between OFF, SOFT (3 bells) and LOUD (obnoxious).

Autoconnect strings are now displayed as part of the Autoconnect Menu.

The setup screens can now be chosen from a setup screen menu. This menu also allows you to save and restore parameters.

Capability to grab text with the mouse and copy it to a field in the "minilog."

Macros can now accept function keys, ALT keys and control characters.

ESC is now used to close all menus rather than ".Back." A period will also close the menu.

New and improved help features including context-sensitive help screens that allow users to peruse the various screens, Index and Table of Contents that allow users to trace back through the help screens and jump from one help screen to another by using hot spots in the help screen.

File upload speed has been increased. Data is now sent in larger blocks to the PK-232. A 2-kbyte file now takes under 10 seconds to send to the PK-232.

For more information, contact Advanced Electronic Applications, Inc, PO Box C-2160, Dept B, Lynnwood, WA 98036-0918.

AUSTRIAN COSMONAUT TO OPERATE FROM *MIR* IN FALL

Later this fall, an Austrian cosmonaut will operate Austrian Amateur Radio Experiment Aboard *Mir* (AREMIR). The mission, tentatively scheduled for

October 2-12, will be part of a 16 experiment package called AUSTROMIR '91. *Mir*'s high inclination (51 degrees) makes it available to practically every radio amateur in the world.

The AREMIR equipment will include a modified 2-meter Alinco DJ-120-E transceiver with its power limited to three watts, a TNC, a CW generator (for the AREMIR beacon) and a laptop computer, which is part of the DATAMIR experiment. The operating frequency has not been selected, but it will be in the 145.8-146.0 MHz subband. Continuous packet-radio bulletins will be 36 characters long and interleaved with a 6-second tone for Doppler measurements. AREMIR equipment is scheduled to be on the manifest of a *Progress* resupply ship in August. Sergi, U5MIR, may set up the equipment and test it prior to the arrival of the Austrian cosmonaut. (In a related story, it has been reported in the Russian press that Sergi will have his stay aboard *Mir* extended for another six months. In October, Sergi will be joined by his old mission commander, Alexander Volkov, U4MIR.)

AREMIR has a strong educational focus and the Austrian team of hams involved has created a special AREMIR receiver for use in Russian and Austrian schools.

The hardware for AREMIR was made possible by members of the Radio Club for Communication and Wave Propagation in Gratz, Austria. All hardware has successfully passed all required testing and is in Russia awaiting the trip to *Mir*. Two Austrian cosmonauts, Franz Viehbock and Clemens Lothaller, have been trained for the mission. Recent information from Russian press sources indicates that Franz Viehbock will fly the mission.

For more information on the educational aspects of AREMIR contact AMSAT headquarters.

—from AMSAT

AMSAT-UK COLLOQUIUM HIGHLIGHTS

The 6th Annual AMSAT-UK Colloquium was held at the University of Surrey in the United Kingdom on July 25-28. Approximately 150 people were present from 21 countries. The list of lecturers looked more like a who's who of the amateur satellite world. Unfortunately the British cosmonaut, Helen Sharman, was unable to be present, but hopes to come next year.

The main topics were about future satellites, but the 42 different presentations also gave much more information, reports, knowledge and wisdom to all present. Some typical subjects were WARC-92 preparations and CCIR participation; selecting orbits for radio amateur missions; telemetry, past, present and future; VITA operations using UO-3; a low-cost receiver for UO-11 and DOVE; digital satellites and equipment required to use them; AO-13 management, past and future; portable antenna systems for use with UO-3 and PACSAT; and the UO-22 CCD camera. The following is a summary of some of the presentations.

Phase 3D

The European Space Agency has confirmed a launch slot on the second ARIANE-5 flight timed for October 1995. The primary payload is the "cluster" spacecraft. Phase 3D will look like a doughnut of non-uniform thickness, 10.5 feet in diameter and about 2.1 feet tall weighing 880-1100 pounds and will also have two deployable "wings" carrying extra solar panels. The power budget is about 200 watts. The inside of the "hole" will be a launch adaptor to carry the main payload. I hope to upload a sketch (in GIF format) to UO-14 soon. Because a 10-foot spacecraft is too big for doors, elevators, etc, Phase 3D will probably be made in separate pieces and the blocks finally assembled at the launch site.

Launched into a standard geostationary transfer orbit, the aim is for the first motor firing to occur at perigee and raise apogee to about 31070 miles. Subsequent firing(s) will be made at apogee to raise the perigee and make a plane change to 60-63 degrees inclination. Energy required for this is actually less than that needed for AO-13.

The intention is to fine tune the orbital period to exactly 16 hours in order to give regular and repeatable access times with consecutive apogees occurring and repeating, over Europe, North America and the Far East. Target times for access are local time synchronous at 0500-0800 and 1800-2400 hours.

The spacecraft will carry gain-agile antennas, possibly 13 dB at 70 cm and 20 dB at 24 cm for narrower beamwidth at apogee and then widening out at lower altitudes. Digital communications links will be similar to existing RUDAK experiments. Analog links will be equipped with the LEILA concept to kill alligators. An excessively strong uplink signal will first be overlaid with a tone and then, if you do not decrease power, it will be notched out. LEILA can handle several signals simultaneously.

The concept of transponder "mode" may be abandoned. Instead Phase 3D could have communications links connected at baseband like a matrix. See Figure 1.

A camera experiment, SCOPE, is likely from Japan. This will have at least two lenses (24 and 90 degree fields) and return color images of the Earth. If possible there will be a third lens to return sky, planet and star images. Resolution of all of these is expected to be about 750 by 580 pixels.

Another possible experiment comes from AMSAT South Africa. This will provide educational broadcasts of up to 15 minutes of digitized speech on 29 MHz using Compatible Amplitude Modulation (SSB and carrier). These transmissions are expected to occur at perigee and are targeted at schools and other educational establishments.

Finally, the doughnut has a hole in the middle. Can we mount something inside this area? It is possible that this void may have an extra AMSAT-DL payload, a spacecraft to send to Mars. The possibility of accurate

```
      29   MHz --+-----o------o-----o--
               ||    ||     ||     ||
U 435      MHz --o-----+------o-----o--
P              ||    ||     ||     ||
L 1260     MHz --+-----o------o-----o--
I              ||    ||     ||     ||
N 2400     MHz --+-----+------+-----o--
K              ||    ||     ||     ||
  5600     MHz --+-----o------+-----o--
               ||    ||     ||     ||
  24 GHz   --+-----+------+-----+-- ?
               ||    ||     ||     ||
               145   435    2400   10 GHz
                     D O W N L I N K
```

Figure 1

arrival is low but, in the interim, much experience would be gained in interplanetary communications. One-way propagation delays of 5-15 minutes would be experienced and links would probably be on 2400 MHz.

ARSENE

Final orbit is still expected to be equatorial with apogee at 22,370 miles and perigee at 12,428 miles, period 17.5 hours. Launch is expected in June or July 1992. The Telecom 2B main payload has been moved to a different flight and the present main payload is not known.

A solid fuel rocket motor will be used to raise the perigee after launch into geostationary transfer orbit. Last year's requirement for deployable solar panels has now gone thanks to GaAs solar panels from Italy, which will provide 50-60 watts. This spin-stabilized satellite will be earth-pointing using nitrogen gas for attitude control. Lifetime expected is of the order of 3-5 years. The six-sided body is 35.5 feet in diameter, 34.7 feet high and weighs about 309 pounds before kick motor firing. Upon ejection, the satellite will spin up to 60 rpm before the kick motor is fired in the first few days of orbit, then it will spin down to about one rpm.

The communications payload will have a 70-cm uplink and use 145 and 2445 MHz for downlinks. The two modes, B and S, will not operate simultaneously. Mode B operation will be a 1200-bit/s digipeater with uplinks at 435.0625, 435.0875 and 435.1125 MHz and a single downlink at 145.975 MHz (expected Doppler is about 100 Hz). Bell 202 tones are specified rather than FO-20 style. There will not be a mailbox because of insufficient memory capacity. Mode S will be a linear transponder, uplink passband 435.050-435.125 MHz and downlink 2446.470-2446.540 MHz.

MicroSats

In six years, there should be enough MicroSats in orbit to spend all of one's waking (and sleeping) hours chasing different birds across the sky. The following details are, unfortunately, brief depending on how much information was given. Hopefully, they will give the readers an impression of the work that is evolving in this field. The main motivation for all of this is to permit different national institutions to attract young people, develop the necessary skills and introduce the technology into their country's future. All the flights are polar orbiters on Ariane and most missions are planned to use commercial as well as amateur frequencies, depending on payload requirements.

An Italian satellite (no name given) will fly in 1992 if ready, otherwise in 1994. Packet radio at 9600-32000 bit/s.

SUNSAT from South Africa will provide store-and-forward communications, position location, imaging, 2-meter and 70-cm PBBS (FSK and AFSK). It also will carry broad bandwidth L-band equipment.

TECHSAT from Israel is a three-axis stabilized satellite carrying digital and imaging equipment, position reporting by GPS, ion and particle counting, MM wave propagation and ozone observations using heat pipes for thermal stabilization. A PBBS will have two 70-cm transmitters, five 2-meter and 1260-MHz receivers. Modulation will be at least 1200-bit/s AFSK on 2 meters, 1200-bit/s Fuji on 70 and 23 cm and 9600-bit/s UO-14/UO-22 on 24 cm. The transmitter power is expected to be in the 3-5 watt range.

KITSAT from Korea is planned for 1992. It is receiving-station size and is intended for emergency communications to the Korean Antarctic base. In addition, it will have CCD, DSP and DCE (Mode B).

—*from Richard Limebear, G3RWL @* GB7HSN

GATEWAY CONTRIBUTIONS

Submissions for publication in Gateway are welcome. You may submit material via the US mail to 75 Kreger Dr, Wolcott, CT 06716, or electronically, via CompuServe to user ID 70645,247, or via Internet to horzepa@gdc.com. Via telephone, your editor can be reached on evenings and weekends at 203-879-1348 and he can switch a modem on line to receive text at 300, 1200 or 2400 bit/s. (Personal messages may be sent to your Gateway editor via packet radio to WA1LOU@N1DCS or IP address 44.88.0.14.)

The deadline for each installment of Gateway is the tenth day of the month preceding the issue date of *QEX*.

Components

By Mark Forbes, KC9C
PO Box, 445
Rocklin, CA 95677

Last month we briefly looked at microprocessors with the promise of digging more deeply this month. Fig 1 diagrams the basic architecture of a microprocessor. You can see that there are four building blocks in the processor: The Arithmetic/Logic Unit (ALU), the Instruction Processor, the Registers (including the Accumulator), and the Control Logic and Address Generator. The blocks are connected together, and communicate via their internal bus.

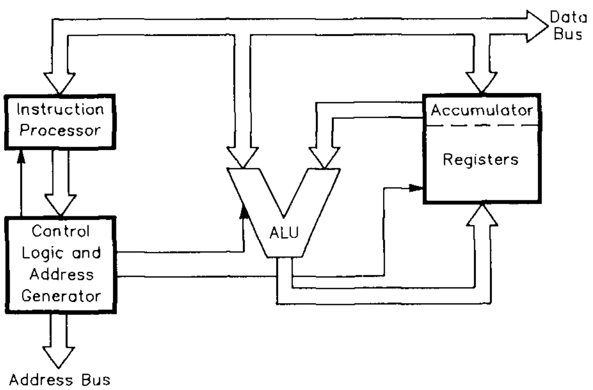


Figure 1

The INSTRUCTION PROCESSOR (IP) receives a string of commands from the program memory, and performs whatever process that's specified by that instruction. For some instructions, the IP executes the command immediately; such as move data in a register. For more complex operations, the IP receives several commands before the operation is actually completed. For example, to add two numbers and store the result the IP must process the addition instruction, then process the store. The IP communicates and receives instructions from the rest of the system through the external DATA BUS.

The ALU contains the "brains" of the microprocessor. It's the section of the microprocessor that actually performs the arithmetic calculations, the logical decisions, and can manipulate numbers (through shifting or "masking"). The instruction processor interprets the command, then instructs the ALU as to what it is to do. The ALU then performs the actual calculation, and stores the result at the location that the IP instructed it.

The REGISTERS are actually small amounts of memory. . . in fact a few microprocessors actually use external memory as registers. The advantage of having registers directly on the microprocessor chip is that operating on them is much quicker (as we'll see in the next column). Most microprocessors have a special register called the ACCUMULATOR. The accumulator usually contains at least one of the operands, and the results of calculations are placed into the accumulator. For example, if the microprocessor was instructed to add register 1 to the accumulator, the ALU would get the number stored in register 1, add to it the number stored in the accumulator, and then put the resulting sum back into the accumulator. Another special register is the Program Counter, which keeps track of the step in the program that is next. Like the IP, the registers are attached to the external DATA BUS.

The CONTROL LOGIC & ADDRESS GENERATOR keeps everything running in the proper order, decides how and when the external DATA BUS is used, and generates the address values for the ADDRESS BUS. The most important function of the control logic is to control the timing of the system. Fast microprocessors must have the timing of signals down to the *nanosecond* (one trillionth of a second!). The control logic also tells memory whether a READ or WRITE is taking place, selects banks of memory, and differentiates between I/O and memory access.

Now that we have an idea of the architecture of the microprocessor, look at Fig 2, which is a diagram of a basic computer system. The system consists of the microprocessor, memory, and Input/Output (I/O). The microprocessors retrieve instructions, and store information in the memory. The I/O is used by the microprocessor to communicate to the "outside world," such as printers, keyboards, video monitors, etc. Some microprocessors, usually called "single-chip microcontrollers" actually have the memory and I/O integrated onto the same chip as the microprocessor. These are used for controlling things such as printers, microwave ovens, transceivers, etc.

Next column, we'll look at how the program actually makes the microprocessor do what it's supposed to!

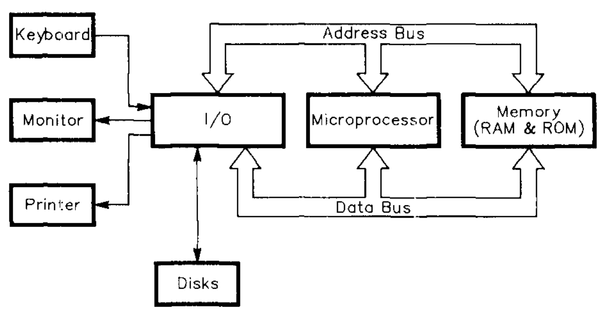


Figure 2

2400-bit/s MODEM CHIP

Silicon Systems has a new 2400-bit/s modem chip that should be interesting to a lot of you involved in packet. The SSI 73K324L chip conforms to all the current landline standards (CCITT V.21, V.22, V.23, and V.22 bis), and is easily interfaced to a microprocessor via an 8-bit multiplexed bus. As an option, the modem can be interfaced via a serial channel. The modem has a number of features which are aimed at landline use, but could be used on radio as well, such as DTMF generation and decoding. Another useful feature is the built-in self diagnostic. The chips are in the $40-50 range at the current time. Silicon Systems can be reached at 14351 Myford Road, Tustin, CA 92680, or telephone 800-624-8999.

DOLBY ON A CHIP

While this may not (yet?) have much application in Amateur Radio, this chip really piqued my interest. Analog Devices SSM-2125 is a complete Dolby Pro-Logic surround-sound decoder, and is the first to integrate autobalance, active decoding matrix, and center-mode control. The chip integrates 30 op amps, 10 voltage-controlled amplifiers, and several other specialized amplifiers, comparators, and logic! Even gain adjustment has been handled by laser trimmed internal resistors. The Total Harmonic Distortion at 100 dB is 0.015%! This looks like something fun to play with, and at about $15-18, is cheap enough that you could. For more information, contact Analog Devices, Inc, Precision Monolithics Division, 1500 Space Park Drive, Santa Clara, CA 95052.

PROGRAMMABLE SINEWAVE GENERATORS

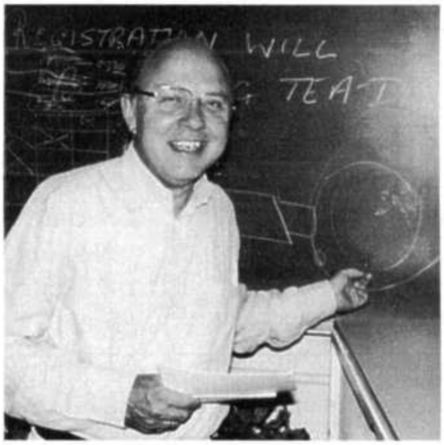
Micro Linear has developed what it claims is the "first integrated programmable sinewave generators." These 8-pin or 14-pin DIPs are packaged ICs and can be programmed from dc to 25 kHz (ML2035) or 50 kHz (ML2036). The frequency reference can either be an external crystal or another digital clock source. There are many possible uses for these chips, including test equipment, modems, controls, etc, and they're only about $6.00. Contact Micro Linear to get more information at: 2092 Concourse Drive, San Jose, CA 95131.

Empirically Speaking

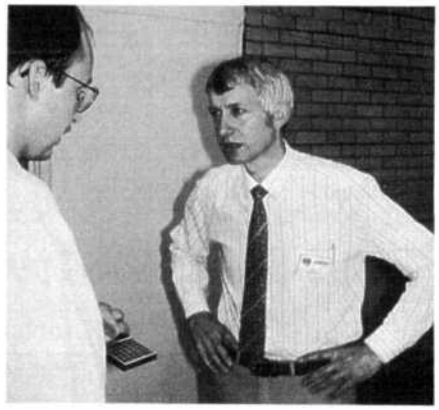
Continued from page 2.

the order of 100 bits per second. See related story in Gateway and on page 11.

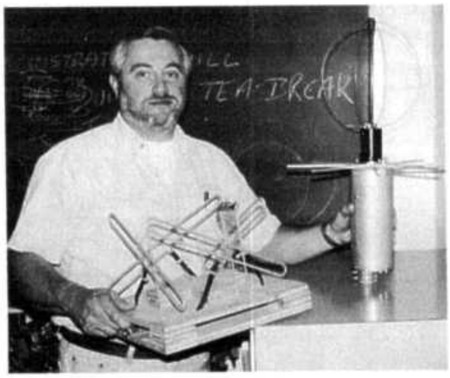
Just for a sanity check, Karl took a straw vote of the people at the Colloquium; 90% said they'd favor a Mars mission. What do you think? *QEX* would welcome your thoughts; we'll be happy to carry representative views in the Correspondence column.—*W4RI*



Karl Meinzer pointed out that the hole in the Ariane 5 cone could be used for a Mars mission if someone comes up with the people and money.

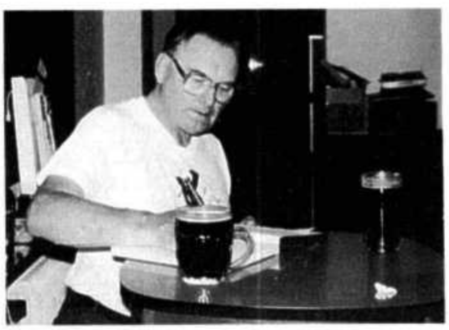


James Miller, G3RUH, is about to make a point.



Vern Riportella, WA2LQQ, gave a presentation on an "eggbeater" antenna—crossed loops for earth stations requiring no rotator.

Karl Meinzer, DJ4ZC, and Dick Jansson, WD4FAB, chat about Phase 3D mechanical design.



Colloquium organizer, Ron Broadbent, G3AAJ, ties up loose ends after the junk sale.